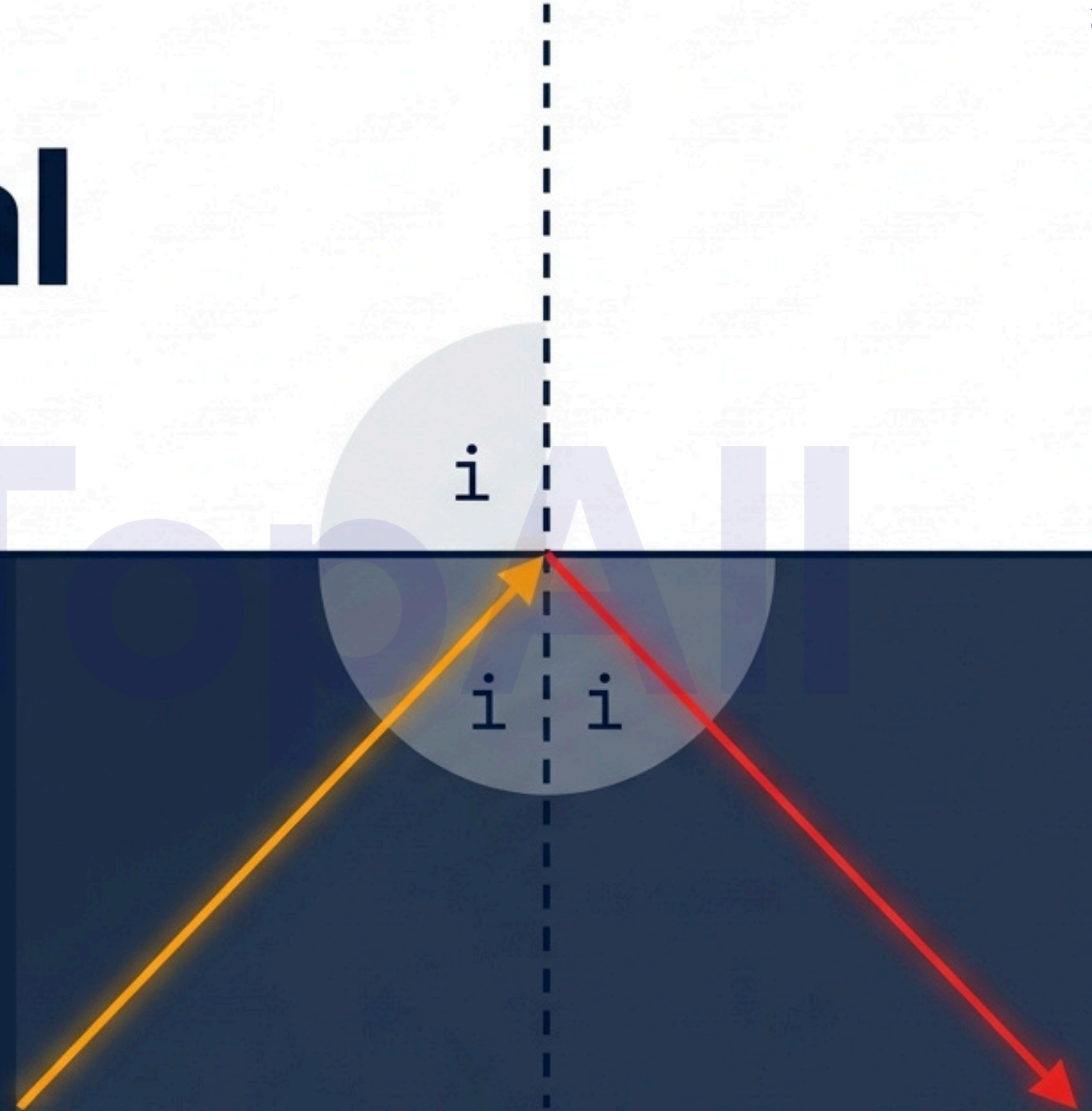
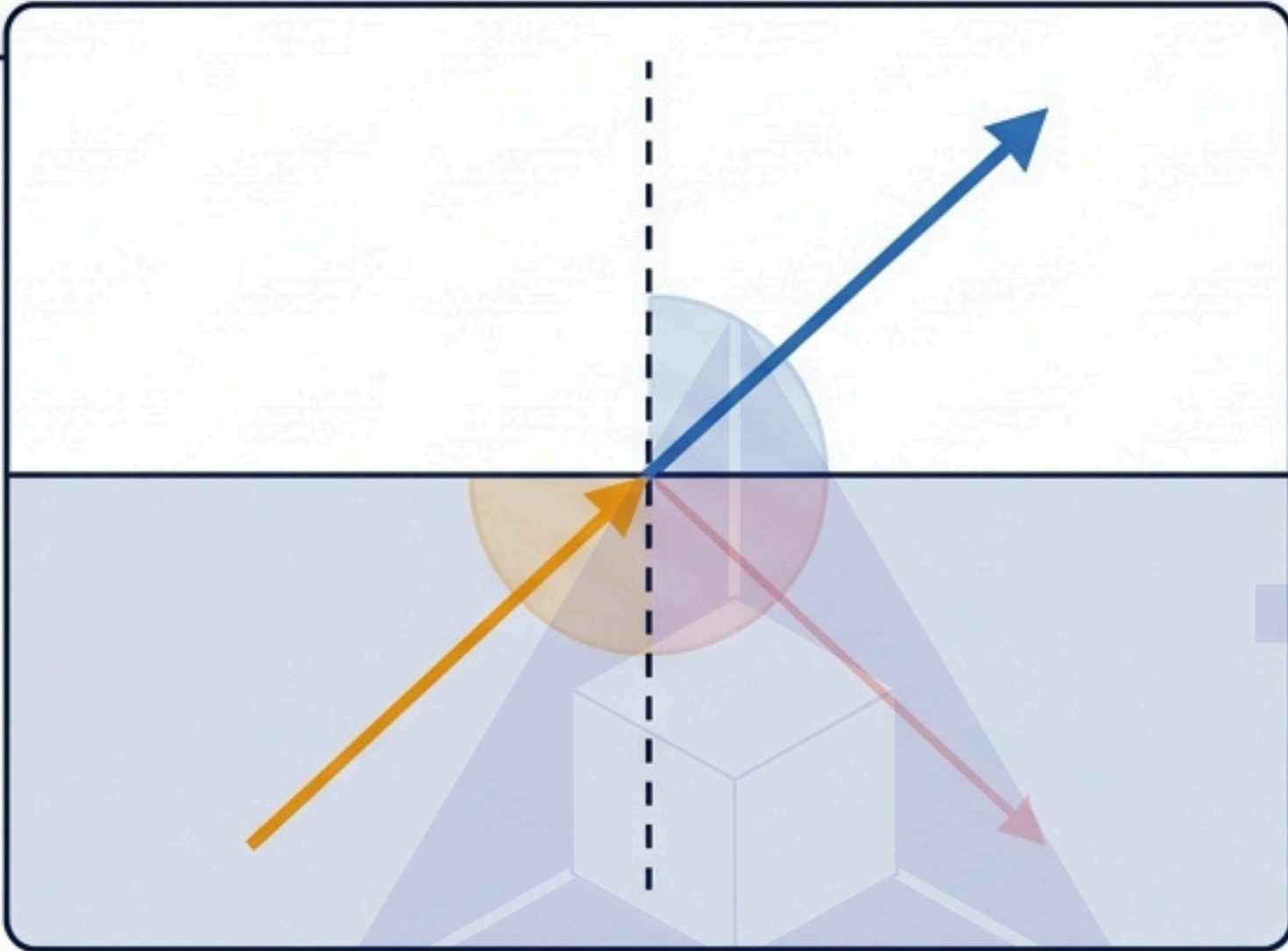


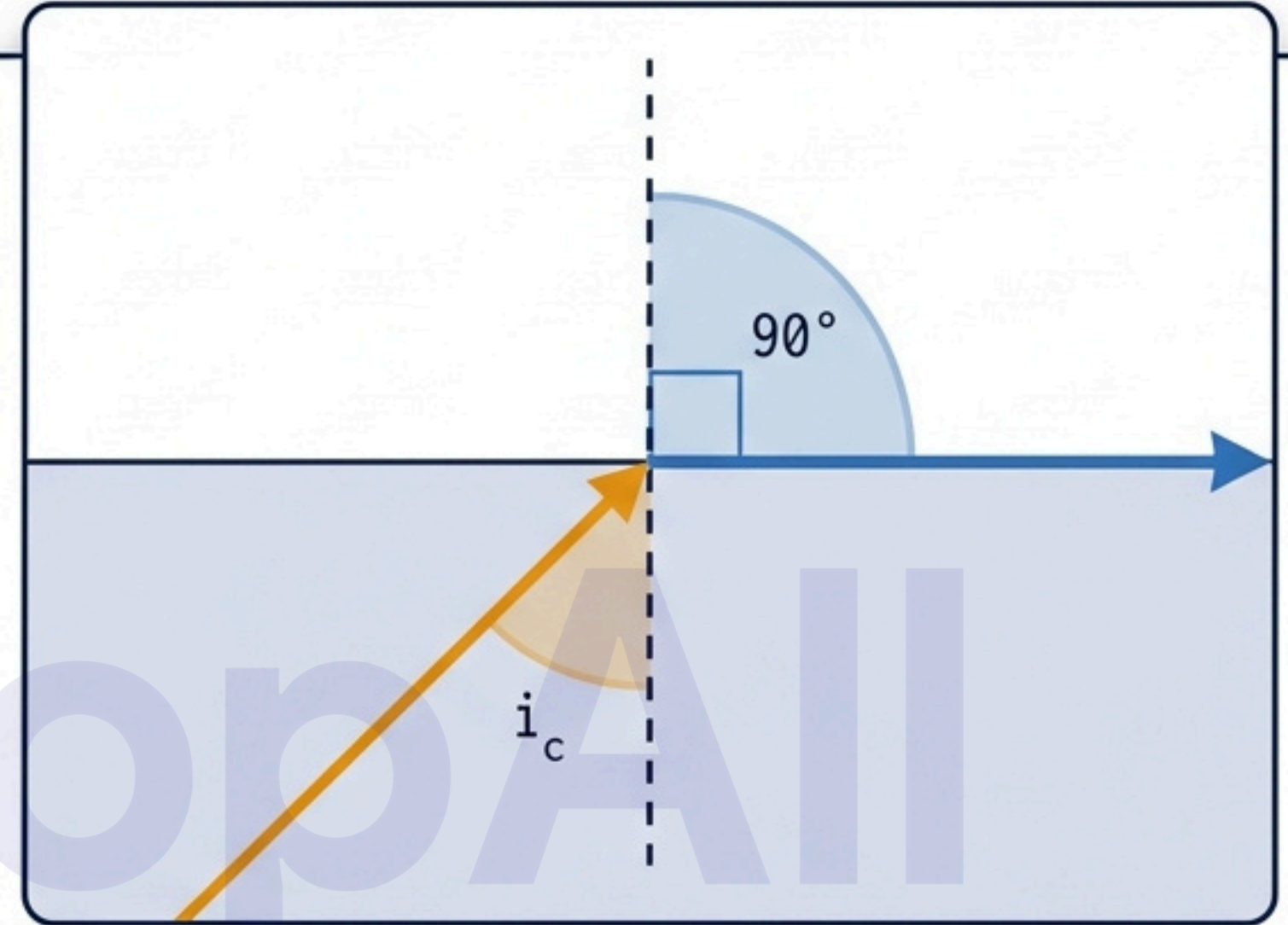
Total Internal Reflection

Mastering the denser-to-rarer optical interface.

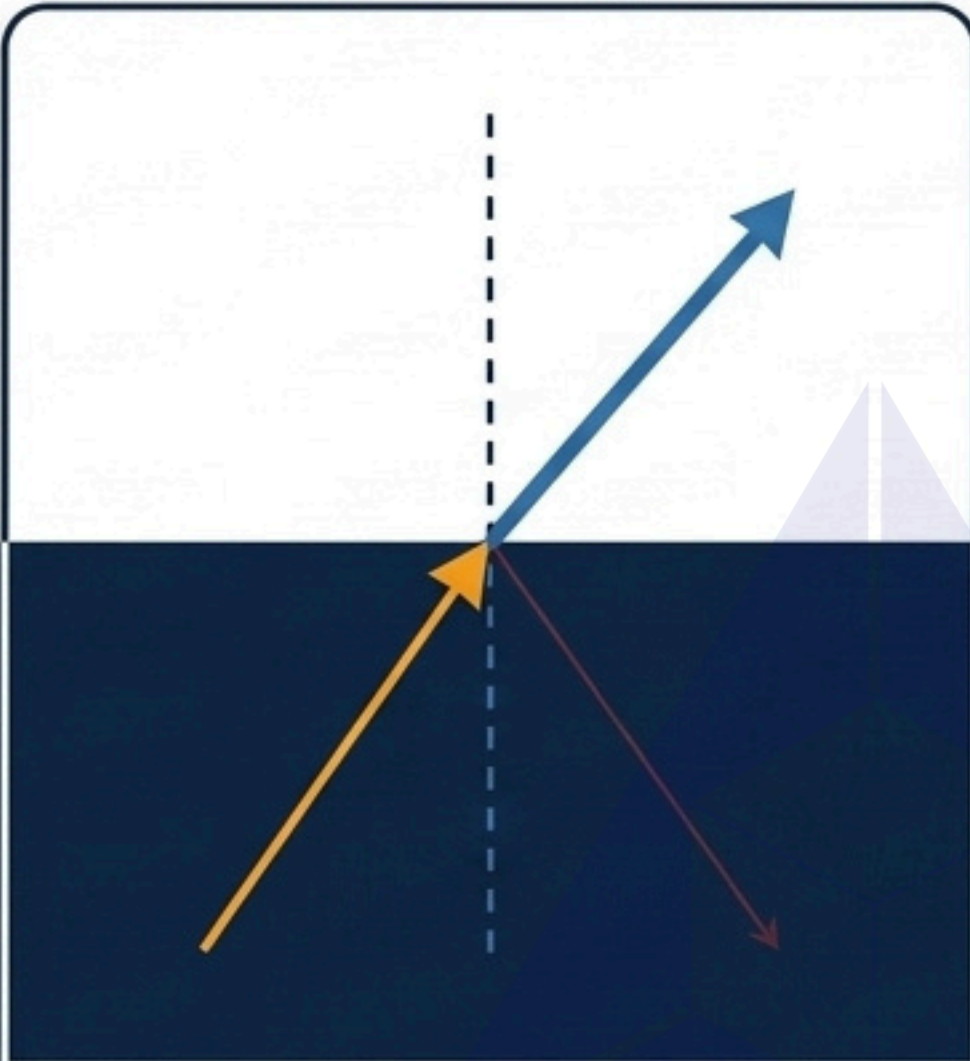




When light travels from an optically denser to a rarer medium, it doesn't just refract. A portion is always reflected back into the denser medium. This is **internal reflection**.



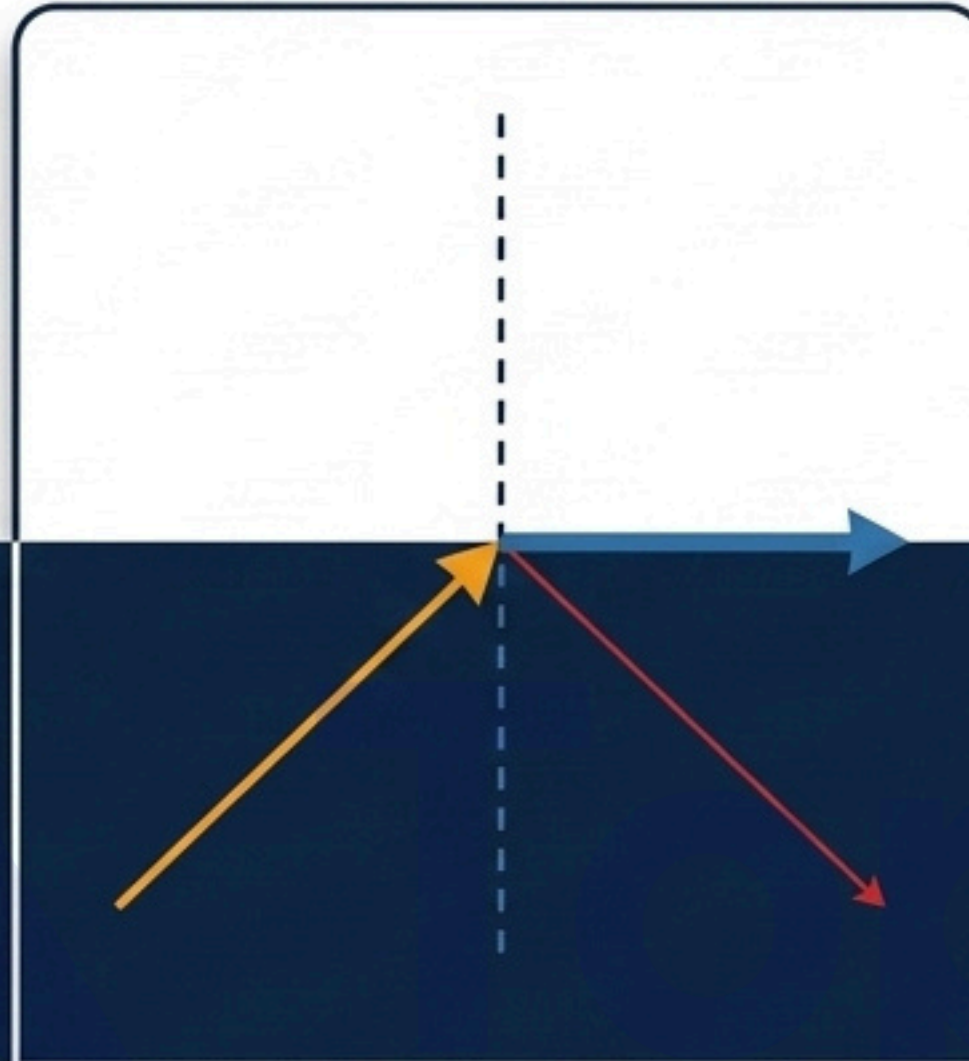
As the incidence angle (i) increases, the refraction angle (r) also increases. **The Critical Angle (i_c)** is the specific angle of incidence where the refracted ray perfectly grazes the boundary ($r = 90^\circ$).



Standard Refraction

$$r > i$$

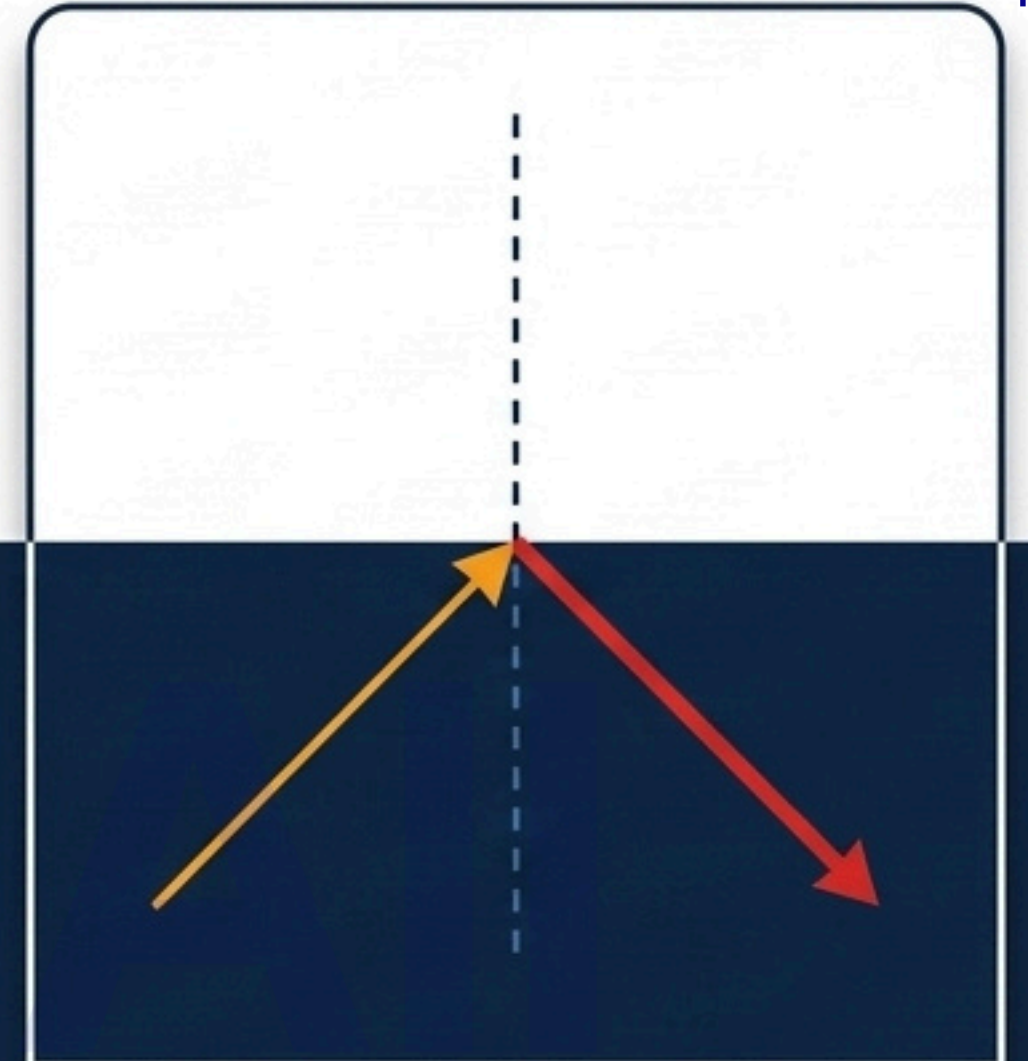
Ray bends away from the normal.
Partial reflection occurs.



The Threshold

$$r = 90^\circ$$

The refracted ray grazes the
interface.



Total Internal Reflection

r is undefined

100% of the light reflects back.
Refraction is impossible.



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Step 1 (Snell's Law at threshold): $n_1 \cdot \sin(i_c) = n_2 \cdot \sin(90^\circ)$

Step 2 (Simplification): $\sin(i_c) = \frac{n_2}{n_1} = n_{21}$ (where $n_1 > n_2$)

Step 3 (Standard JEE Form): $\sin(i_c) = \frac{1}{n_{12}} = \frac{1}{\mu_{rel}}$

Rule Bank

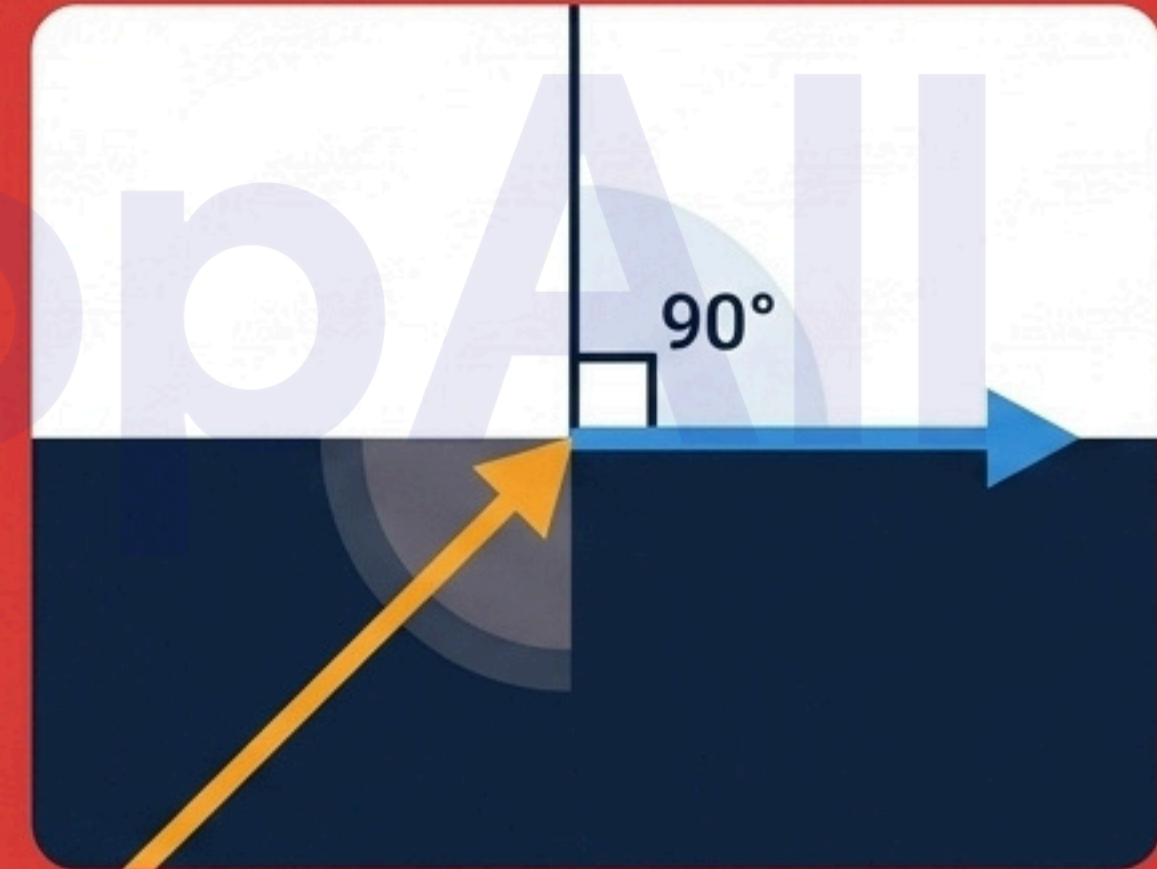
$\mu_{rel} (n_{12})$ is the refractive index of the denser medium with respect to the rarer medium.



JEE Trap Alert: The Boundary Condition

The Trap: Assuming Total Internal Reflection occurs at the critical angle ($i = i_c$).

The Truth: At exactly $i = i_c$, TIR has NOT started. The ray simply grazes the interface (emerges at 90°). Total Internal Reflection strictly requires $i > i_c$. If an exam option says TIR occurs at $i \geq i_c$, it is incorrect.



Mini Problem

A ray travels from
Glass ($\mu = \sqrt{2}$) to Air.

Classify the ray
behavior for incidence
angles
 $i = 30^\circ$, 45° , and 60° .

Step 1: Calculate threshold

$$\rightarrow \sin(i_c) = 1/\sqrt{2} \rightarrow i_c = 45^\circ$$

$i = 30^\circ$	$(30^\circ < 45^\circ)$	Refraction + Partial Reflection
$i = 45^\circ$	$(45^\circ = 45^\circ)$	Grazing Emergence
$i = 60^\circ$	$(60^\circ > 45^\circ)$	Total Internal Reflection

Key Takeaways:

The 2 Absolute Conditions for TIR



Condition 1: Light MUST travel from an Optically Denser medium to an Optically Rarer medium ($n_1 > n_2$).



Condition 2: The angle of incidence MUST be Strictly Greater than the critical angle ($i > i_c$).

$$\sin(i_c) = n_{\text{rarer}} / n_{\text{denser}}$$



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