Expt.No.1. **Optical fiber**

Aim:

1) To measure light gathering power in terms of NA assuming that the angle of emergence is equal to angle of acceptance.
2) Comment on how the light gathering capacity of an optical fiber changes as the value of numerical aperture and the fractional index change changes.

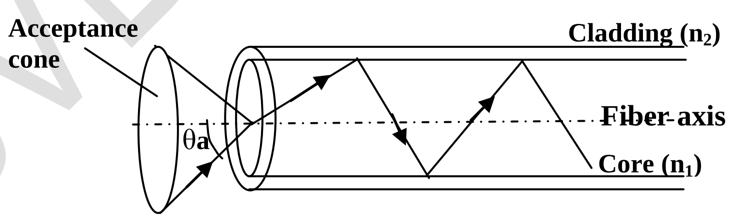
Apparatus:

Power supply, laser source (semiconductor), optical fiber cable (multimode),converging lens, holders and screen.

Theory:

Optical fibers which act as light guides are the medium of communication using light rays. They are very thin, flexible and are made of pure silica glass or plastic. Optical fibers operate on the principle of Total Internal Reflection (TIR). Optical fiber consists of 3 parts; the inner most regions is the light guiding, which is called "Core". It is made up of pure silica glass. The refractive index (n_1) of the core is very high. The core is surrounded by a middle region called "Cladding" which is also made up of pure silica glass or plastic but of lower refractive index (n_2) than the core material. In turn the cladding is enclosed in a plastic jacket which protects the fiber and gives mechanical strength.

The well known optical phenomenon of total internal reflection (TIR) is made use to guide light rays along the optical fiber. These transparent light guides are able to guide the light over long distances. The maximum angle of incidence below which only TIR takes place is called **acceptance angle** '**θ_a**' And Sinθ_a is called **Numerical Aperture** (**NA**) of the fiber. Numerical aperture represents the light gathering capacity of fiber. It is a basic descriptive characteristic of a specific optical fiber.



Applying Snell's law, expression for NA can be written as

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

Where θ_a is the acceptance angle

n_1 is the R.I of core and n_2 is the R.I of cladding

Light propagates in different paths within the optical fiber. The number of possible paths of light in an optical fiber is referred as '**modes**'. In any optical fiber the cladding material has constant R.I value. But the R.I of core may either constant or varying in a particular way. The graph which represents the variation of R.I with respect to the radial distance from the fiber axis is called **refractive index profile (RIP)**. Based on RIP and the number of modes propagating in a fiber the optical fibers are broadly classified as single mode step index fiber, multimode step index fiber and multimode graded index fiber.

Procedure:

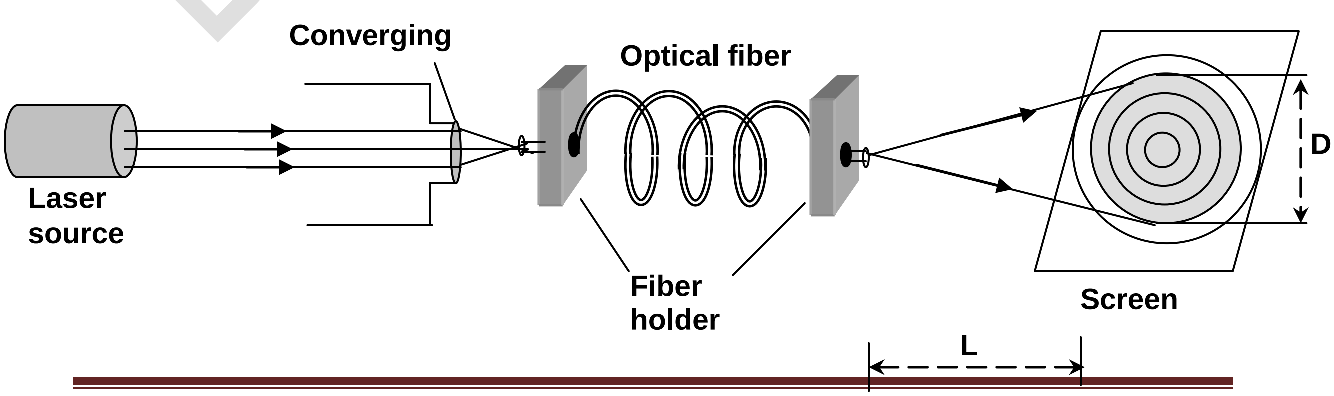
1. Arrange laser source, holders, converging lens so that all are collinear.
2. Insert the multimode optical fiber ends in the holders.
3. Place the screen normal to the fiber axis and move the screen towards or away from the output end of the fiber such that a circular spot appears on the screen.
4. Couple the laser light properly into the fiber such that, the circular spot should have maximum intensity.
5. Measure the distance between the output end of the fiber and screen (**L** in cm) and also measure the diameter of the circular spot (**D** in cm).
6. The acceptance angle '$\boldsymbol{\theta_a}$' can be calculated using the formula, $\theta_a = \tan^{-1}(D/2L)$.
7. Substitute the value of θ_a, and calculate the NA using the formula **NA=** $\sin[\tan^{-1}(D/2L)]$.
8. The experiment is repeated for different diameter of the circular spot and corresponding numerical apertures are calculated. Finally mean Numerical aperture is calculated.

Formula:

$$\textbf{Numerical aperture} = \sin\left[\tan^{-1}\frac{D}{2L}\right]$$

Where L is the distance between the output fiber end and screen.
D is the diameter of the circular spot formed on the screen

Experimental setup:



Tabular column:

Sl. No.	Distance between output end of optical fiber & screen 'L' in cm	Diameter of the circular spot 'D' in cm	$\frac{D}{2L}$	Acceptance angle $\theta_a = \left[\tan^{-1}\frac{D}{2L}\right]$ in degrees
Error value	±	±		
1				
2				
3				
4				

Calculation:

Numerical Aperture: **NA=** $\sin\left[\tan^{-1}\frac{D}{2L}\right]$

Mean Numerical Aperture (NA) = (NA_1 + NA_2 + NA_3 + NA_4) / 4

Result: The numerical aperture of the given optical fiber = ----------