

EXPERIMENT No. -----

Aim: - To Determine Numerical Aperture of Optical Fibre.

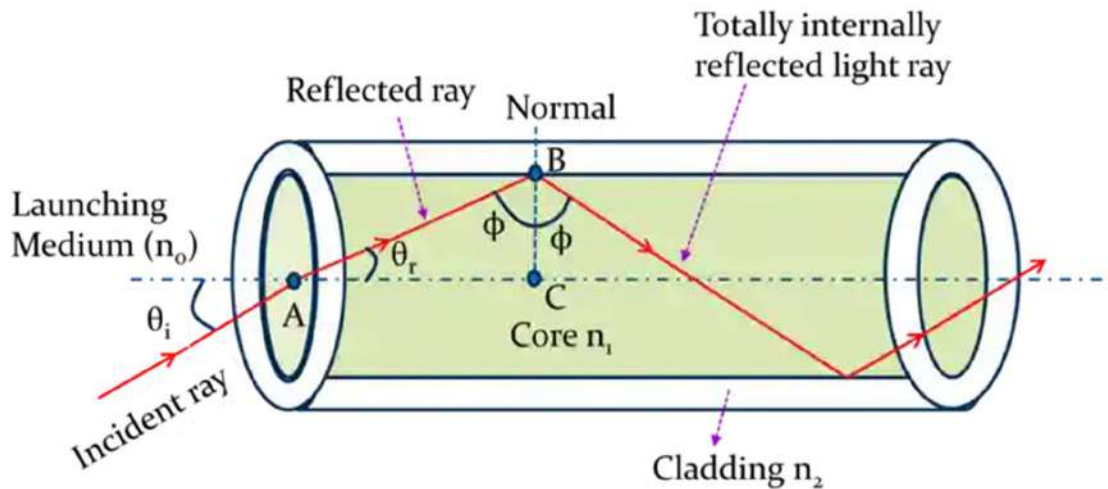
Apparatus Required:

S. No.	Name of Equipment	Specifications	Required Quantity	Remark
1	Laser source (or LED source)	with fibre-coupling mount	1	
2	Step-index optical fibre patch cord	both ends polished	1	
3	Numerical aperture measurement jig	with a graph-ruled screen	1	
4	Measuring scale	-	1	
5	Fibre-holding clamp	-	1	

Theoretical Background:

The Numerical Aperture (NA) of an optical fibre is a measure of its light-gathering ability. A fibre with a higher Numerical Aperture can accept light over a larger range of angles, making light coupling from a laser or LED easier and more efficient.

The propagation of light inside an optical fibre is based on the principle of Total Internal Reflection (TIR). When light enters the fibre within a certain maximum angle, called the acceptance angle (θ_a), it undergoes repeated total internal reflections at the core-cladding interface and travels through the fibre with very little loss. If the light enters at an angle greater than the acceptance angle, it escapes into the cladding and is not guided.



For an optical fibre placed in air, the Numerical Aperture is given by:

$$NA = \sin \theta_{\max}$$

Where $\theta_{\max}$ is acceptance angle.

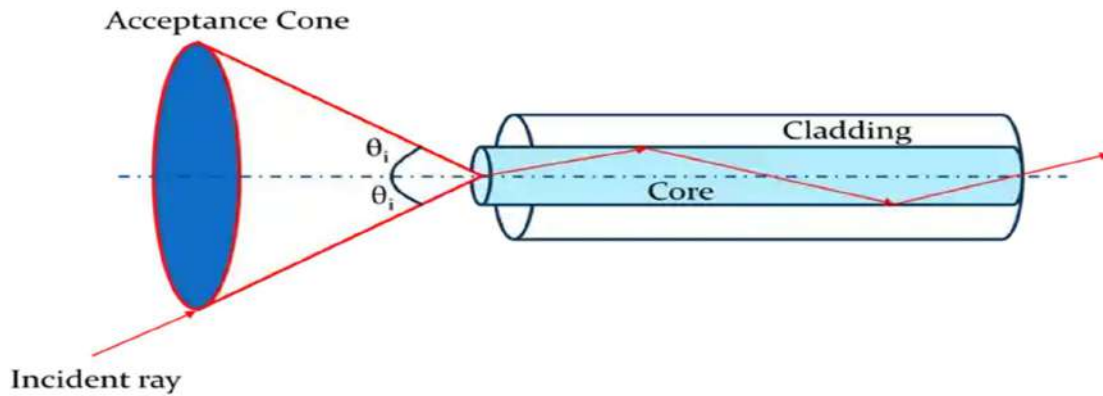
The Numerical Aperture can also be expressed in terms of the refractive indices of the core and cladding:

$$NA = \sqrt{n_1^2 - n_2^2}$$

where:

- n_1 = Refractive index of the core
- n_2 = Refractive index of the cladding

The acceptance angle forms an imaginary cone called the **acceptance cone**. Any light ray entering within this cone will propagate through the fibre with minimal loss, whereas rays entering outside the cone are rejected.



During the laboratory experiment, this acceptance cone is observed indirectly by allowing light to emerge from the other end of the fibre. As the light exits, it spreads into a circular spot whose diameter depends upon the numerical aperture of the fibre.

By measuring the spot diameter and the distance between the fibre end and the screen, the acceptance angle can be calculated using simple trigonometry.

The relationship between these quantities is given by

$$\tan \theta = \frac{D}{2d}$$

where:

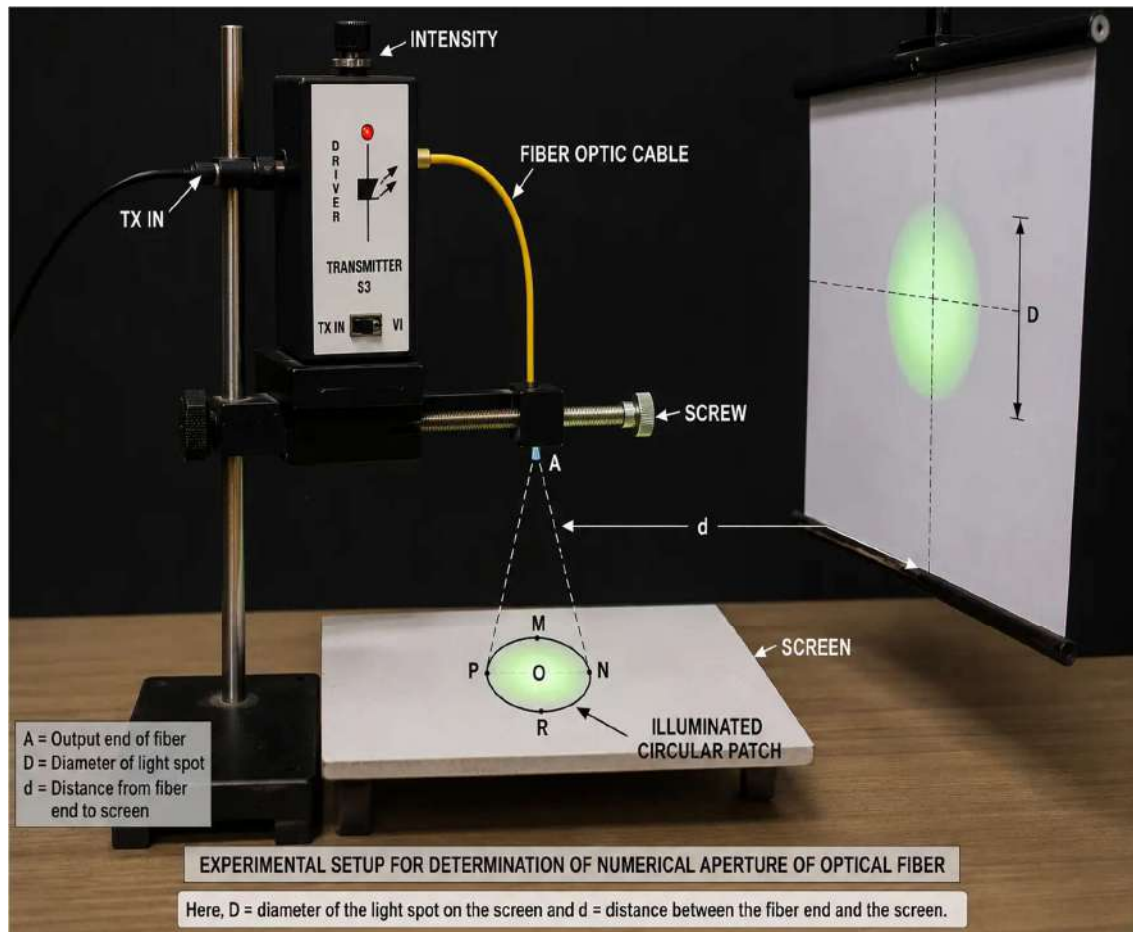
- **D** = Diameter of the light spot on the screen
- **d** = Distance between the fibre end and the screen

By combining geometry and optics, the practical expression often used in laboratories becomes

$$NA = \frac{D}{\sqrt{4d^2 + D^2}}$$

IF r is the radius of the spot, then $NA = \frac{r}{\sqrt{r^2 + d^2}}$

Experimental Setup:



Experimental Procedure:

1. Connect the optical fibre to the transmitter unit and switch on the power supply.
2. Adjust the intensity control to obtain a bright and uniform light output from the fibre.
3. Fix the output end of the optical fibre vertically using the holder provided in the experimental setup.
4. Ensure proper alignment so that the light emerging from the fibre falls normally on the screen and forms a clear circular spot.
5. Measure the distance (d) between the output end of the fibre and the screen using a scale.

6. Measure the diameter (D) of the illuminated circular spot on the screen in two mutually perpendicular directions and calculate the average diameter.
7. The radius of the light spot was calculated as: $r = D / 2$ (or using $r = (MR + PN) / 4$ for crossed directions).
8. Repeat the observations for two or three different values of d by changing distance between the output end of the fibre and the screen.
9. Calculate the Numerical Aperture (NA) for each observation using the formula:

$$NA = \frac{r}{\sqrt{r^2 + d^2}}$$

10. Determine the average value of the Numerical Aperture.
11. Switch off the power supply and disconnect the apparatus after completing the experiment.

Observation Table:

S. No.	Distance d (cm)	Diameter of the Spot		Radius $r = \frac{PN+M}{4}$ (cm)	$NA = \frac{r}{\sqrt{r^2 + d^2}}$
		Along one direction (PN)	Along perpendicular direction (MR)		
1					
2					
3					

Calculation:

Average NA =

Result:

The Numerical Aperture of the given optical fibre is

Precautions:

1. **Handle the optical fibre carefully** and avoid sharp bending, as it may damage the fibre and affect the results.
2. **Clean the fibre end faces** to remove dust or dirt, which can reduce light transmission.
3. **Measure the distance (d)** between the fibre end and the screen accurately without parallax error.
4. **Measure the diameter (D)** of the light spot carefully through its centre for accurate calculations.
5. **Keep the screen perpendicular** to the emerging light beam to obtain a circular spot.
6. **Take multiple observations** and use the average values to minimize experimental errors.
7. **Switch off the power supply** after completing the experiment and handle the equipment safely.