

Chapter 10 · Wave Optics

CBSE Class 12 Physics (042) · Unit VI Optics · Unit V + VI = 18 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS Fringe width: final expression only, NO derivation. Learn

$\beta = D\lambda/d$ and how to use it.

Single-slit diffraction and the width of the central maximum: qualitative treatment only.

What IS fully examinable: Huygens' principle, and the proof of the laws of reflection and refraction using wavefronts. That proof is the big derivation of this chapter.

60-SECOND RECALL

Huygens' principle	Every point on a wavefront is a source of secondary wavelets ; their common tangent gives the new wavefront
Fringe width	$\beta = D\lambda/d$ (formula only)
Bright fringe	Path difference = $n\lambda$
Dark fringe	Path difference = $(2n - 1)\lambda/2$
Intensity	$I \propto a^2 \cdot I_{\max}/I_{\min} = (a_1 + a_2)^2 / (a_1 - a_2)^2$
Coherent sources	Constant phase difference and the same frequency
Single slit	Central maximum is twice as wide as the others (qualitative)

1. Wavefront and Huygens' Principle

DEFINITIONS A wavefront is the locus of all points vibrating in the same phase. A ray is simply the direction perpendicular to the wavefront.

Shapes: point source → spherical; line source → cylindrical; source at infinity → plane.

WRITE THIS VERBATIM Huygens' principle: every point on a given wavefront acts as a source of secondary wavelets which spread out in the forward direction with the speed of the wave; the envelope (common tangent) of these wavelets at a later instant gives the new position of the wavefront.

THE TWO PROOFS — the main derivation of this chapter **Reflection:** constructing the reflected wavefront gives two congruent right triangles, and therefore $i = r$.

Refraction: in the same time, the wave covers $v_1 t$ in medium 1 and $v_2 t$ in medium 2, so

$$\sin i / \sin r = v_1/v_2 = \mu_2/\mu_1 \text{ — Snell's law}$$

The frequency never changes on refraction; the wavelength and speed do. This one-liner is a frequent 1-marker.

2. Interference and Young's Double Slit

COHERENT SOURCES

Two sources are **coherent** if they emit waves of the **same frequency** with a **constant phase difference**. Two independent bulbs can never be coherent, which is why YDSE uses **one source split into two**.

CONDITIONS AND FORMULAS

Constructive (bright): path difference = $n\lambda$, $n = 0, 1, 2, \dots$

Destructive (dark): path difference = $(2n - 1)\lambda/2$

Fringe width $\beta = D\lambda/d$ final expression only — no derivation required

Position of n^{th} bright fringe: $y_n = nD\lambda/d$

$$I = 4I_0 \cos^2(\phi/2) \cdot I_{\max}/I_{\min} = (a_1 + a_2)^2/(a_1 - a_2)^2$$

WHAT CHANGES β — asked constantly $\beta \propto \lambda \rightarrow$ red fringes are **wider** than blue.

$\beta \propto D \rightarrow$ moving the screen back widens the fringes.

$\beta \propto 1/d \rightarrow$ bringing the slits closer widens them.

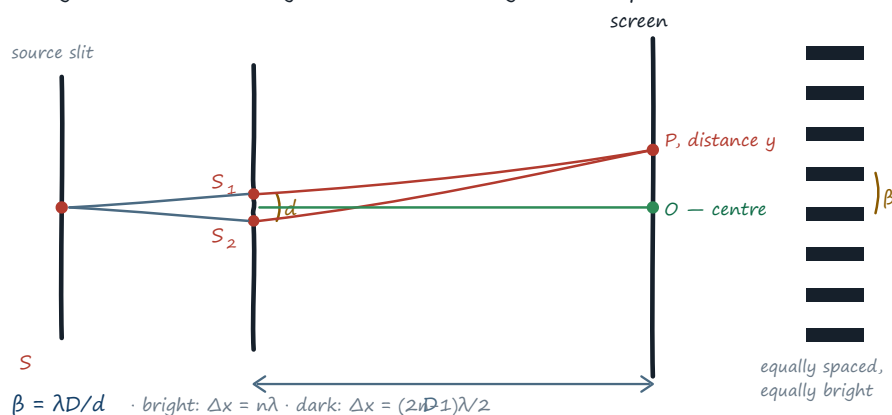
In **water** the wavelength falls to λ/μ , so β **decreases** by a factor μ .

In **white light** the centre is **white** and the surrounding fringes are **coloured**, with violet nearest the centre.

TRAP

Interference **does not create or destroy energy** — it only **redistributes** it. The energy missing from the dark fringes appears in the bright ones, so the average intensity is unchanged. That sentence is the whole answer to "does interference violate conservation of energy?" If one slit is covered, the interference pattern **disappears** and only a broad single-slit pattern remains.

Young's double slit — the syllabus wants the fringe-width expression, not its derivation



Interference gives **equally spaced, equally bright** fringes. Diffraction does not — its central maximum is twice as wide and the rest fade. That contrast is the usual 1-mark question.

3. Diffraction at a Single Slit qualitative only

WHAT TO KNOW Light bends around the edges of an obstacle comparable in size to its wavelength. The pattern has a **wide bright central maximum** flanked by much weaker maxima. Minima at: $a \sin \theta = n\lambda$ · Half-angular width $\theta = \lambda/a$ · Width of the central maximum = $2D\lambda/a$

The central maximum is twice as wide as any other, and grows wider as the slit is made narrower.

INTERFERENCE vs DIFFRACTION — the comparison asked

Basis	Interference	Diffraction
Arises from	Two coherent sources	Secondary wavelets from the same wavefront
Fringe width	All equal	Central is widest, others shrink
Intensity of maxima	All equal	Falls off rapidly
Dark fringes	Perfectly dark	Not perfectly dark

WORKED EXAMPLE In a YDSE, $d = 0.5 \text{ mm}$, $D = 1 \text{ m}$, $\lambda = 500 \text{ nm}$.

$$\beta = D\lambda/d = (1 \times 500 \times 10^{-9}) / (0.5 \times 10^{-3}) = 1 \times 10^{-3} \text{ m} = 1 \text{ mm}$$

Distance of the **3rd bright fringe** from the centre = $3\beta = 3 \text{ mm}$

If the whole apparatus is immersed in water ($\mu = 4/3$), $\beta' = \beta/\mu = 0.75 \text{ mm}$

4. Question Triggers what the wording is really asking

If the question says...	The answer is...
"prove the laws of reflection / refraction"	Huygens' construction
"fringe width when screen is moved back"	$\beta \propto D \rightarrow$ increases
"apparatus immersed in water"	β decreases by a factor μ
"white light used in YDSE"	Central fringe white , rest coloured
"does interference violate energy conservation?"	No — energy is redistributed
"central maximum is twice as wide"	Single-slit diffraction
"what changes on refraction"	Speed and wavelength; frequency stays the same

MOST-ASKED BOARD QUESTIONS

- [3M]** State Huygens' principle and use it to prove the laws of reflection / refraction.
- [3M]** In YDSE, discuss how the fringe width changes with λ , D , d and the medium (numerical).
- [2M]** Write the conditions for **constructive and destructive** interference.
- [2M]** Distinguish between **interference and diffraction**.
- [2M]** What are **coherent sources**, and why are two separate bulbs never coherent?

6. [1M] How does the frequency of light change when it enters glass? → It does not

THE HABIT THAT SCORES — The syllabus removed the fringe-width derivation but kept the Huygens proofs. So practise **drawing** the two wavefront constructions until they are automatic — and do not waste a single revision minute deriving $\beta = D\lambda/d$.