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REFRACTION

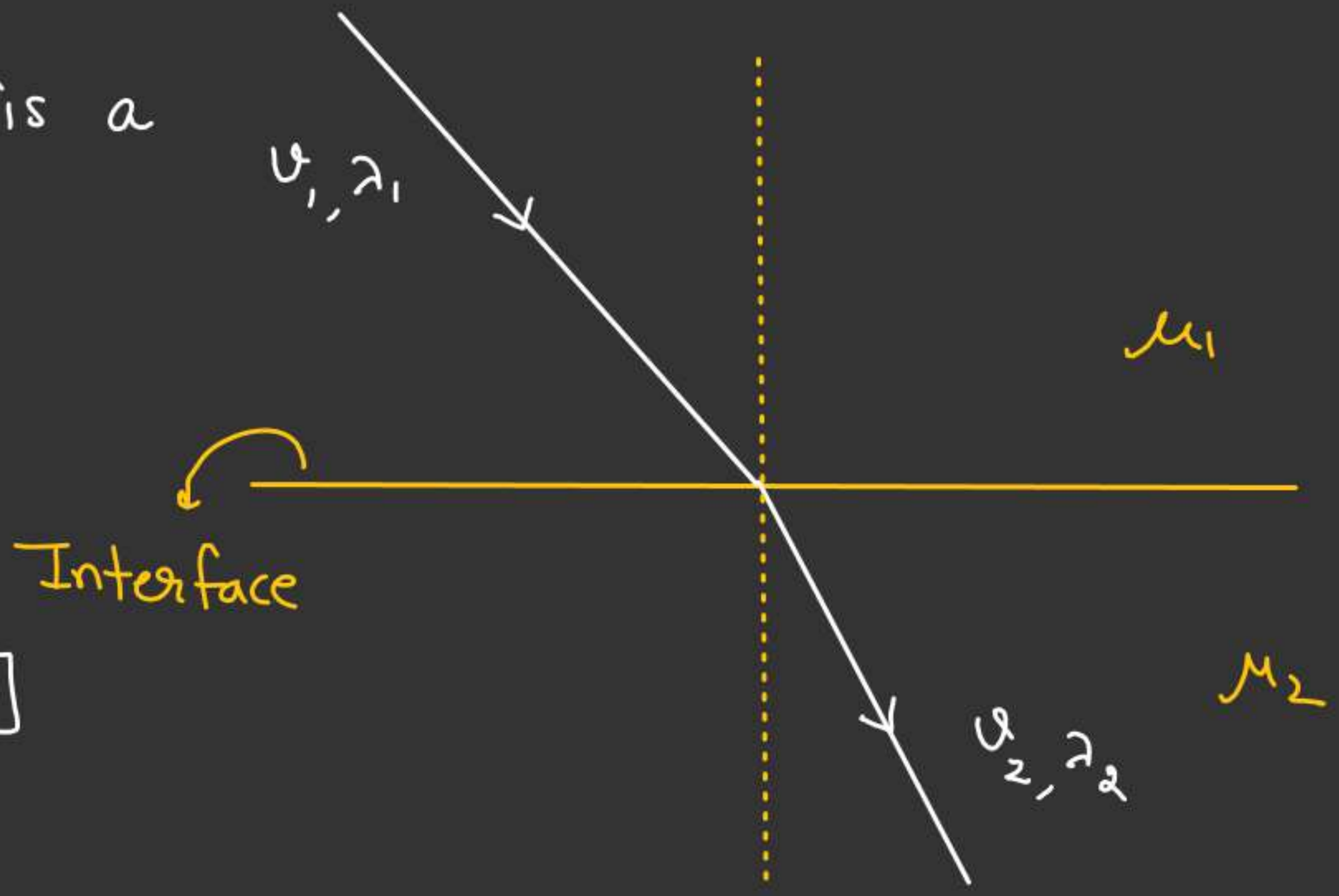
Def^n:- Phenomena by virtue of which light ray suffer change in its speed at the interface seperating two media. when light travel from one medium to another.

- Due to change in speed there is a change in the path of light ray

- Frequence doesn't change as. it depends on the source when light ray travel from one medium to another.

$[v = f\lambda]$

$$\left(f = \frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2} \right)$$



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** When light ray bends towards the normal then the medium is optically denser & when light ray move away from the normal then the medium is optically Rarer.

** Refractive Index

- Absolute refractive Index = $\frac{\text{Speed of light in air}}{\text{Speed of light in Medium}}$

$$\boxed{\mu = \frac{c}{v}}$$

- Relative Refractive Index

$_1\mu_2 \rightarrow$ Refractive Index of 2 w.r.t. 1.

$$_1\mu_2 = \left(\frac{\mu_2}{\mu_1}\right) = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2} = \frac{f\lambda_1}{f\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

$$\boxed{\frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}}$$

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$$\boxed{{}_1\mu_3 = {}_1\mu_2 \times {}_2\mu_3}$$

$${}_1\mu_2 = \frac{\mu_2}{\mu_1}$$

$${}_2\mu_3 = \frac{\mu_3}{\mu_2}$$

$${}_1\mu_2 \times {}_2\mu_3 = \frac{\mu_2}{\mu_1} \times \frac{\mu_3}{\mu_2} = \frac{\mu_3}{\mu_1}$$

$${}_1\mu_2 \times {}_2\mu_3 = {}_1\mu_3$$

$$\mu > 1 \leftarrow \mu = \frac{c}{v} \quad c > v$$

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LAW OF REFRACTION

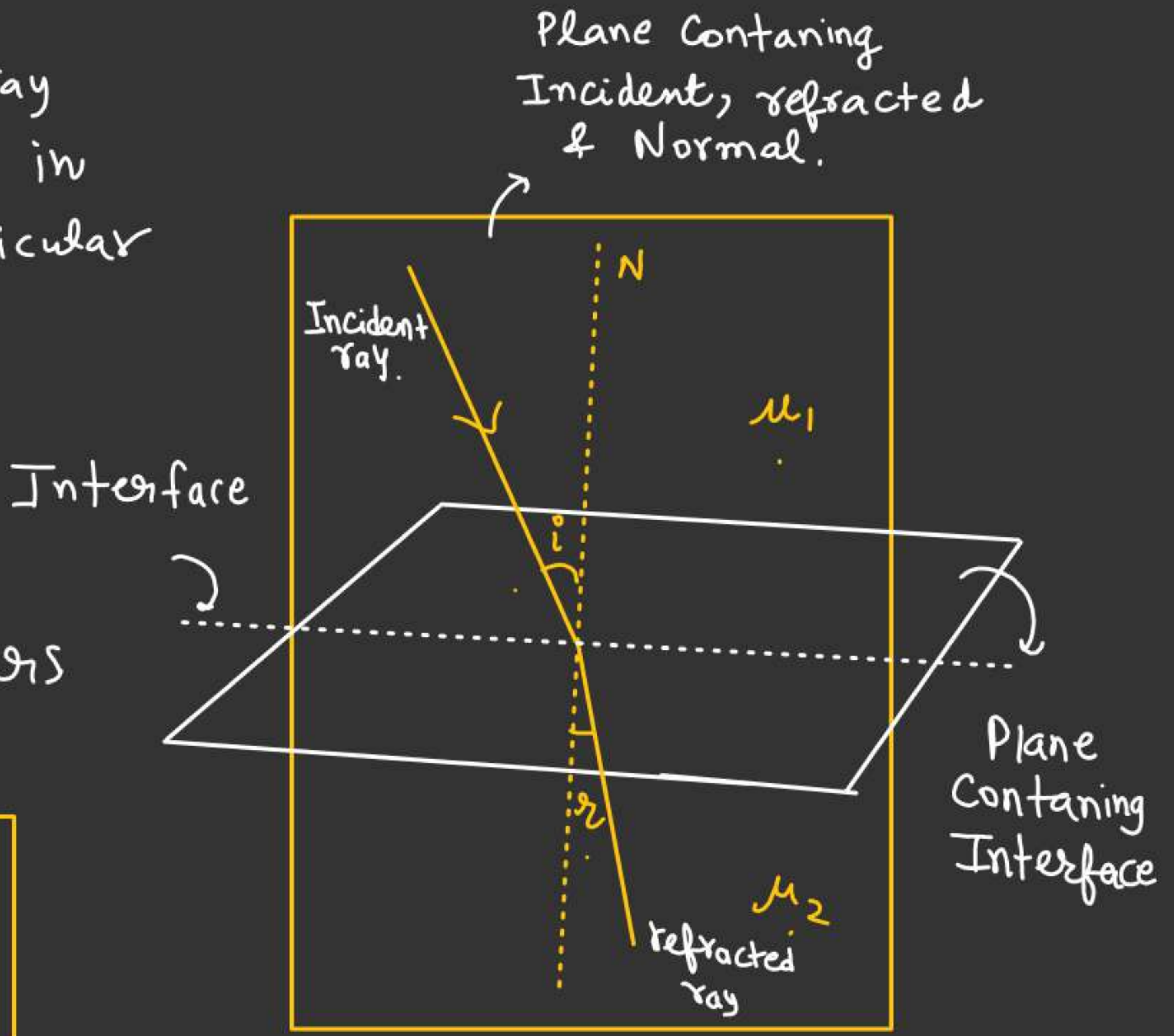
- Incident ray, Normal & Refracted ray at the point of incidence all lie in the plane & the plane is perpendicular to the plane containing interface.

SNELL'S LAW

- The ratio of Sine of angle of incidence to Sine of angle of refraction with normal bears a Constant ratio

$$\boxed{\frac{\sin i}{\sin r} = C = {}_1\mu_2 = \frac{\mu_2}{\mu_1}}$$

$$\Rightarrow \boxed{\mu_1 \sin i = \mu_2 \sin r = C}$$



SNELL'S LAW AT PARALLEL INTERFACE

Snell's law at frist interface.

$$\mu_1 \sin i = \mu_2 \sin r \quad \text{—①}$$

For 2nd Interface.

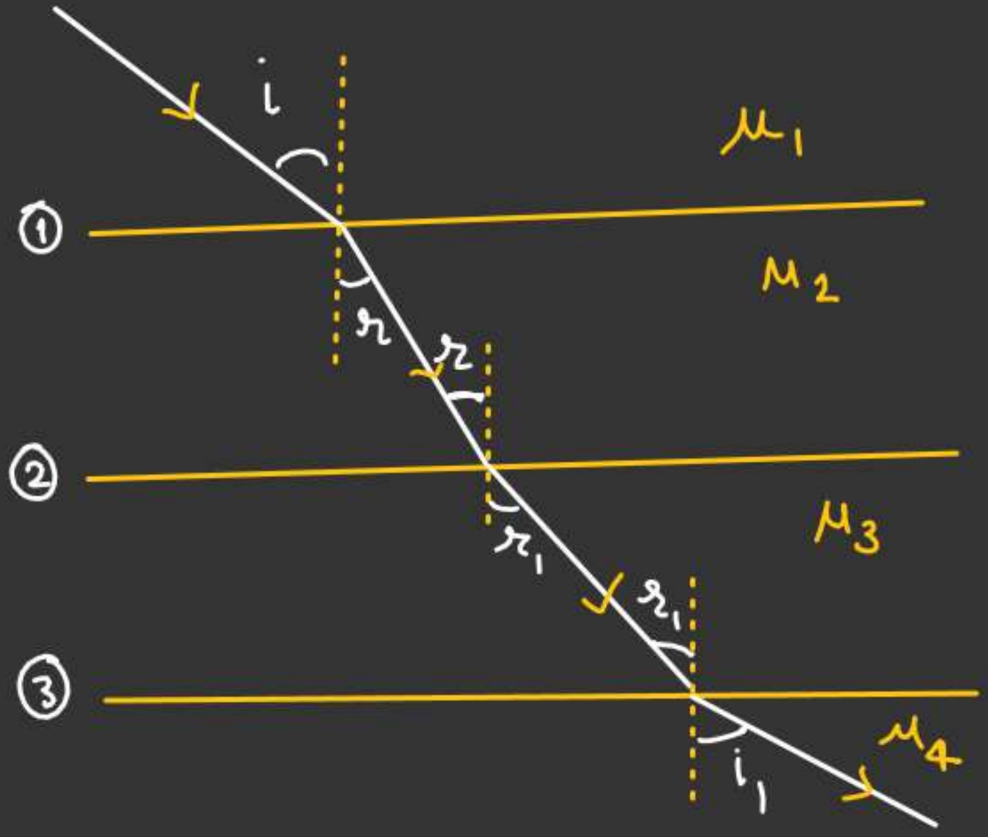
$$\mu_2 \sin r = \mu_3 \sin r_1 \quad \text{—②}$$

For 3rd Interface

$$\mu_3 \sin r_1 = \mu_4 \sin i_1 \quad \text{—③}$$

From ①, ② & ③

$$\boxed{\mu_1 \sin i = \mu_4 \sin i_1}$$



If $\mu_1 = \mu_4$

$\sin i = \sin i_1$

$\Rightarrow (i = i_1)$

$\Rightarrow$ Incident ray & final refracted ray Parallel

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Refraction at plane surface

Angle of deviation

$$\delta = \underline{i - r}$$

By Snell's Law.

$$1 \cdot \sin i = \mu \sin r$$

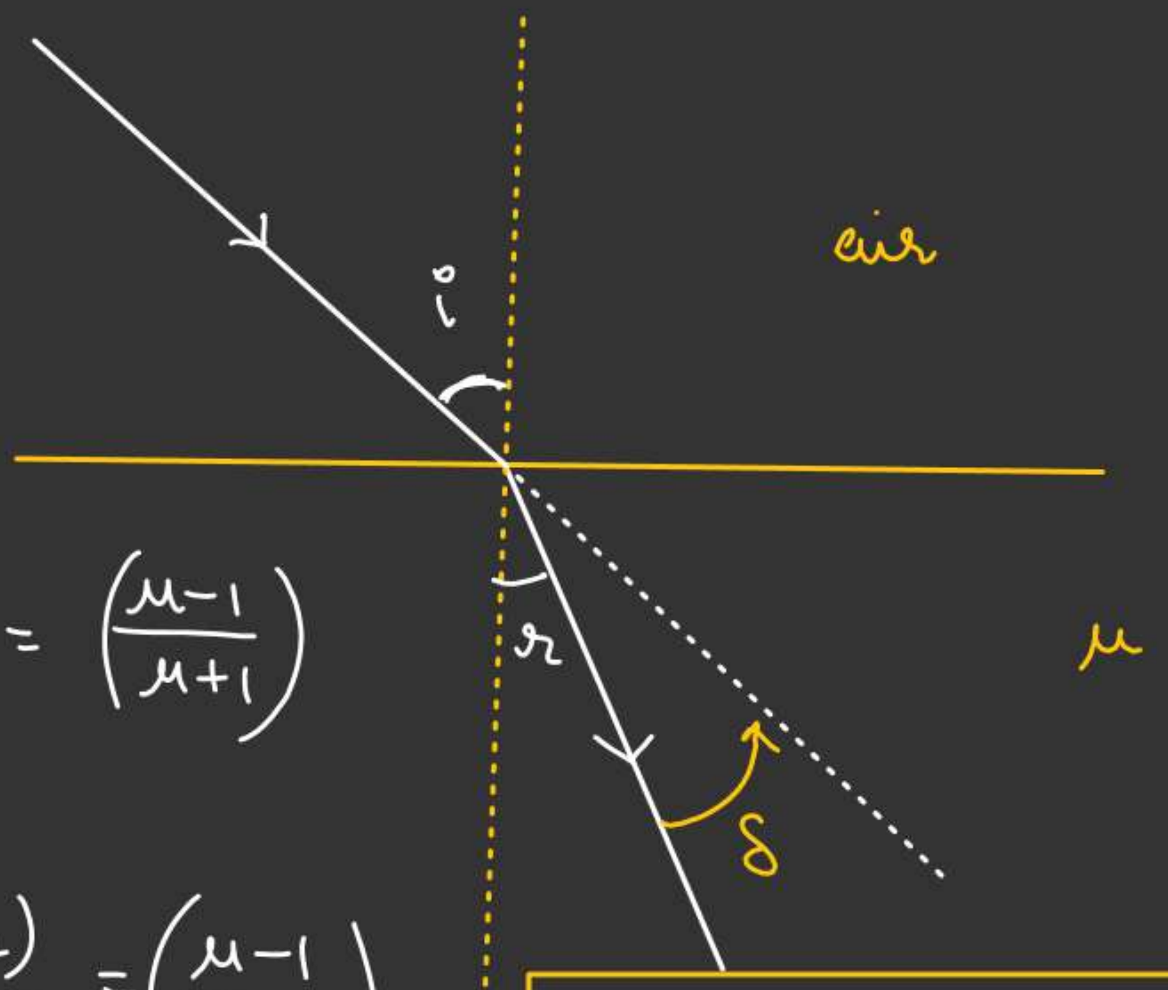
$$\frac{\sin i}{\sin r} = \mu$$

$$\frac{\sin i - \sin r}{\sin i + \sin r} = \left(\frac{\mu - 1}{\mu + 1}\right)$$

$$\frac{\cancel{2}\cos\left(\frac{i+r}{2}\right)\cdot\sin\left(\frac{i-r}{2}\right)}{\cancel{2}\sin\left(\frac{i+r}{2}\right)\cdot\cos\left(\frac{i-r}{2}\right)} = \frac{\mu-1}{\mu+1}$$

$$\frac{\tan\left(\frac{i-r}{2}\right)}{\tan\left(\frac{i+r}{2}\right)} = \left(\frac{\mu-1}{\mu+1}\right)$$

$$\frac{\tan(\delta/2)}{\tan\left(\frac{i+r}{2}\right)} = \left(\frac{\mu-1}{\mu+1}\right) \Rightarrow \boxed{\tan\left(\frac{\delta}{2}\right) = \left(\frac{\mu-1}{\mu+1}\right)\tan\left(\frac{i+r}{2}\right)}$$



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LATERAL SHIFT (REFRACTION)

$d =$ lateral Shift

In $\triangle$ ABD.

$$\cos r = \frac{BD}{AB}$$

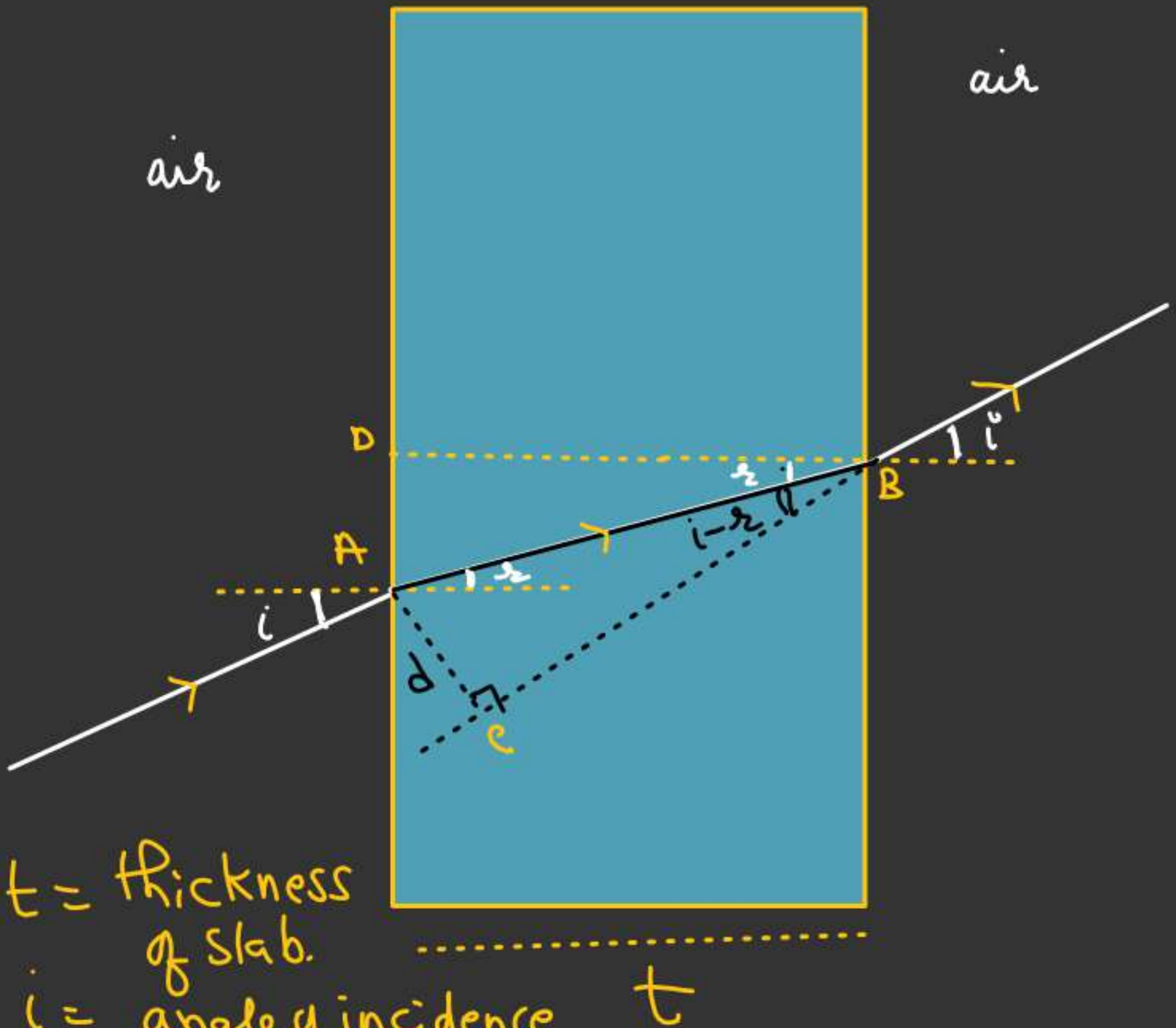
$$AB = \frac{BD}{\cos r} = \left(\frac{t}{\cos r}\right)$$

In $\triangle$ABC

$$\sin(i-r) = \frac{AC}{AB}$$

$$AC = AB \sin(i-r)$$

$$\boxed{d = \left(\frac{t}{\cos r}\right) \sin(i-r)}$$



t = thickness of slab.
i = angle of incidence
r = angle of rafraction

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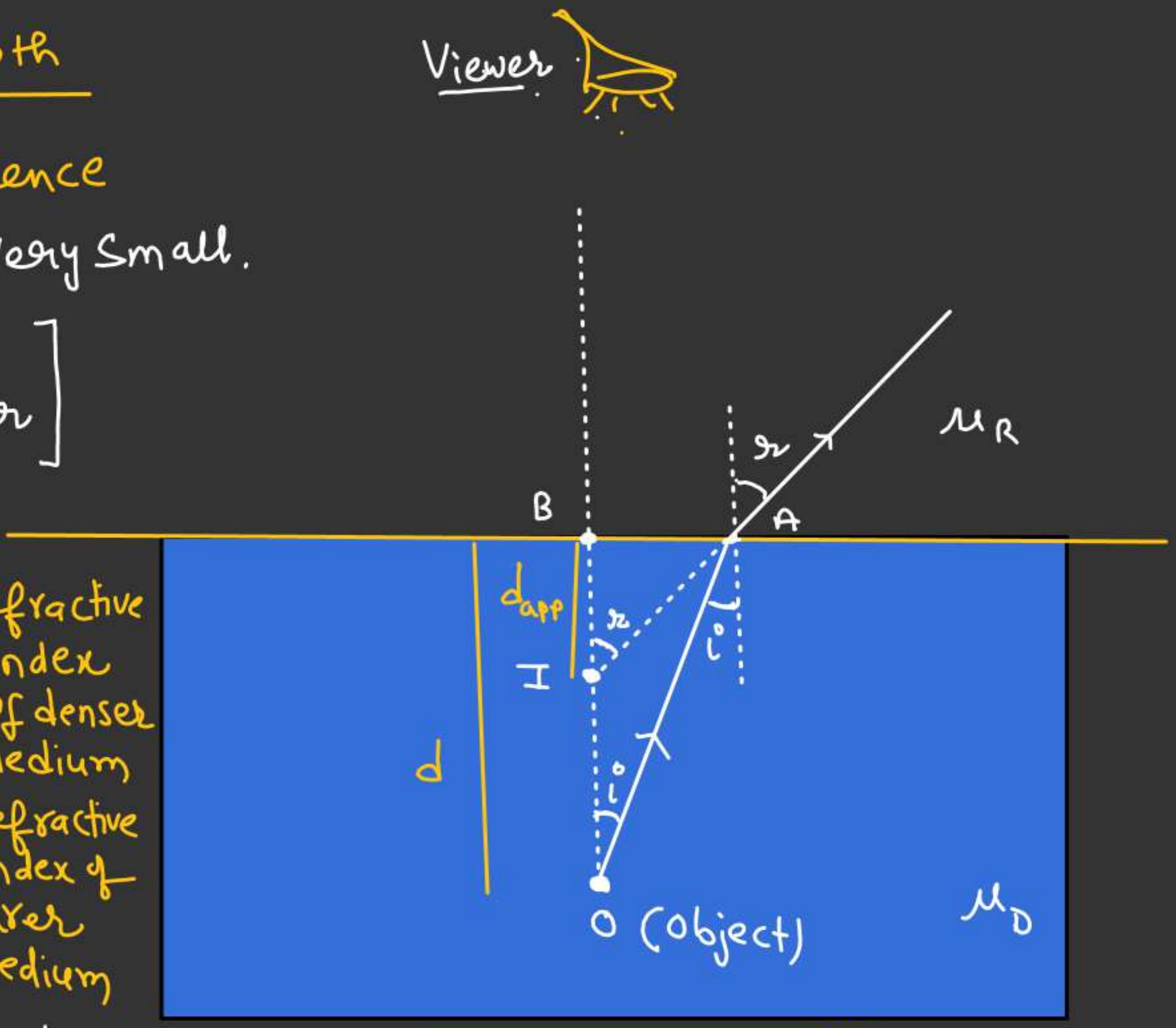
Concept of Apparent depth

Assumption :- Normal Incidence

↳ i & r are very small.



In $\triangle OAB$.

$$\tan i = \frac{AB}{d}.$$

$$\left[\begin{array}{l}\tan i \simeq \sin i \\ \tan r \simeq \sin r\end{array}\right]$$

In $\triangle AIB$

$$\tan r = \frac{AB}{d_{app}}.$$

μ_D = Refractive Index of denser Medium

μ_R = Refractive index of Rarer Medium

By Snell's law.

$$\mu_D \sin i = \mu_R \sin r.$$

$$\mu_D\left(\frac{\cancel{AB}}{d}\right) = \mu_R\left(\frac{\cancel{AB}}{d_{app}}\right)$$

$$d_{app} = \left(\frac{\mu_R d}{\mu_D}\right) \longrightarrow d_{app} = \frac{d}{\frac{\mu_D}{\mu_R}} \Rightarrow \boxed{d_{app} = \frac{d}{{}_R\mu_D}}$$

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$$d_{app} = \frac{d}{{}_{R}\mu_{D}}$$

d = Real depth.
d_{app} = Apparent depth

$\Rightarrow$ Alway measure from the interface.

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Concept of Apparent height

In $\triangle$ IAB.

$$\sin r \simeq \tan r = \frac{AB}{h_{app}}$$

In $\triangle$ OAB.

$$\tan i \simeq \sin i = \frac{AB}{h}$$

By Snell's law.

$$\mu_R \sin i = \mu_D \sin r$$

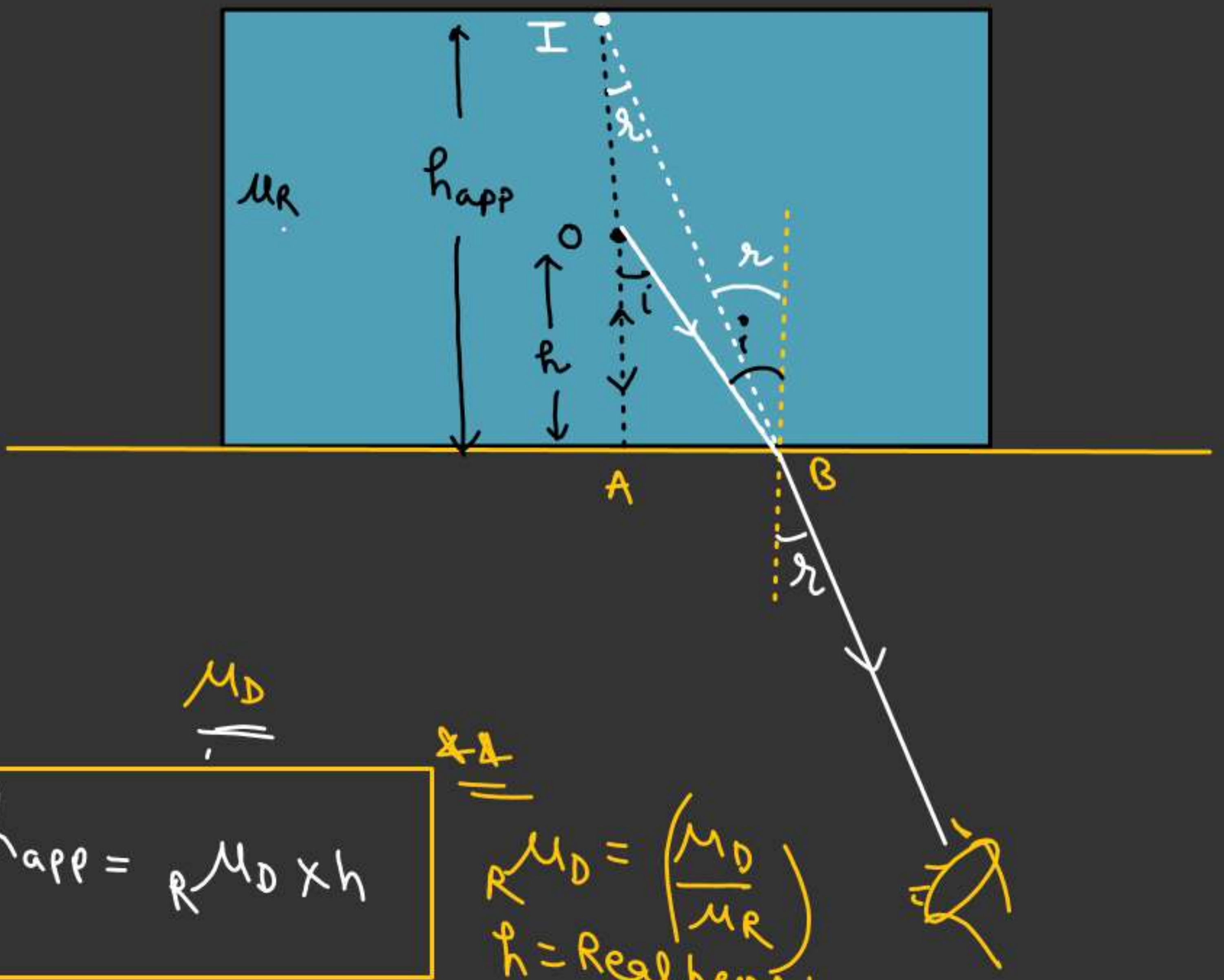
$$\mu_R\left(\frac{\cancel{AB}}{h}\right) = \mu_D\left(\frac{\cancel{AB}}{h_{app}}\right)$$

$$h_{app} = \frac{\mu_D}{\mu_R} \times h$$

$$\boxed{h_{app} = {}_R\mu_D \times h}$$

$${}_R\mu_D = \left(\frac{\mu_D}{\mu_R}\right)$$

h = Real height



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Shift due to glass slab. (Normal Incidence)

$$h_{app} = {}_R\mu_d \cdot h$$

$$= \mu d$$

$\left[\begin{array}{l} \mu_d = \mu \\ \mu_R = 1 \\ h = d \end{array}\right.$

OI = Shift.

$$OI = (d+t) - d_{app}$$

$$OI = (d+t) - \left(\frac{\mu d + t}{\mu}\right)$$

$$OI = (d+t) - \left(d + \frac{t}{\mu}\right)$$

$$OI = t - \frac{t}{\mu}$$

$$\boxed{OI = t\left(1 - \frac{1}{\mu}\right)}$$