Principle of a light transmission in a Fibre:-

When light beam enters into a fibre the entire light may not pass threw the core and only the rays which make the angle of incidence is greater than critical angle ($\theta_i > \theta_c$) at the core clad interface undergo total internal reflection and propogate threw the core, the other rays are refracted to the cladding and are lost. Hence it is necessary to know at what angle called acceptance angle the beam can be launched to pass threw the core.

Acceptance Angle, can be defined as, maximum angle of launch that a beam can have with r. to the axis of fibre. In order, all the rays within this angle propogates threw the fibre by TIR.

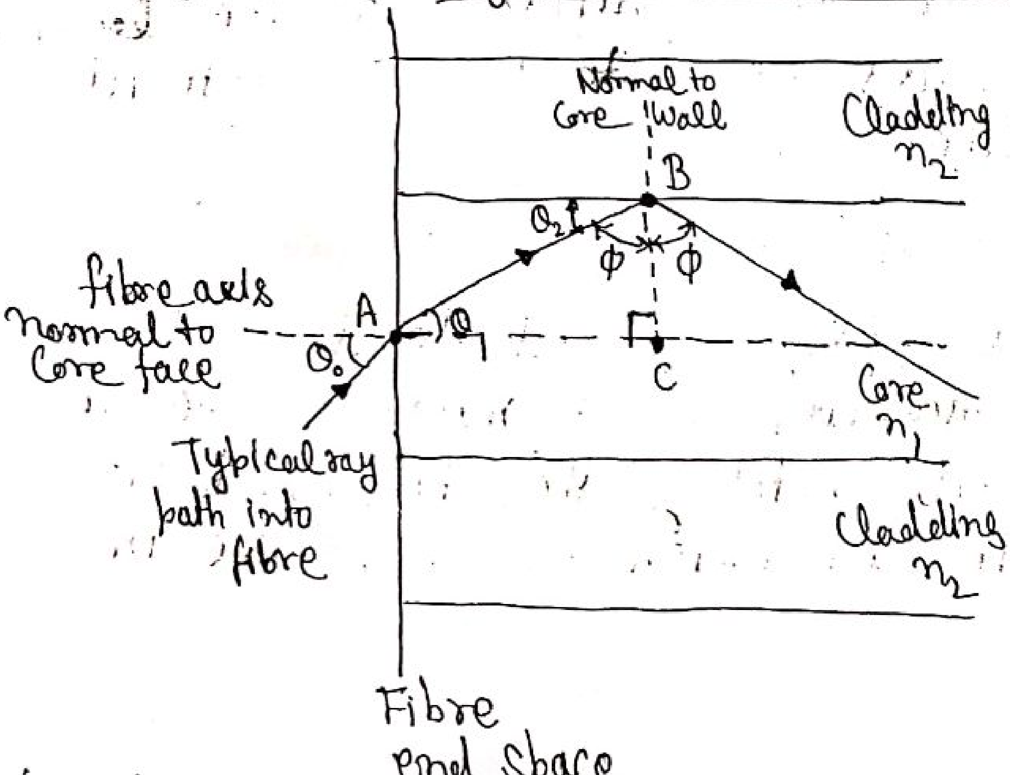


Fig. shows, a longitudnal cross section of launch end of a fibre with a ray entering it. Let, us now calculate upto what value θ_0 at A, TIR at B is possible.

In $\triangle ABC$

$$\theta_1 = 90^\circ - \phi \quad \text{——— (1)}$$

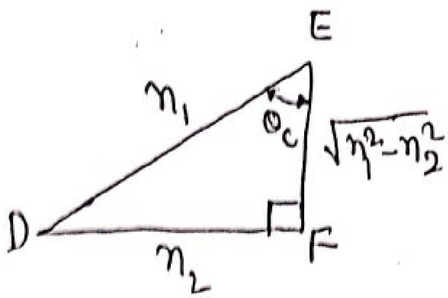
from Snell's law

$$\sin\theta_0 = \frac{n_1}{n_0}\sin(90-\phi)$$

$$\sin\theta_0 = \frac{n_1}{n_0}\cdot\cos\phi \quad \text{——— (2)}$$

If, $\phi < \phi_c$, the ray will be lost by refraction.
Let, $(\theta_0)_{max}$, be the maximum possible angle of incidence at the fibre at A for which $\phi = \phi_c$, then eq^n (2) can be written as,

$$\sin(\theta_0)_{max} = \frac{n_1}{n_0}\cdot\cos\phi_c \quad \text{——— (3)}$$



$$= \frac{n_1}{n_0}\sqrt{1-\sin^2\phi_c}$$

$$= \frac{n_1}{n_0}\sqrt{1-\frac{n_2^2}{n_1^2}}$$

$$= \frac{n_1}{n_0}\cdot\frac{\sqrt{n_1^2-n_2^2}}{n_1}$$

$$\sin(\theta_0)_{max} = \frac{\sqrt{n_1^2-n_2^2}}{n_0}$$

or, $$\boxed{(\theta_0)_{max} = \sin^{-1}\frac{\sqrt{n_1^2-n_2^2}}{n_0}}$$

This maximum angle is called the Acceptance angle or the acceptance cone half angle.

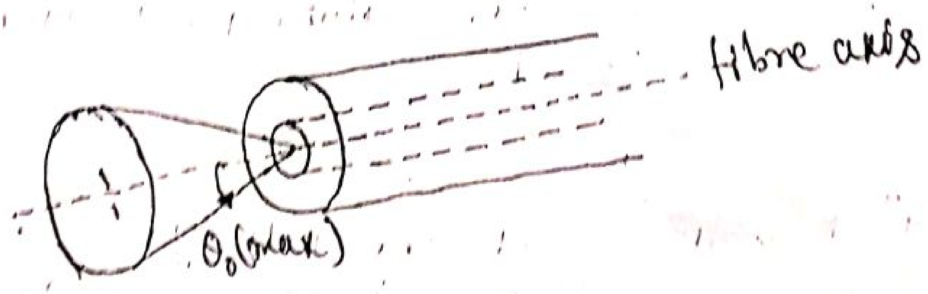


fig.

fig. shows the rotation of acceptance angle about the fibre axis the light can be launched within this acceptance cone

Numerical aperture (NA):-

Light collecting capacity of a fiber is expressed in terms of Numerical Aperture.

def:- the sine of the maximum acceptance angle is called the NA of fibre

$$NA = \sin(\theta_0)_{max}$$

$$NA = \frac{\sqrt{n_1^2 - n_2^2}}{n_0} \quad \text{——— (1)}$$

Since, for most of the fibres,

$n_1 \simeq n_2$

then,

$$n_1^2 - n_2^2 = (n_1+n_2)(n_1-n_2)$$

$$= 2n_1(n_1-n_2)$$

$$= \frac{2n_1^2(n_1-n_2)}{n_1} \quad \text{——— (2)}$$

let, $\frac{n_1-n_2}{n_1} = \Delta$

then,

$$n_1^2 - n_2^2 = 2n_1^2 \cdot \Delta$$

or, $\sqrt{n_1^2-n_2^2} = n_1\sqrt{2\Delta}$

using this in eqn (1)

$$\boxed{NA = \frac{n_1}{n_0}\sqrt{2\Delta}}$$

If light is launched into fibre from air,

$n_0 = 1$

then,

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

this eqn. indicates that the NA of a fibre is dependent only on the refractive indexes of the core and cladding materials and is not a function of the fibre dimensions.

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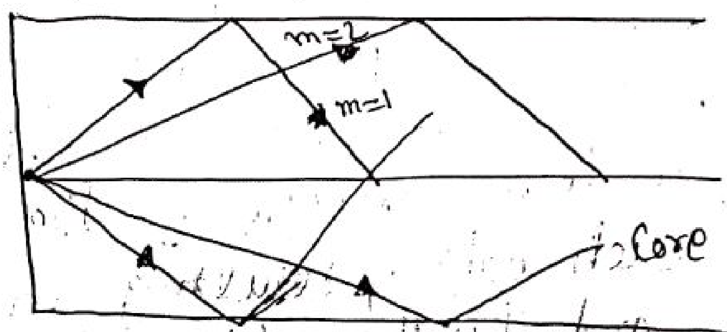
Types of optical fibre

Single and multimode fibre:- It is known that the light launched at one end of the fibre propogate threw the fibre. When incident within acceptance cone, but not all, the light within acceptance cone propogate, only specifi direction are allowed which satisfies cond^ns for constructive interferance. the rays travelling in these specified direction are called modes. The no. of mode that the fibre supports depends on the dimension of fibre.



If the thickness of fibre is very small it support only one mode and it is called monomode or singl mode fibre, If it supports more than one mode than it is called multimode. the core diameter of mono mode fibre 2 to 8 µm and in multimode fib 50 µm.

Step index fibre:- In this type of fibre the entire core has uniform refractive index slightly greater than the refractive index of cladding. Since, the index profile is in steps, It is called step index fibre