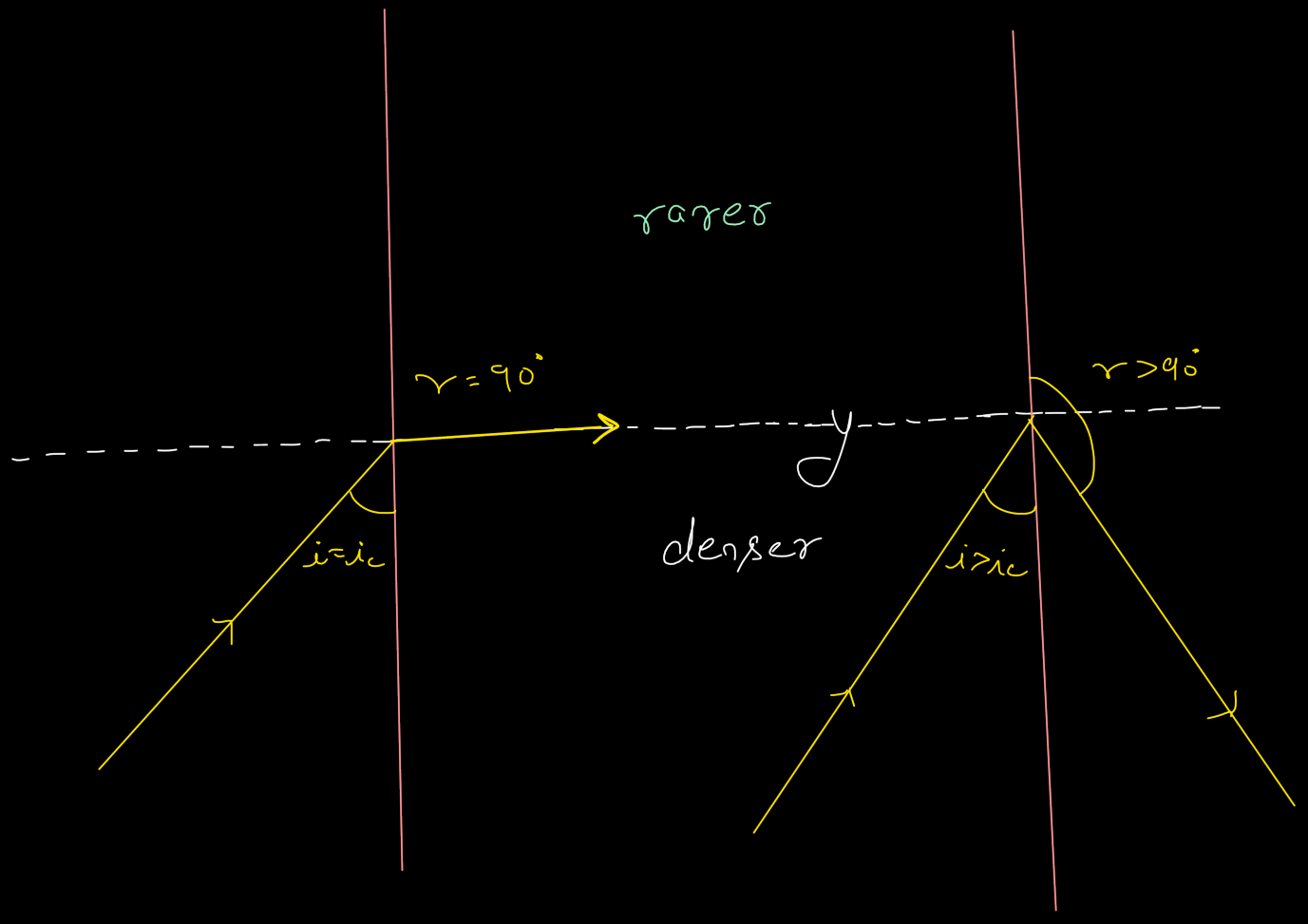
OPTICAL FIBRE

Total internal Reflection (TIR):-



from shell Law

$$d\mu_r = \frac{\sin i}{\sin r}$$

when $i = i_c$

then $r = 90°$

$$d\mu_r = \frac{\sin i_c}{\sin 90°}$$

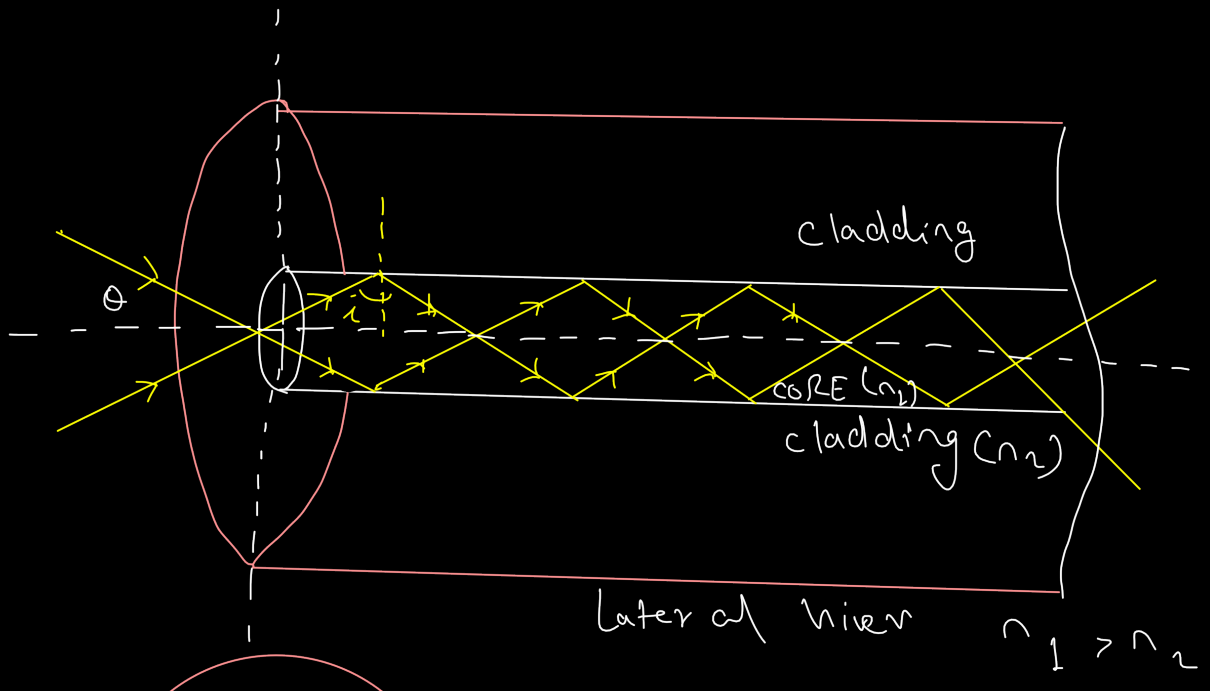
$$\mu_r = \sin i_c \longrightarrow (1)$$

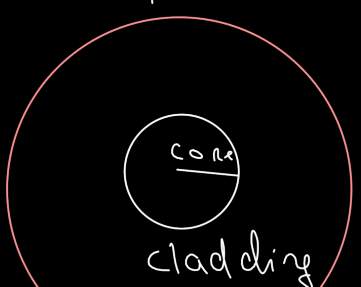
$$\because \mu_r = \frac{1}{\sin \mu_d} \longrightarrow (2)$$

$$\boxed{\sin i_c = \frac{1}{\mu_d}}$$

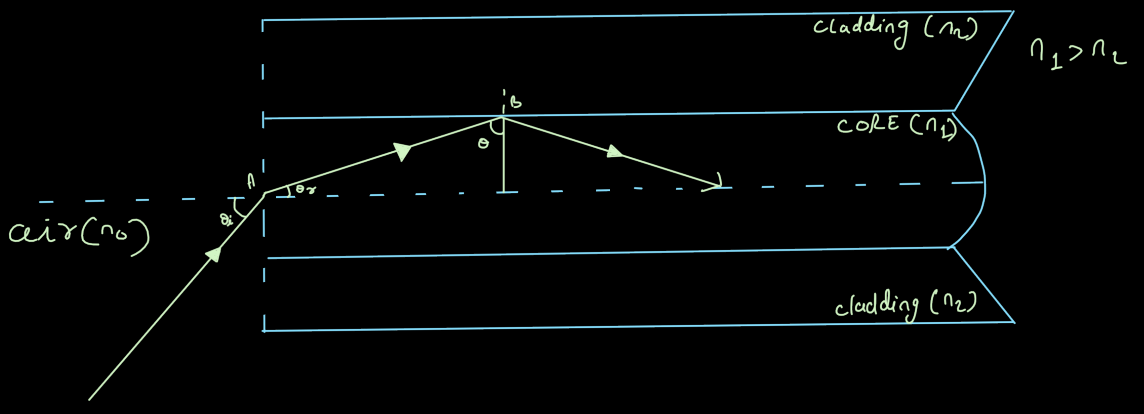
∴ If first medium rarer and second medium denser

$$\sin i_c = \frac{1}{\mu_2}$$





⊙ Expression for numerical Aperture (NA) :-



1. for total Internal Reflection:-

$$\theta \geq \theta_c$$

$$\text{or} \quad \sin\theta \geq \sin\theta_c \quad \text{——— (1)}$$

$$\because \sin\theta_c = \frac{n_2}{n_1}$$

$$\text{from (1)} \quad \sin\theta \geq \frac{n_2}{n_1} \quad \text{——— (2)}$$

2. from Snell's Law :-

$$n_0 \sin\theta_i = n_1 \sin\theta_r$$

$$\sin\theta_i = \frac{n_1}{n_0} \sin\theta_r$$

for air $n_0 = 1$

$$\sin\theta_i = (n_1)\sin\theta_r \quad \text{---} \quad (3)$$

3. From fig.

$$\theta_r + \theta = 90^\circ$$

$$\theta_r = 90^\circ - \theta$$

$$\sin\theta_r = \sin(90^\circ - \theta)$$

$$\sin\theta_r = \cos\theta$$

$$\sin\theta_r = \sqrt{1-\sin^2\theta}$$

$$\sin^2\theta_r = 1 - \sin^2\theta$$

$$\sin^2\theta = 1 - \sin^2\theta_r \quad \text{---} \quad (4)$$

from (2) & (4)

$$\frac{n_2^2}{n_1^2} \leq 1 - \sin^2\theta_r$$

$$\sin^2\theta_r \leq 1 - \frac{n_2^2}{n_1^2}$$

$$\sin\theta_r \leq \sqrt{1 - \frac{n_2^2}{n_1^2}} \quad \text{---} \quad (5)$$

from (3) & (5)

$$\sin\theta_i \leq (n_1)\sqrt{1 - \frac{n_2^2}{n_1^2}}$$

$$\sin\theta_i \leq (n_1)\frac{\sqrt{(n_1^2 - n_2^2)}}{n_1}$$

If θ_m is max. angle of incidence for which TIR Takes place :-

$$\sin\theta_m = \sqrt{n_1^2 - n_2^2}$$

$$\sin\theta_m = N_A$$

$$N_A = \sin\theta_m = \sqrt{n_1^2 - n_2^2}$$

$$N_A = \sqrt{\frac{(n_1+n_2)\ (n_1-n_2)n_1}{n_1}}$$

$$n_1 \approx n_2$$

$$N_A = \sqrt{\frac{2(n_1)\ (n_1)(n_1-n_2)}{(n_1)}}$$

$$\because \quad \Delta = \frac{n_1 - n_2}{n_1}$$

$$\boxed{N_A = \sqrt{2\Delta}\ n_1}$$