Practical No.15: Determination of the Numerical Aperture (NA) of a given step index optical fiber.

I Practical Significance

In optics, the numerical aperture (NA) of an optical system is a dimensionless number that characterizes the range of angles over which the system can accept or emit light. By incorporating index of refraction in its definition, NA has the property that it is constant for a beam as it goes from one material to another, provided there is no refractive power at the interface. The exact definition of the term varies slightly between different areas of optics. Numerical aperture is commonly used in microscopy to describe the acceptance cone of an objective (and hence its light-gathering ability and resolution), and in fiber optics, in which it describes the range of angles within which light that is incident on the fiber will be transmitted along it.

II Industry/ Employer Expected Outcome

Apply principles of physics and chemistry to solve broad based relevant engineering problems.

III Course Level Learning Outcome

Determine the Numerical Aperture (NA) of a given step index optical fiber.

IV Laboratory Learning Outcome(s)

Apply basic principles of thermometry and fibre optics to solve engineering problems.

V Relevant Affective domain related Outcomes

a) Handle the apparatus carefully.

b) Practice good housekeeping.

VI Relevant Theoretical Background

Optical fibers are fine transparent glass or plastic fibers which can propagate light. They work under the principle of total internal reflection from diametrically opposite walls. In this way light can be taken anywhere because fibers have enough flexibility. This property makes them suitable for data communication, design of fine endoscopes, micro sized microscopes etc. An optic fiber consists of a core that is surrounded by a cladding which are normally made of silica glass or plastic. The core transmits an optical signal while the 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 an optic fiber is shown in figure (1). In order to understand the propagation of light through an optical fibre, consider the figure (2). Consider a light ray (i) entering the core at a point A , travelling through the core until it reaches the core cladding boundary at point B. As long as the light ray intersects the core-cladding boundary at a small angles, the ray will be reflected back in to the core to travel on to point C where the process of reflection is repeated .ie., total internal reflection takes place. Total internal reflection occurs only when the angle of incidence is greater than the critical angle. If a ray enters an optic fiber at a steep angle(ii), when this ray intersects the core-

VIII Resources required

Sr. No.	Name of the equipment	Specification	Quantity
1	Laser light		1
2	Fibre optic cable		1
3	Microscope objective		1
4	Fiber chunks		1
5	Screen		1
6	Optical mount & post holder		1
7	Optical bench/ breadboard		1
8	Optical rollers		1

IX Precautions

1. Handle the equipment carefully.
2. Do not obstruct the path of the LASER beam

X Procedure

1. On optical bench arrange the apparatus in a proper sequence
2. Arrange the laser light at one end of the board.
3. Adjust the microscope in front of the laser light.
4. Optical mount and fiber chunks arrange in front of the microscope.
5. Adjust the fibre optical cable with both the stands.
6. When laser light passing through the microscope.
7. Adjust the microscope and monochromatic light is enters in the fibre optical cable.
8. When light passing through the fibre optical cable it will falls on the screen.
9. Adjust the distance of the screen, so we get the diversions of the beam on the screen.
   a. Plot graph of spot size (r) vs distance between source and screen (d).Find slope of the graph.

XI Observations and Calculations

Sr.No.	Distance, (d) cm	Radius, (r) cm	NA = $\left(\frac{r}{\sqrt{r^2 + d^2}}\right)$	Average NA
1	10 cm	1	0.0995	
2	15 cm	1.5	0.0991	
3	20 cm	2	0.0990	0.0991
4	25 cm	2.5	0.0990	
5	30 cm	3	0.0990	

Calculations

$r = 1$, $d = 10cm$

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

$$= \frac{1}{\sqrt{1^2+10^2}} = \frac{1}{\sqrt{1+100}}$$

$$NA = \frac{1}{\sqrt{101}} = 0.0995037$$

XII Results

The numarical aperture of O.F. was determined by various r, d and found average NA = 0.0991.

XIII Interpretation of results

NA suggest the acceptance angle of O.F.

XIV Conclusions and Recommendations

Hence, we conclude that as distance increases NA decreases vice versa.

XV Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design **more such questions so as to ensure the achievement of identified CO.**

1. Define Numerical aperture.
2. What are three layers in optical fiber?
3. Optical fiber depends on which phenomenon?
4. If the refractive index of core is 1.55 and refractive index of cladding is 1.33, Calculate Numerical aperture.
5. What is the significance of NA?

[Space to Write Answers]

1] Numerical aperture (NA) is as unitless number that measures the range of angles at which an optical system can emit or accept light.

2] The three layers of an optical fiber are
1] core.
2.] Cladding.
3.] outer coating.

3.] optical fiber ~~debe~~ depend on the phenomenon of total internal reflaction (TIR).

5] NA is significant factor in deteremining the perfomance of an optical system, such as a microscope or optical fiber.