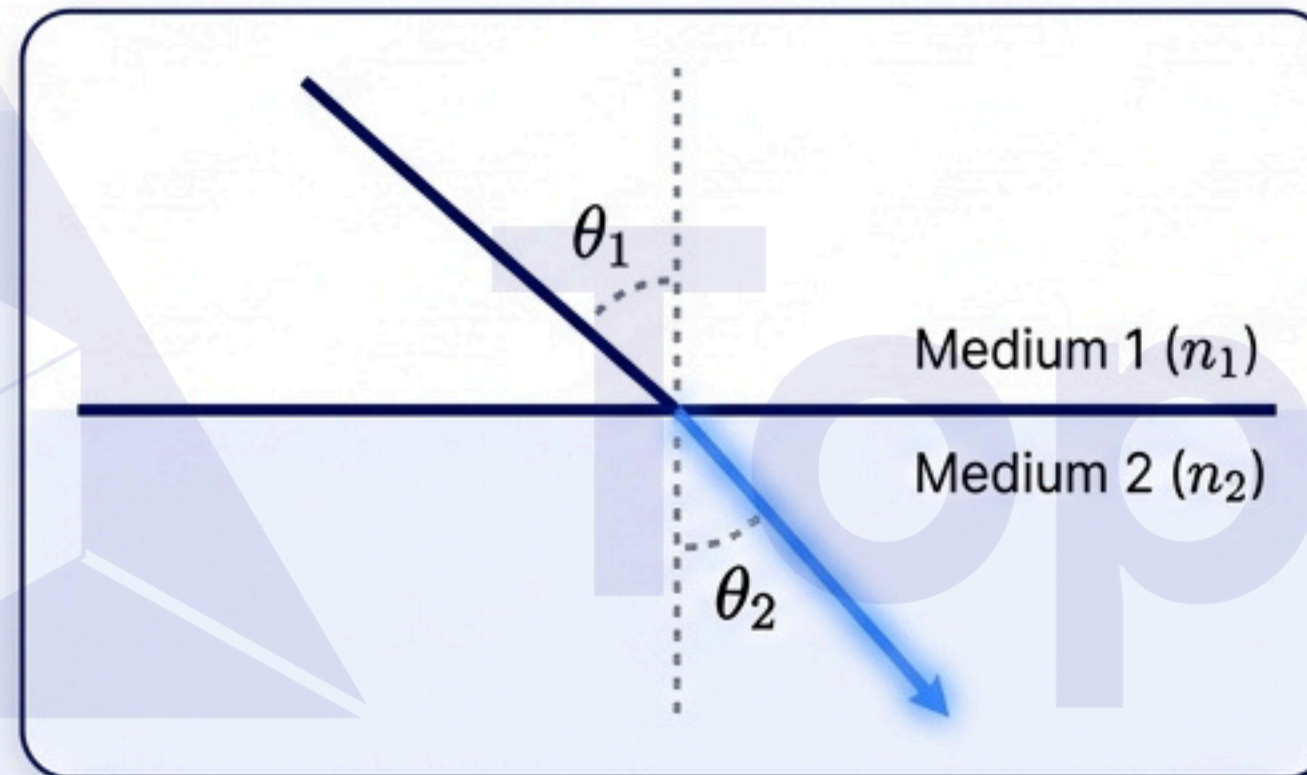


Refraction and Snell's Law

Ray Optics | Core Concept 9.3



Concept & Definition

Refraction is the bending of a wave as it passes from one medium to another with a different optical density. The change in speed causes the change in direction.

Key Insight: Light slows down and bends towards the normal when entering a denser medium.

Snell's Law (Formula)

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

Where:

n_1 = Refractive index of medium 1

n_2 = Refractive index of medium 2

θ_1 = Angle of incidence,

θ_2 = Angle of refraction.

Common Pitfall

⚠ Angles θ_1 and θ_2 must be measured relative to the NORMAL, not the surface.

Final Takeaway

✓ The ratio of the sines of the angles is equal to the inverse ratio of the refractive indices.

What is Refraction?

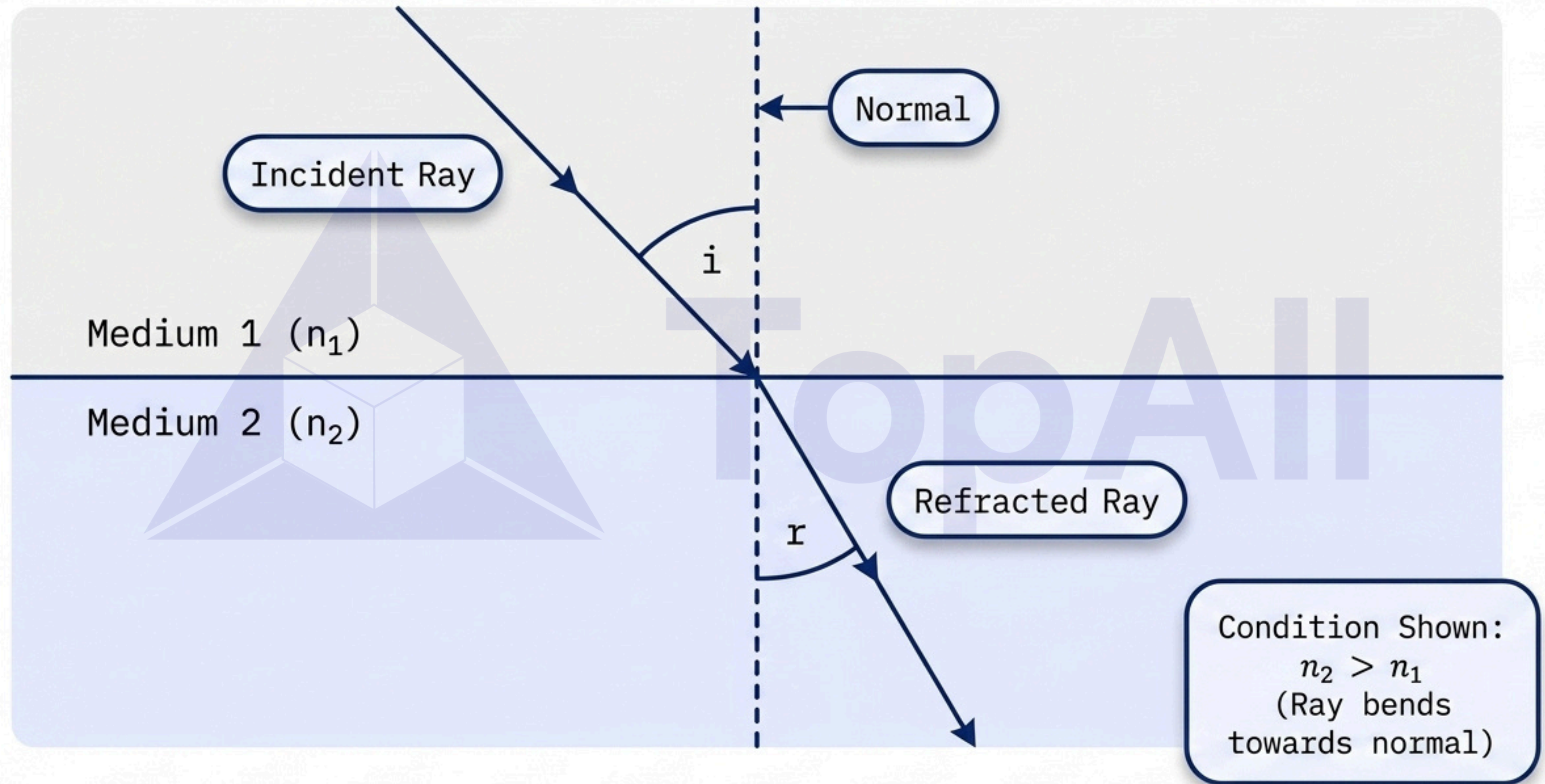
The phenomenon where an obliquely incident ray of light changes its direction of propagation at the interface of two transparent media.

$$0^\circ < i < 90^\circ$$

The Refractive Index

Bending occurs because light travels at different speeds in different media. This determines the medium's optical density.

- Light **slows down** = Optically **Denser**
- Light **speeds up** = Optically **Rarer**





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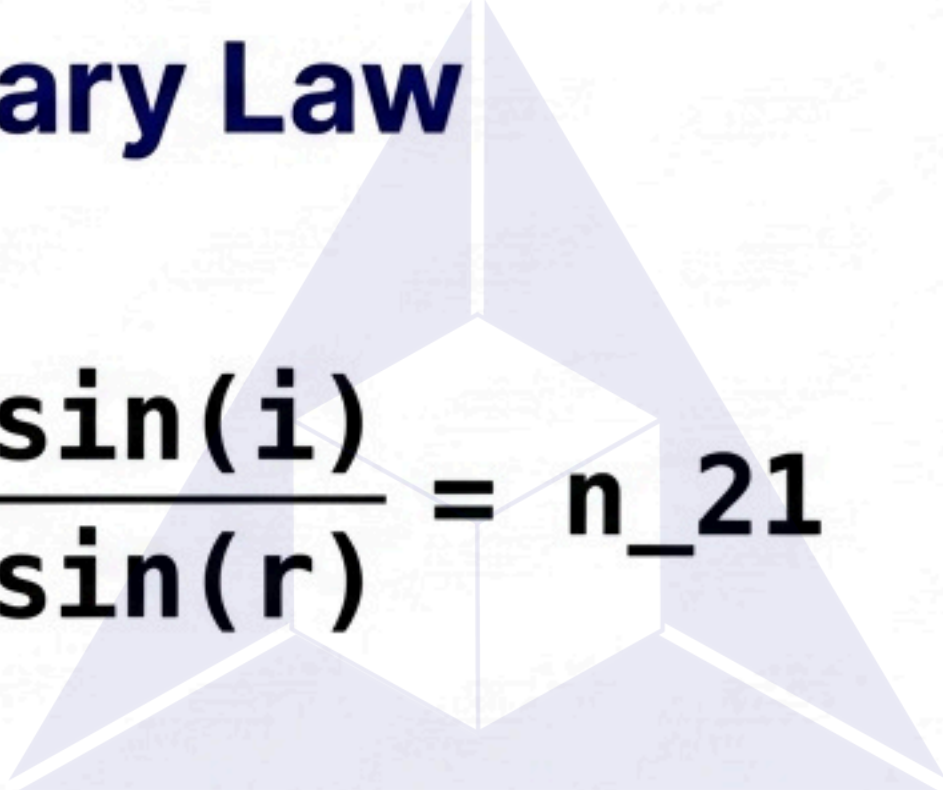
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Formula Bank: Refraction

Primary Law


$$\frac{\sin(i)}{\sin(r)} = n_{21}$$

n_{21} is a constant for a given pair of media and wavelength.
Independent of angle of incidence.

Index Relations

$$n_{21} = \frac{n_2}{n_1} \quad (\text{Medium 2 w.r.t Medium 1})$$

$$n_{12} = \frac{1}{n_{21}}$$

$$n_{32} = n_{31} * n_{12}$$

JEE Trap Alert

Optical Density $\neq$ Mass Density

The Trap

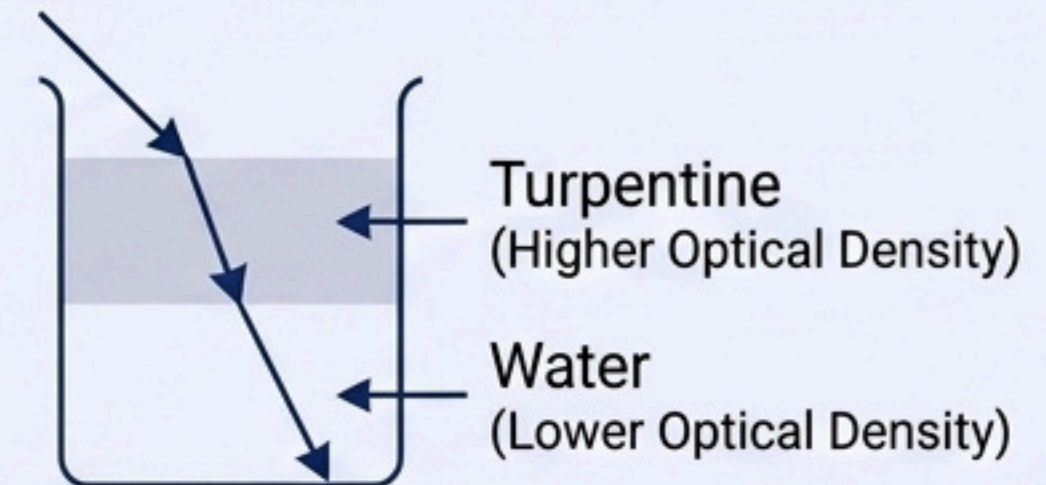
Assuming that a medium with higher mass density (mass/volume) is automatically more optically dense.

The Reality

Optical density is determined **ONLY** by the speed of light in the medium.

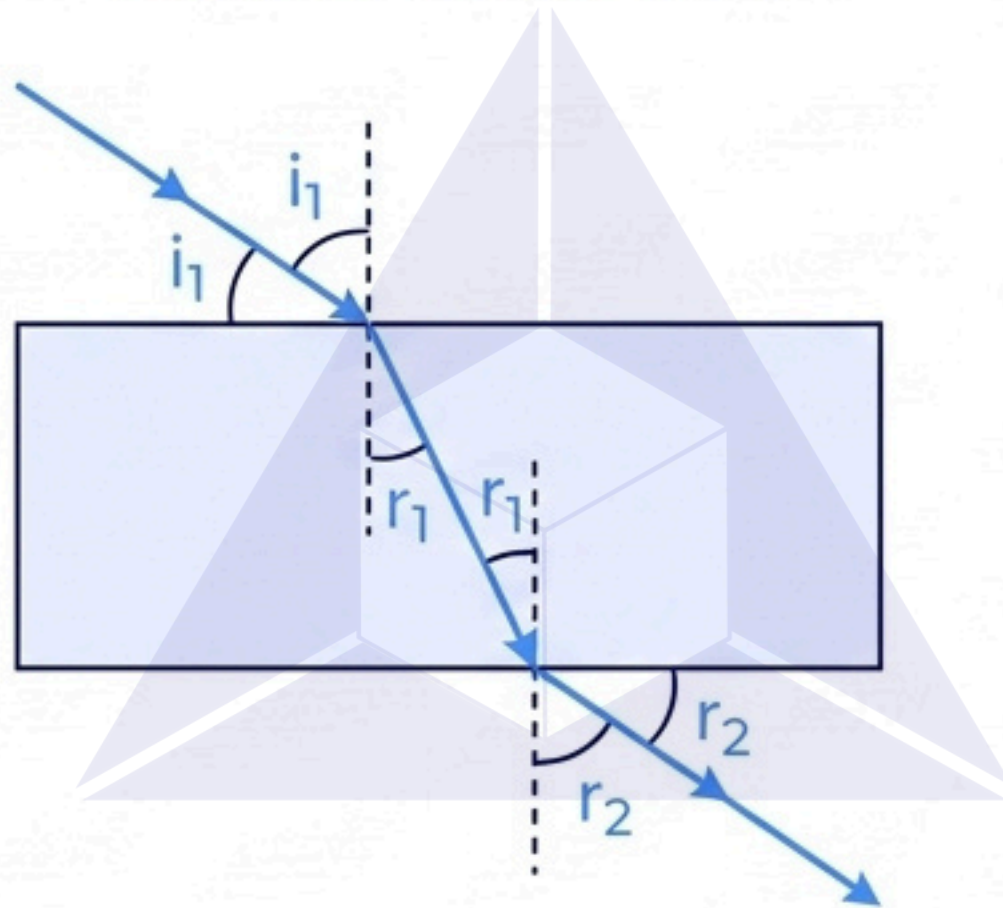
Turpentine vs. Water

Turpentine has a lower mass density than water (it floats on it), but a higher optical density (refractive index). Light bends more in turpentine!



Standard Applications

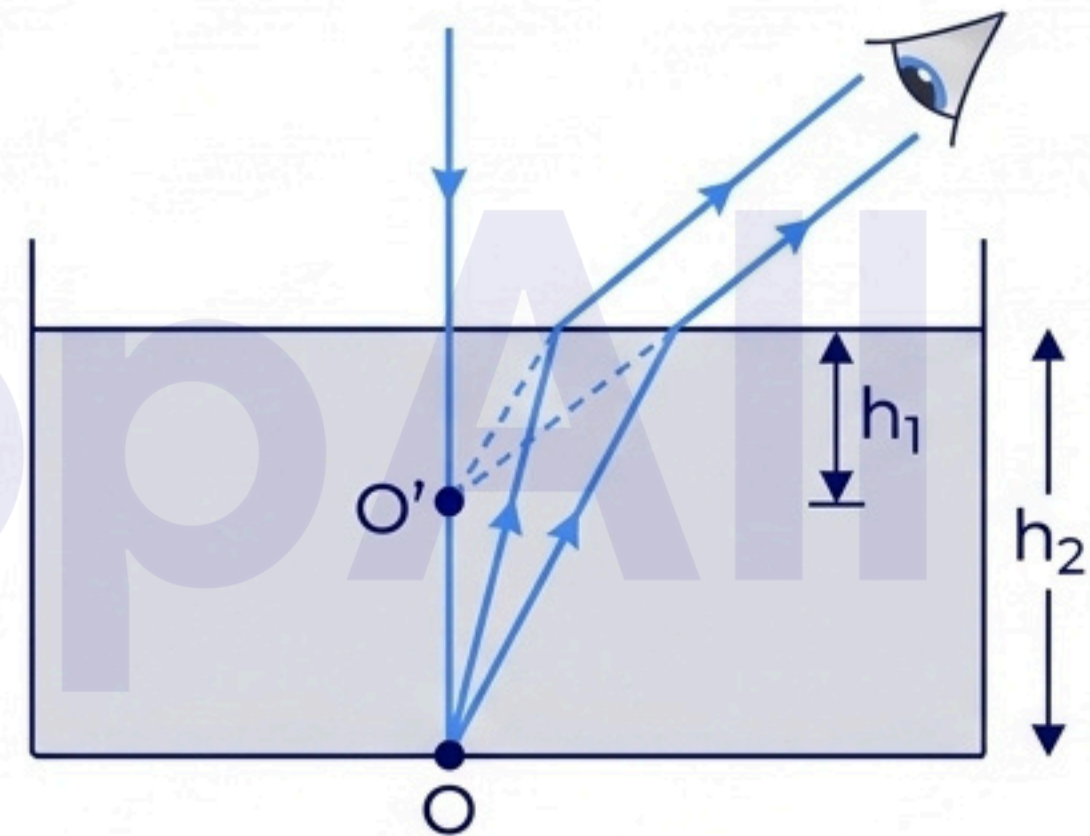
Lateral Shift



$$r_2 = i_1$$

The emergent ray is parallel to the incident ray. Zero angular deviation.

Apparent Depth



$$h_{\text{apparent}} = h_{\text{real}} / n$$

(For near-normal viewing)

Key Takeaways

The 3 Rules of Ray Bending

Rarer → Denser

Light slows down. Bends TOWARD the normal.

$$i > r$$

Denser → Rarer

Light speeds up. Bends AWAY from the normal.

$$r > i$$

Zero Deviation

Incidence exactly along the normal. Ray passes straight through without bending.

$$i = 0, r = 0$$



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