EXP NO: 10.1 MEASUREMENT OF NUMERICAL APERTURE OF OPTICAL FIBER

10.1.1 OBJECTIVE:

To measure the numerical aperture of a given optical fiber at 650 nm

10.1.2 HARDWARE REQUIRED:

Optical fiber, Numerical Aperture Measurement Kit

10.1.3 INTRODUCTION:

Numerical aperture (NA) of a fiber is a measure of the acceptance angle of light in the fiber. Light which is launched at angles greater than this maximum acceptable angle does not get coupled to propagating modes in the fiber and therefore does not reach the receiver at the other end of the fiber. The Numerical aperture is useful in the computation of optical power coupled from an optical source to the fiber, from the fiber to a photo detector and between two fibers.

DIAGRAM

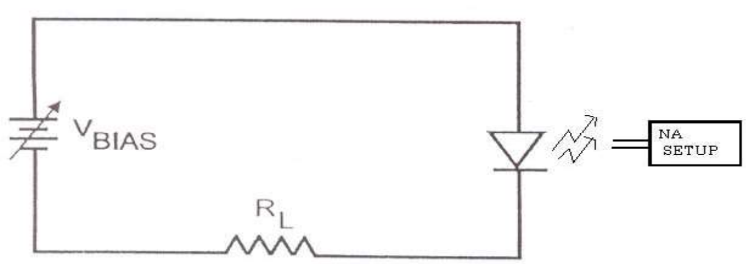

Figure 1: Numerical aperture setup

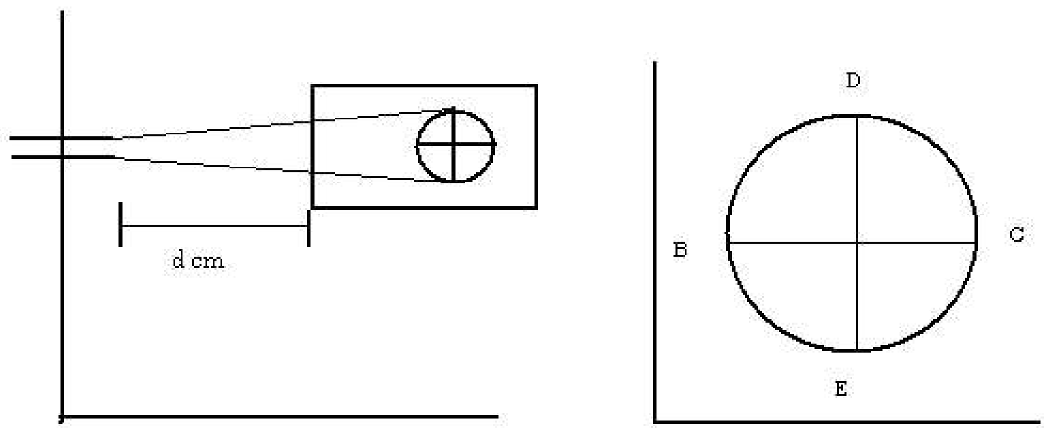

Figure 2: Numerical aperture

10.1.4 PRELAB QUESTIONS

1. Define angle of acceptance.
2. If the angle of acceptance is 30 degree, what is the value of numerical aperture?
3. What is the formula for numerical aperture?
4. What is lens coupling and butt coupling
5. How to relate Snell's law with Numerical Aperture.
6. Why light can travel faster in water compared to glass?
7. How fast is the light traveling inside the water?

10.1.5 TABULATION:

S. No.	Radius of the circular path (X)	Distance (d)	NA = Sin $\theta = X/(d^2 + X^2)^{1/2}$

Average:

10.1.6 PROCEDURE:

1. Insert one end of the fiber into the numerical aperture measurement kit as shown in the figure. Adjust the fiber such that its tip is 10 mm from the screen
2. Gently tighten the screw to hold the fiber firmly in the place.
3. Connect the other end of the fiber to the LED Source through a connector. The fiber will project a circular patch of red light onto the screen. Let **d** be the distance between the fiber tip and the screen. Now measure the diameter of the circular patch of red light in two perpendicular directions (BC and DE in figure). The mean radius of the circular patch is given by

$$\boldsymbol{X = (DE + BC)/4}$$

4. Carefully measure the distance d between the tip of the fiber and the illuminated screen (OA) as shown in figure. The Numerical aperture of the fiber is given by

$$\mathbf{NA = Sin}\boldsymbol{\theta = X/(d^2 + X^2)^{1/2}}$$

5. Repeat steps 1 to 4 for different values of d, compute the average value of Numerical aperture.

10.1.7 POST LAB QUESTIONS

1. Why do single mode fiber have larger bandwidth as compared to that of multimode fiber?
2. What is pulse dispersion?
3. Light travels from denser medium glass into rarer medium air. What is the critical angle at the interface?
4. Can optical fiber conduct electricity? Why?
5. At what wavelength does silica fiber show minimum attenuation?
6. Give the relation between bandwidth and Numerical aperture (NA).
7. A light ray incident on air water interfaces and refracted at an angle of 40º in the water. Calculate the angle of incidence.
9. A multi-mode optical fiber index has $n_1 = 1.5$ and $n_2 = 1.4142$. Find the maximum value of θ_A for which the incident light from air will be guided in the optical fiber.

10.1.8 RESULT

Thus, the numerical aperture of a fiber optic cable is determined.

EXP NO: 10.2 MEASUREMENT OF PROPAGATION LOSS IN OPTICAL FIBER

10.2.1 OBJECTIVE:

To measure the propagation loss in an optical fiber.

10.2.2 HARDWARE REQUIREMENT:

Kit (Fiber link-D), 1 m, 3 m Fiber Cable Link Patch cords Power supply

10.2.3 INTRODUCTION:

Optical fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics of different wavelengths of light. Losses are introduced in fiber due to various reasons. As light propagates from one end of fiber to another end, part of it is absorbed in the material exhibiting absorption loss. Also, part of the light is reflected back or in some other direction from the impurity particles present in the material contributing to the loss of the signal at the other end of the fiber. It is known as Propagation loss.

10.2.4 PRELAB QUESTIONS

1. What are the different types of dispersion?
2. What is group velocity dispersion?
3. What is the difference between attenuation and dispersion?
4. How to increase the signal strength in optical fibers
5. Define attenuation coefficient.
6. What are the reasons for optical signal loss in fiber?

FORMULA:

Propagation loss: Attenuation in dB/m

$$\alpha = \ln(P_{o1}/P_{o2}) / (l_2 - l_1)$$

where

P_{o1} ---- Output power level (μw) at the end of the fiber of length l_1 (m)

P_{o2} ---- Output power level (μw) at the end of the fiber of length l_2 (m)

10.2.5 PROCEDURE:

1. Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF.
2. Connect the AMP O/P as a constant signal to the TX I/P using a patch cord.
3. You will measure the light output using SIGNAL STRENGTH section of the kit. The loss will be more for a longer piece of fiber. In order to measure the loss in the fiber you first need a reference of how much light goes into the fiber from the Light transmitter, you will use the short piece of fiber to measure this reference.
4. Switch on the power supply. Connect the short piece of fiber between the TX and RX of the kit. Adjust the transmitter level until the signal strength reads 6, this will be your reference value. Now connect the long piece of fiber instead of the short piece. What reading do you get? Loss in optical fiber system is usually measured in dB. Loss of fiber itself is measured in dB/meter.
5. Subtract the length of the short fiber from the length of the long fiber to get the difference in the fiber lengths (4m-1m). The extra length of 3 m is what created the extra loss you measured. Then take the signal strength reading you obtained for the loss of the long fiber directly from the power meter.

MODEL GRAPH

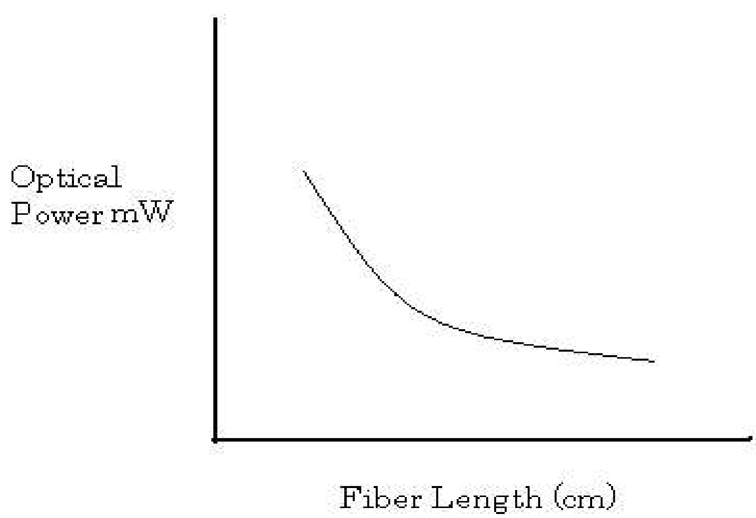

Figure 1: Optical power vs. Fiber length

10.2.6 TABULATION:

S. No.	Length of the optical fiber cable (*m*)	Optical Power Signal Strength		Propagation Loss
		dBm	mW	

10.2.7 POST LAB QUESTIONS

1. Consider a 10 km optical fiber in which 100 mW power is launched from one end and 50 mW power is received from the other end. Calculate the attenuation in dB/Km.
2. Why optical power decreases with increase in fiber length.
3. A 30 km long optical fiber that has an attenuation of 0.8 dB/km at 1300 nm. Find the optical output power Pout if 200µw of optical power is launched into the fiber.

10.2.8 RESULT

The propagation loss in fiber optic cable is measured.

EXP NO: 10.3 MEASUREMENT OF BENDING LOSS IN AN OPTICAL FIBER

10.3.1 OBJECTIVE

To measure the bending loss of a fiber optic cable

10.3.2 HARDWARE REQUIREMENTS:

Kit (Fiber Link-D), 1 m or 3 m fiber cable, Spindles to wound the fiber around it Power supply.

10.3.3 INTRODUCTION:

Though the fibers are good at bending, each time the fiber is bent, a little light is lost. This experiment will measure how much of this light is lost for different sizes of bends.

10.3.4 PRELAB QUESTIONS

1. What is micro bending and macro bending loss?
2. What is total internal reflection?
3. Define Snell's law.
4. Differentiate reflection, refraction and diffraction.

MODEL GRAPH

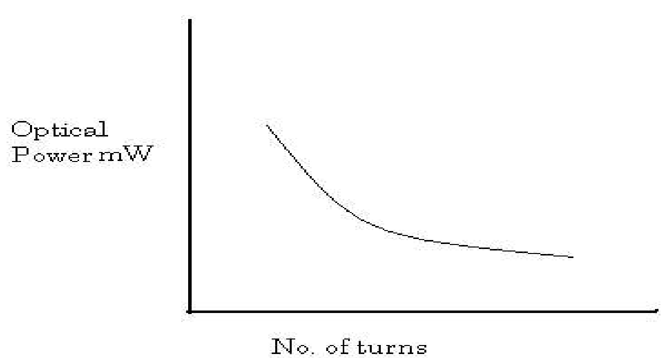

Figure 1: Optical power vs. No. of turns

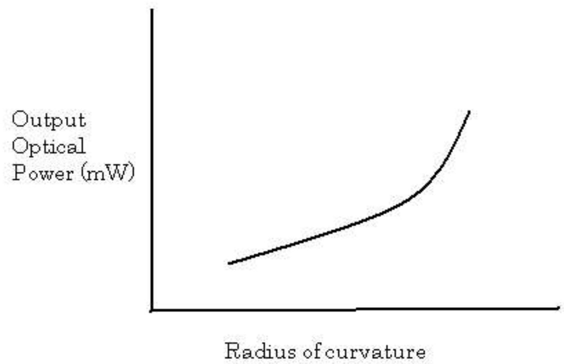

Figure 2: Optical power vs. Radius of curvature

10.3.5 EXPERIMENT

10.3.5.1 PROCEDURE:

1. Connect the power supply cables with proper polarity to kit. While connecting this, ensure that the power supply is OFF.
2. Connect the AMP O/P as a constant signal to the TX I/P using a patch cord. You will measure the light output using SIGNAL STRENGTH section of the kit.
3. Switch on the power supply. Connect the long piece of fiber between the TX and RX of the kit so there are no sharp bends in the fiber between them
3. Adjust the transmitter level until the signal strength reads 6, this will be your reference value. Now take the portion of the fiber and loop it into the spindle and note the signal strength from the power meter, which give the optical signal power in dBW/m.
4. Repeat it for various diameters of the spindle and for various numbers of bend on the spindle and measure the corresponding signal strength from the optical power meter.

10.3.5.2 TABULATION:

i) No. of turns vs. Signal Strength:

Diameter of Spindle

S. No.	Bending	Signal Strength in mW
1.	No Bend	
2.	1	
3.	2	
4.	3	

ii) Radius of the Spindle vs. Signal Strength:

S. No.	Radius of spindle	Signal Strength in mW
1.		
2.		
3.		
4.		

10.3.6 POST LAB QUESTION:

1. How light is propagated inside a fiber?
2. Give the merits and demerits of Optical fiber cable.
3. In optical fiber propagation loss increases or decreases with the increase in length of the fiber cable?
4. When the mean optical power launched into an 8 km length of fiber is 120 mW, the mean optical power at the output is 3 mW.

   Determine:

   a. The overall signal attenuation (or loss) in decibels through the fiber assuming there are no connectors or splices.

   b. The signal attenuation per kilometer for the fiber.

   c. The overall signal attenuation for a 10 km optical link using the same fiber with splices (i.e. fiber connections) at 1 km intervals, each giving an attenuation of 1 dB.

   d. The output/input power ratio.

10.3.7 RESULT

The bending loss in fiber optic cable is determined.