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Experiment :5

* **Aim:-**

To find the numerical aperture of a given optic fibre and hence to find its acceptance angle.

* **Material Required:-**

Ouput unit, Detector, fiber stand, fiber, Concentrator, Emitter.

* **Theory:-**

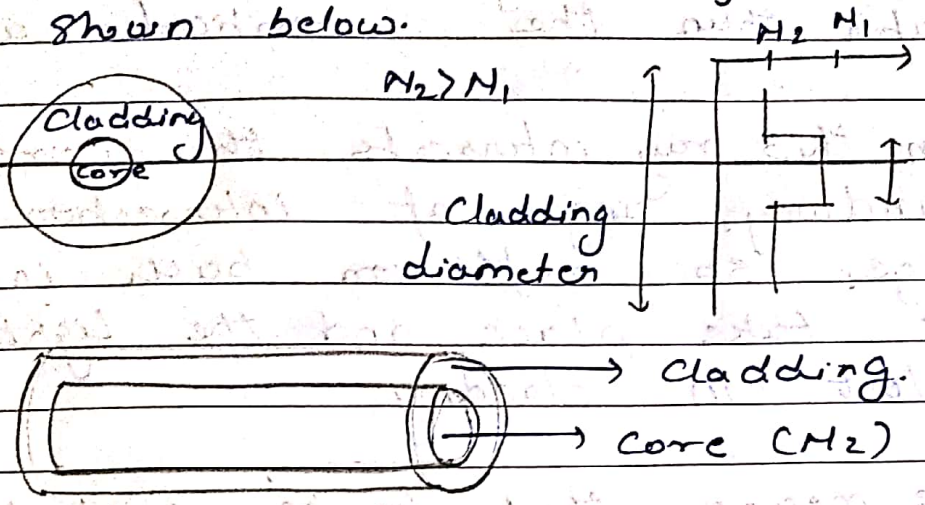
Optical fibers and fine transparent glass or plastic fibers which can propagate light. They work under the principle of Total (interval) r internal reflection from diametrically opposite walls.

In this way light can be taken any where because fibers have enough flexibility.

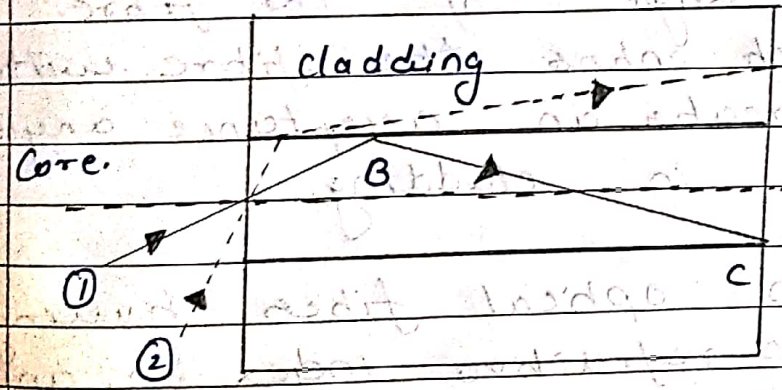
This property makes them suitable for data communication, design of fine endoscopes, micro signed microscope etc.

An optic fibre consist of core which surrounded by cladding guides the light within the core.

Since light is guided through the fiber it is sometimes called an optical wave guide.
The Basic Construction of optical fibre is shown below.



In order to understand the propagation of light through an optical fibre consider the diagram given below.



Propagation of light in Optical fibre.

1) Consider a light rays entering the core at a point A, travelling through the core untill it reaches the core cladding boundary at point B.

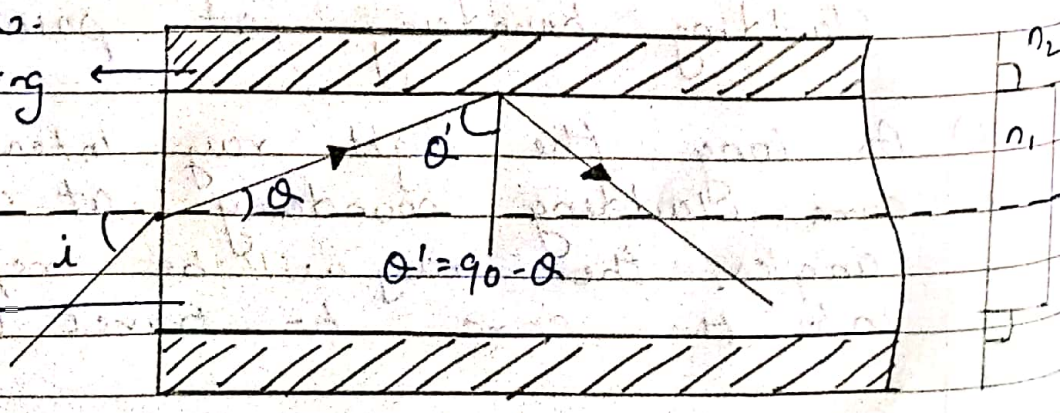
2) As long the light ray intersects the core cladding boundary at a small angles, the ray will be reflected back into the core to travel on to point.

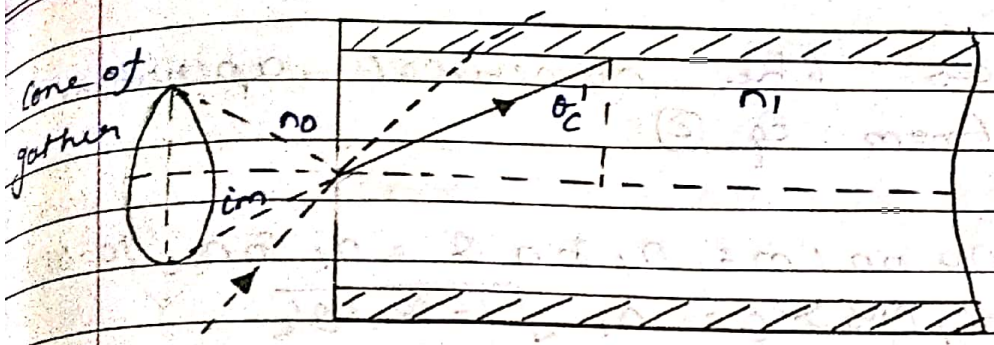
3) The Total internal reflection take place. Total internal reflection occur only when the angle of incidence is greater than the critical angle.

4) When this ray intersects the core cladding boundary, angle of intersection is too large, so reflection back into the core not take place and the light ray is lost in cladding.

5) This means that to be guided through an optic fibre, a light ray must enter to the core with an angle less than a particular angle called the acceptance angle of the fibre. A ray which enters the fibre with an angle greater an acceptance angle will lost in cladding.

* Consider an optical fibes having a core of refractive index n_1 and cladding of refractive index n_2, let the incident light makes an angle i with the core axis as shown below:





Then the light gets reflected at an angle α and fall on the core cladding interface at angle where,

$$\theta = 90 - \alpha \quad \text{——} (1)$$

By Snell's law at a point of entrance of light in to the optical fibre we get,

$$n_0 \sin i = n_1 \sin\alpha \quad \text{——} (2)$$

where n_0, is refractive index of medium and n_1 = refractive index of outside the optical fibre.

The critical angle is that angle of incidence in denser medium (n_1) for which angle of refraction become 90. Using Snell's law at core cladding interface.

$$n_1 \sin\theta'_c = n_2 \sin 90$$

$$\sin\theta'_c = \frac{n_2}{n_1} \quad \text{——} (3)$$

$\boxed{\sin 90^\circ = 1}$

formed as the numerical aperature (NA) from Eq (2)

$$NA = n_0 \sin i'm = n_1 \sin \theta = n_1 \sin (90 - \theta_c)$$
$$NA = n_1 \cos \theta'_c = n_1 \sqrt{1 - \sin^2 \theta'_c}$$

From Eq (2) $\sin \theta'_c = \frac{n_2}{n_1}$

Therefore, $NA = n_1 \sqrt{1 - \frac{n_2^2}{n_1^2}}$

$$NA = \sqrt{n_2^2 - n_2^2}$$

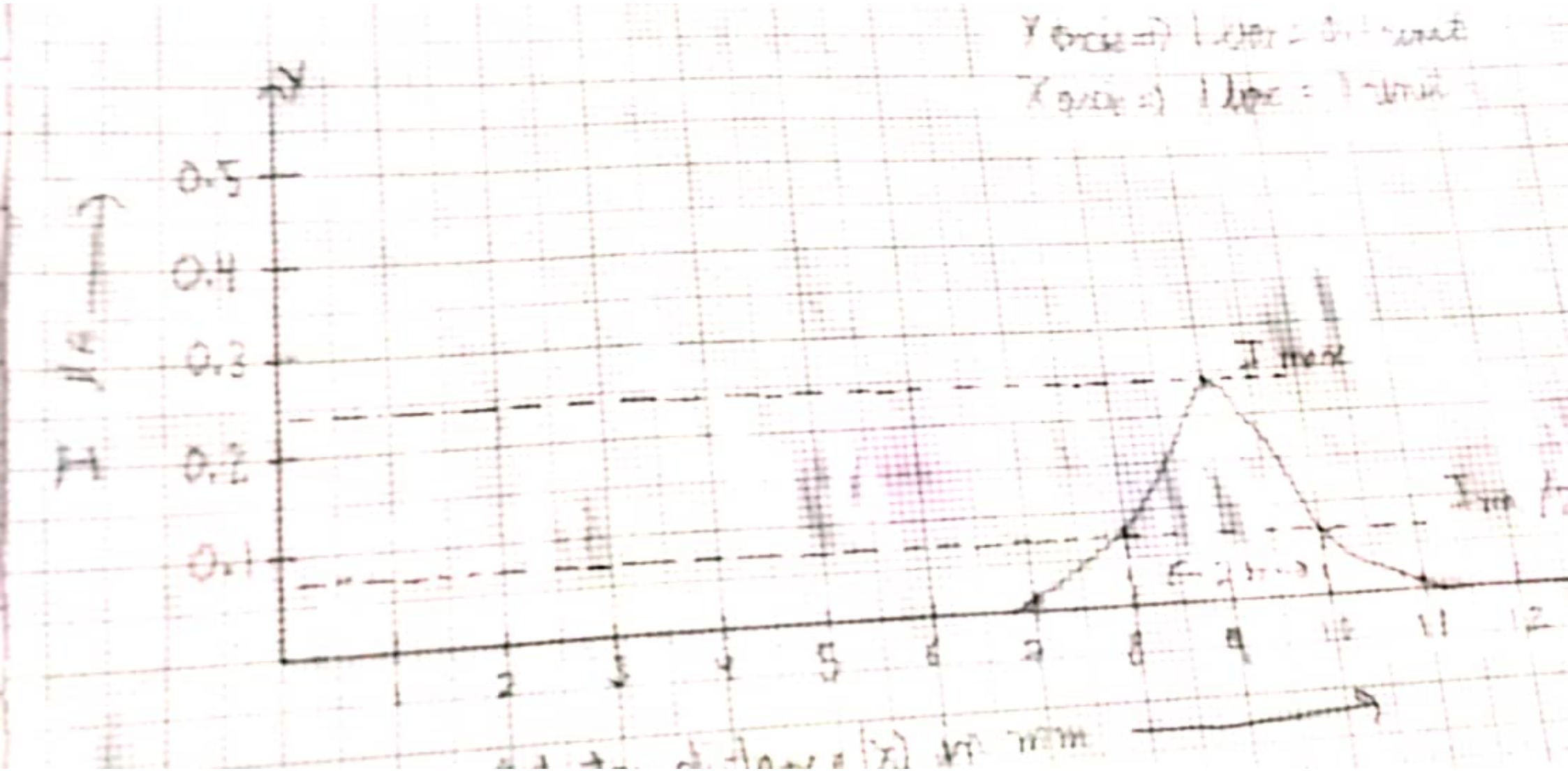
Numerical aperature is defined as the sine of the half of the angle of fibre light acceptance cone .ie. $NA = \sin \theta_a$ where θ_a is called acceptance Core angle.

Let the Spot size of the beam at a distance d (distance between the fibre and detector) as the radius of the Spot (r), Then,

$$\sin \theta = \frac{r}{\sqrt{r^2 + d^2}} \quad \text{——— (4)}$$

* Observation Table:-

S.No	Distance in mm	Current in A
1)	7mm	0.00503
2)	8mm	0.03429
3)	9mm	0.20391
4)	10mm	0.07592
5)	11mm	0.00735



* Calculations:-

Distance between the fiber and the detector (d) = 3 mm.

Radius of sport (r) = 5 mm.

Numerical Aperature = $\sin\theta = \frac{r}{\sqrt{r^2+d^2}}$

$$\sin\theta = \frac{5}{\sqrt{5^2+3^2}}$$

$$\sin\theta = \frac{5}{\sqrt{34}}$$

Acceptance angle, $\theta = \sin^{-1}\left(\frac{r}{\sqrt{r^2+d^2}}\right)$

$$= \sin^{-1}\left(\frac{5}{\sqrt{34}}\right)$$

* Result:-

Numerical aperature of the optic fibre is $5/\sqrt{34}$.

Angle of acceptance is $\sin^{-1}\left(\frac{5}{\sqrt{34}}\right)$ ans