

RAY OPTICS & OPTICAL INSTRUMENTS – COMPLETE STUDY GUIDE (CLASS 12)

(Simple • Visual • Exam-Focused)

★ 1. THEORY IN SIMPLE WORDS (WITH VISUALS & ANALOGIES)

What is Ray Optics?

Ray Optics = Light travels in straight lines called rays.

Think of light like arrows or laser beams shooting straight unless something bends or reflects them.

☀ 1. Reflection of Light

Law of Reflection

1. Angle of incidence = Angle of reflection
2. Incident ray, normal, and reflected ray → lie in the *same plane*.

Mental Image

Imagine a **basketball** bouncing off the floor.

The angle you throw it with = angle it bounces off at.

☀ 2. Refraction of Light

Refraction = bending of light when going from one medium to another (air → water).

Why it bends?

Because light changes speed.

- Faster in air
- Slower in water or glass

Mental Image

Imagine running on a beach:

- On sand → slow
 - On pavement → fast
- When you cross the boundary, your direction changes.
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Snell's Law

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

Where μ is refractive index.

3. Total Internal Reflection (TIR)

Occurs when:

1. Light travels from **denser** → **rarer** medium
2. Angle of incidence > **critical angle (C)**

Examples

-  Sparkle of diamonds
 -  Water appearing like a mirror when seen from underwater
 -  Optical fibers
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4. Lenses

Types of Lenses

- Convex (Converging) → Bulges out
- Concave (Diverging) → Caves in

Mental Images

Convex → "Fat lens brings rays together."

Concave → "Thin lens pushes rays apart."

Lens Formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Magnification:

$$m = \frac{v}{u}$$

5. Optical Instruments

Human Eye

- Retina → Screen
- Iris → Camera aperture
- Lens → Adjustable focal length
- Ciliary muscles → Autofocus system

Microscope

Two lenses: **Objective + Eyepiece**

Magnification:

$$M = m_{\text{objective}} \times m_{\text{eyepiece}}$$

Telescope

Designed to view far objects

Magnification:

$$M = \frac{f_e}{f_o}$$

2. KEY CONCEPTS & FORMULAS TABLE

Concept	Formula	Trick to Remember
Snell's Law	$\sin i / \sin r = \mu_2 / \mu_1$	"Sine over Sine, μ in line"
Lens Formula	$1/f = 1/v - 1/u$	F stands for <i>Focus: Very Useful</i>
Mirror Formula	$1/f = 1/v + 1/u$	For mirrors → "PLUS in the middle"
Magnification	$m = v/u$	"Image/Object = v/u"
Critical Angle	$\sin C = 1/\mu$	Bigger μ → Smaller critical angle

Sign Convention (Quick Mnemonic)

L I M → Left Is Minus

Anything measured to left of optical center = negative.

3. SOLVED NUMERICAL PROBLEMS

Example 1 (Refraction)

Light enters water from air at 30° . Find angle of refraction ($\mu = 1.33$).

✓ Solution

Snell's Law:

$$\frac{\sin 30}{\sin r} = 1.33$$

$$\sin r = \frac{0.5}{1.33} = 0.376$$

$$r = 22^\circ$$

Tip: Always write Snell's Law first!

❓ Example 2 (Lens Formula)

Object at 20 cm from convex lens ($f = +10$ cm). Find image distance.

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{10} = \frac{1}{v} - \frac{1}{-20}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$$

$$v = 20 \text{ cm}$$

→ Real, inverted, size equal.

❓ Example 3 (TIR)

Critical angle for glass ($\mu = 1.5$)?

$$\sin C = \frac{1}{1.5} = 0.666$$

$$C = 41.8^\circ$$

★ 4. PREVIOUS YEARS' BOARD QUESTIONS (SOLVED)

(Covered conceptually—they follow the usual CBSE style)

Q1. What is Total Internal Reflection? State its conditions.

✓ Explanation included above.

Q2. Draw a labelled diagram of a compound microscope.

✓ Practice diagram included in revision notes.

Q3. A convex lens forms a real image twice the size of the object. Find the object distance if $f = 15 \text{ cm}$.

$$(m = v/u = 2)$$

Solve $\rightarrow u = -22.5 \text{ cm}$

Q4. Derive lens formula ($1/f = 1/v - 1/u$)

✓ Keep steps short: Similar triangles \rightarrow sign convention \rightarrow final relation.

🔍 Pattern:

Ray diagrams, lens formula numericals, TIR concepts appear **every year**.

★ 5. QUICK REVISION NOTES (1–2 PAGES)

虹 Important Terms

- Refraction = bending
 - TIR = 100% reflection
 - Principal axis = central line
 - Focal length = focus distance
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★ Must-Learn Diagrams

- Ray diagram for concave/convex lens
 - Image formation in mirrors
 - Human eye
 - Microscope
 - Telescope
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★ Most Tested Formulas

- Lens formula
 - Magnification
 - Critical angle
 - Snell's Law
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★ High-Yield Topics

- TIR and applications

- Power of lens ($P = 1/f$)
 - Defects of vision
 - Microscope magnification
 - Telescope magnification
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★ 6. PREDICTED / LIKELY QUESTIONS (2025 BOARDS)

Short Answer

1. Define critical angle.
2. What is myopia? How is it corrected?
3. Why does a coin appear raised in water?

Numerical-Based

1. Calculate μ of a glass slab given i and r .
2. Lens formula problems with both signs.
3. Magnification of microscope/telescope.

Diagram-Based

1. Ray diagram for image by convex lens
 2. Eye defects correction
 3. Working of optical fiber
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★ 7. EXAM TIPS & TRICKS

✓ TIP 1: For sign convention

"Left is Minus" → LIM

✓ TIP 2: Ray Diagrams

Always draw:

- Principal axis
- Lens/mirror
- 2 standard rays

✓ TIP 3: Numerical

Write formula → substitute → solve → add unit.

✓ TIP 4: Time-Saving

If $f > 0 \rightarrow$ Convex lens

If $f < 0 \rightarrow$ Concave lens

Memorize signs first!

✓ TIP 5: Don't Forget

For TIR → write both conditions!

★ 8. VISUAL & KID-FRIENDLY MEMORY HACKS

★ Memory Trick for Lenses

- CONVEX → CONverge
- CONCAVE → CAVE in → rays diverge

★ For Refraction

"Fast → Slow = Bend Toward"

"Slow → Fast = Bend Away"

★ For TIR

"Denser → Rarer, Angle must be Greater."

★ For Human Eye

- Iris = Colored curtain
- Pupil = Window
- Lens = Autofocus
- Retina = Screen