Experiment Name / No.: 06

Date 12 / 02 / 2021

Experiment No:-> 06.

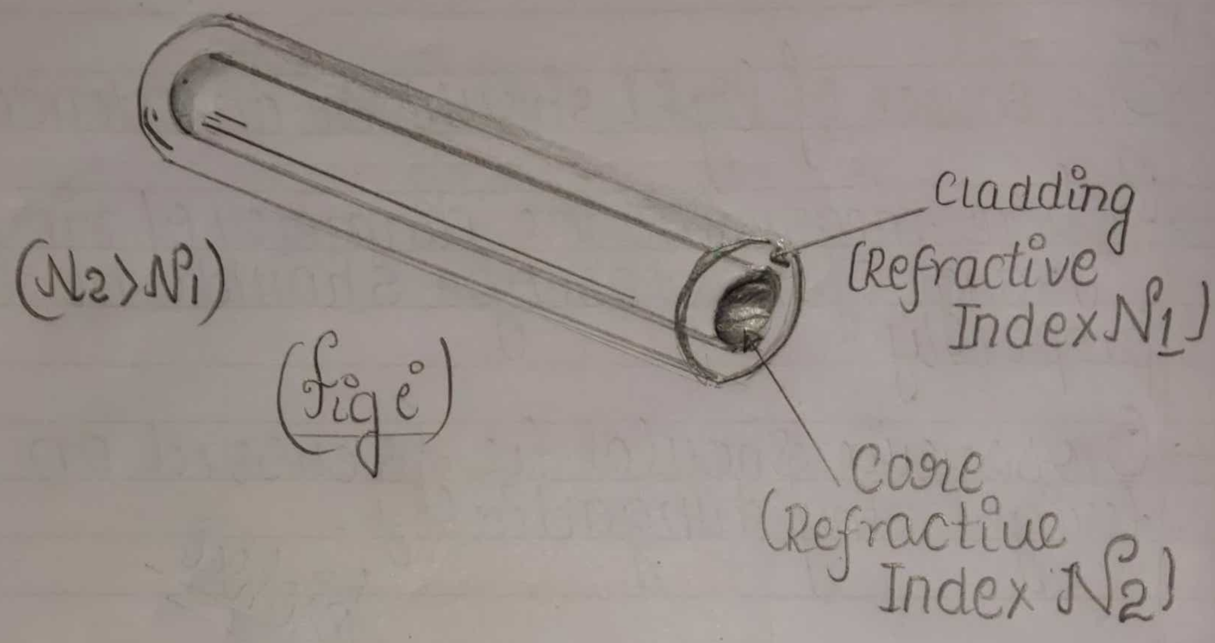
1.) Aim:-> To determine the numerical aperture of the optical fiber

2.) Apparatus:-> Detector, fiber, concentrator, output unit, Emitter, Fiber Stand

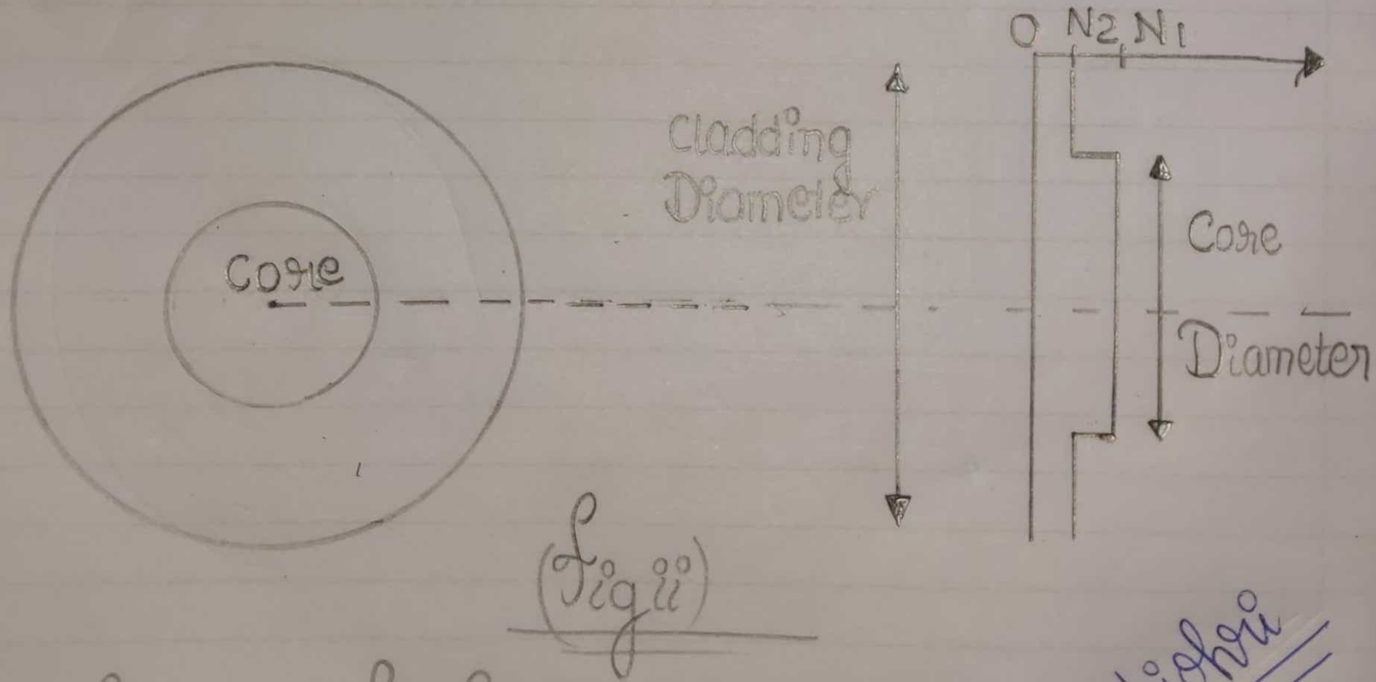
3.) Theory:-> Optical fibers are fine transparent glass or plastic fibers which can propagate light. They work under the principle of total internal reflection from diametrically opposite walls. In this way light can be taken anywhere because fibers have enough flexibility. This property makes them suitable for data communication, design of fine endoscopy, micro sized microscopes etc. An optic fiber consists of a core that is surrounded by a cladding which

Teacher's Signature

Experiment No:-> 06



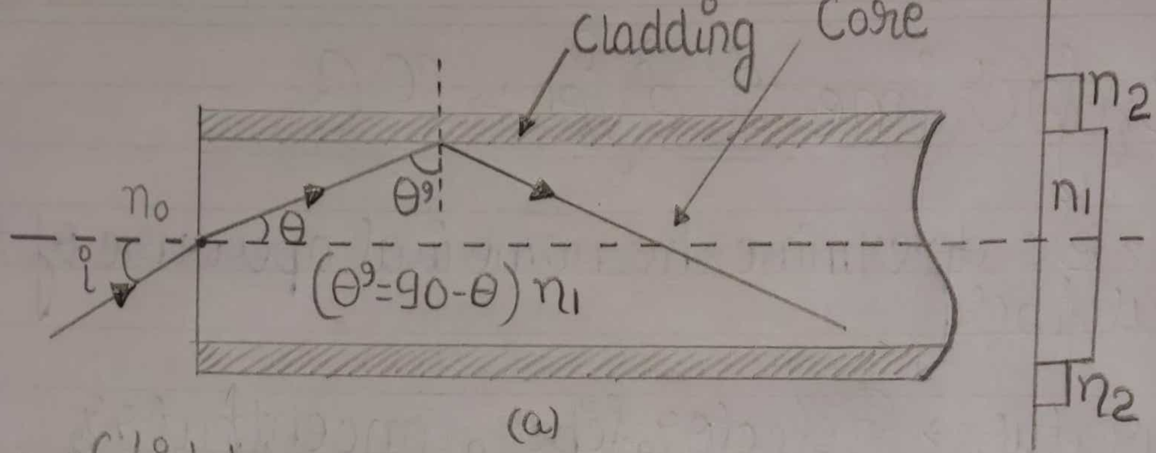
(fig i)



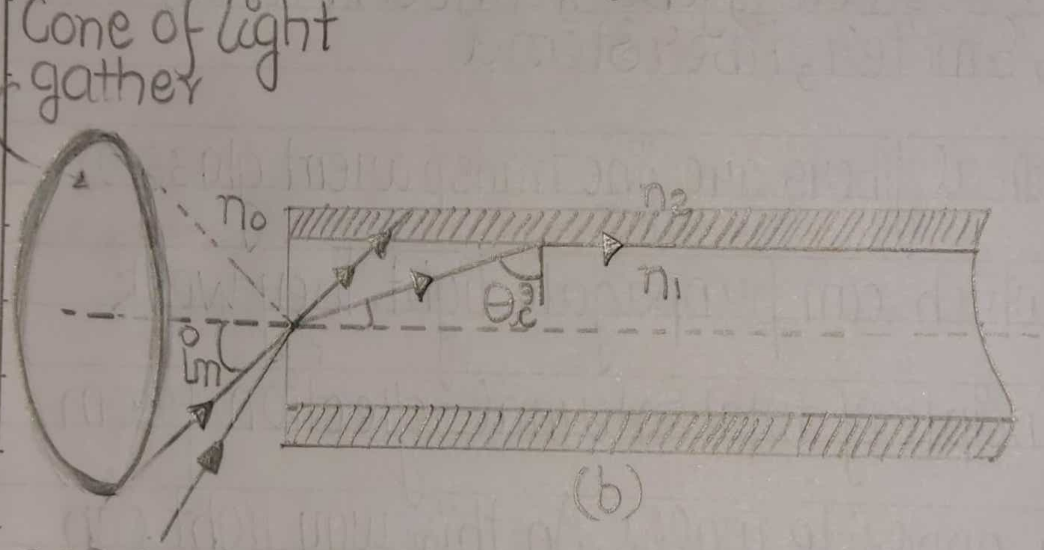
(fig ii)

CONSTRUCTION OF OPTICAL FIBER

bjohri

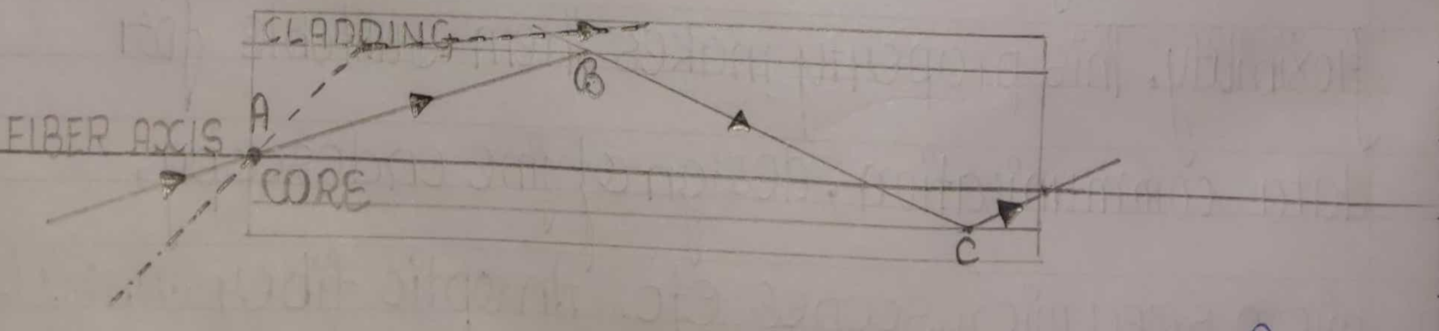


(a)



(b)

PROPAGATION OF LIGHT IN AN OPTICAL FIBRE



Experiment Name / No.: 06

Camlin Page No.
Date / /

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 the diagram.

In order to understand the propagation of light through an optical fiber, consider the diagram, Consider a light ray entering the core at a point A, travelling through the core until it reaches the core-cladding boundary at small angles, the ray will be reflected back to the core to travel on to point C where the process of

Teacher's Signature Jjohri

Experiment Name / No.: 06

Camlin Page No.
Date / /

reflection is repeated i.e. the 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, when this ray intersects the core-cladding boundary, the angle of intersection is too large. So, reflection back in to the core does not take place and the light ray is lost in the cladding.

This means that to be guided through an optic fiber, a light ray must enter the core with an angle less than a particular angle called the acceptance angle of the fibre.

A ray which enters the fiber with an angle greater than the acceptance angle will be lost in the

Teacher's Signature

Experiment Name / No.: 06

Camlin Page No.
Date / /

cladding.

Consider an optical fibre 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 in figure. Then the light gets refracted at an angle 'θ' and fall on the core-cladding interface at an angle where,

$$\theta' = (90 - \theta) \longrightarrow (1)$$

By snell's law at the point of ~~int~~ entrance of light in the optical fiber, we get

$$n_0 \sin(i) = n_1 \sin(\theta) \longrightarrow (2)$$

where n_0 is refractive index of medium outside the fiber

(for air $n_0 = 1$)

Teacher's Signature:

Experiment Name / No.: 06

When light travels from core to cladding it moves from denser to rarer medium and so it maybe totally reflected back to the core medium if θ_i exceeds the critical angle θ_c. The critical angle is the angle of incidence in denser medium (n_1) for which angle of refraction becomes 90°, Using Snell's Laws at core cladding interface,

$$n_1 \sin\theta_c = n_2 \sin(90°)$$

or

$$\sin(\theta_c) = \left(\frac{n_2}{n_1}\right) \longrightarrow (3)$$

Therefore, for light to be propagated within the core of a optical fiber as guided wave, the angle of incidence at core-cladding interface should be greater than θ_c. As i increases

Teacher's Signature:

Experiment Name / No.: 06

Camlin | Page No.
Date / /

θ increases and θ^i decreases. Therefore, there is maximum value of angle of incidence beyond which, it does not propogate rather it is ~~reflected~~ refracted in to cladding medium. The maximum value of 'i' say 'im' is called the maximum angle of acceptance and $n_0 \sin(i_m)$ is termed as the numerical aperture (NA)

$$NA = n_0 \sin(i_m) = n_1 \sin\theta$$
$$= n_1 \sin(90 - \theta_c)$$

or $N.A = n_1 \cos(\theta_c)$
$$= n_1 \sqrt{1 - \sin^2(\theta_c^i)}$$

$$\boxed{\sin\theta_c^i = \left(n_2/n_1\right)}$$

from eq (2)

$$\Rightarrow \boxed{NA = n_1 \sqrt{1 - \left(\frac{n_2^2}{n_1^2}\right)}}$$

Teacher's Signature

Experiment Name / No.:

Camlin | Page No.
Date / /

4) Formula used:-> Least count of screw gauge :->

Number of circular scale divisions = 50

Distance covered on main scale on 1 complete rotation of circular scale = 0.5mm

Least count = $\frac{\text{Pitch}}{\text{No of divisions}}$

where:->

(Pitch = $\frac{\text{Distance measured by screw gauge}}{\text{No of full rotation}}$ = $\left(\frac{0.5mm}{1}\right)$)

Least count = $\left(\frac{0.5 mm}{50}\right)$

Least count = 0.01 mm = 1CSD.

Least count = 0.01mm

Numerical aperture of optical fiber:->

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

r = radius of spot

d = distance between fiber & detector

Teacher's Signature:

Observations:-> Least count of Screwgauge

Number of circular scale divisions = 50

Distance covered on main scale on 1 complete rotation of circular scale = 0.5mm

$$\boxed{\text{Least count} = \frac{\text{Pitch}}{\text{No of Divisions}}} \rightarrow \text{Eq}(1)$$

Where:->

$$\text{Pitch} = \frac{\text{Distance measured by screw gauge}}{\text{No of full Rotations}} = \left(\frac{0.5\,mm}{1}\right)$$

$$\text{Least count} = \left(\frac{0.5\,mm}{50}\right)$$

Least count = 0.01 mm = 1 CSD

Least count = 0.01 mm

Jyoti

Experiment Name / No.:

Camlin Page No.
Date / /

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

where,

$\Rightarrow r =$ radius of spot

$\Rightarrow d =$ distance between fiber and detector

Teacher's Signature:

Observation Table.

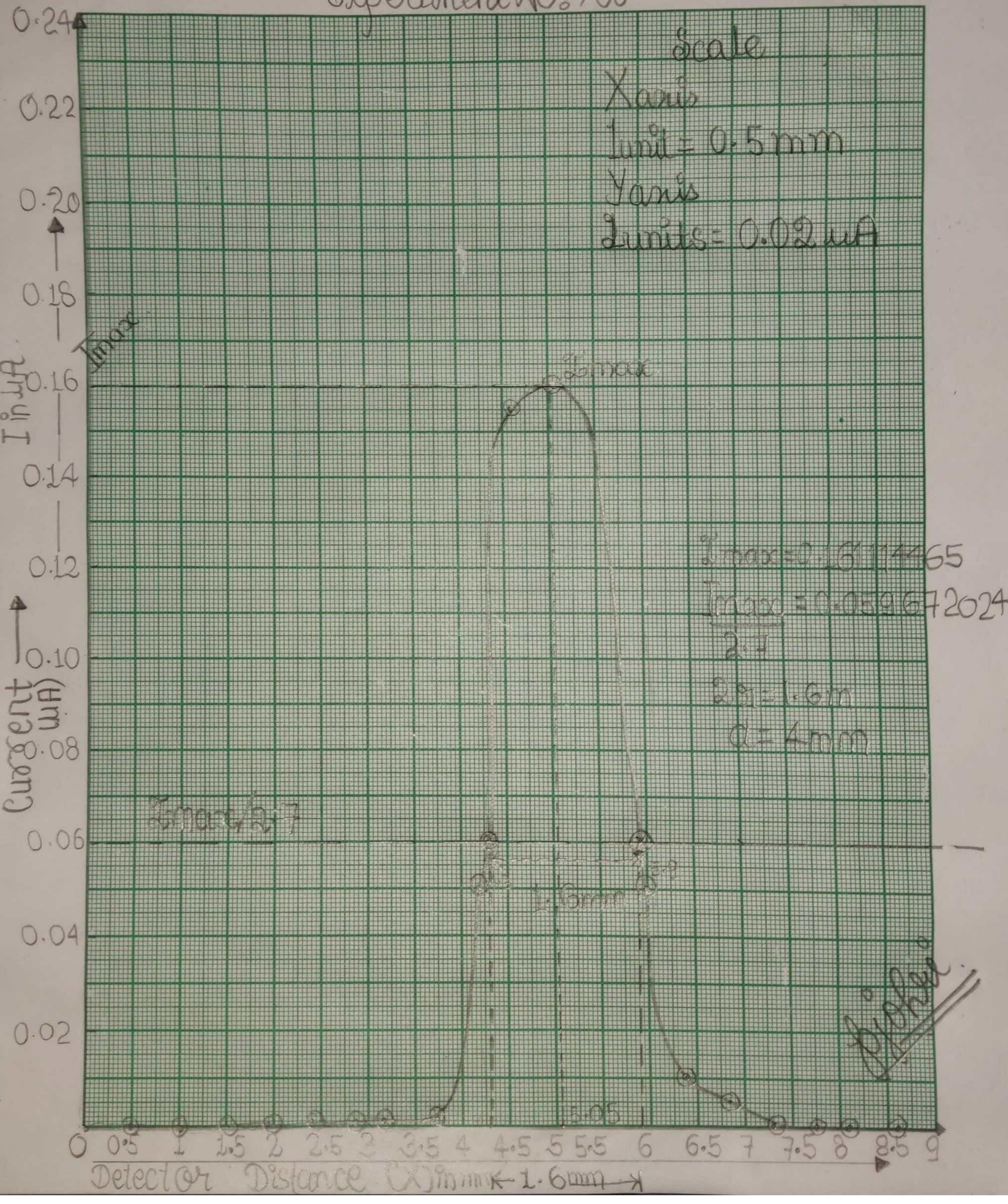
Sr. No.	Screw gauge M.S.R (mm)	Readings C.S.R	Distance =MSR+L.C*CSR	Current (μA)
1	0	0	0	0
2	0.5	0	0	0
3	1	0	0	0
4	1.5	40	1.9	0
5	2	40	2.40	0.000000001
6	2.5	36	2.86	0.000000806
7	3	30	3.30	0.000103297
8	3.5	28	3.78	0.005268341
9	4	22	4.22	0.053948455
10	4.5	11	4.61	0.15655311
11	5	05	5.05	0.161114465
12	5.5	49	5.99	0.049630472
13	6	41	6.41	0.00526841
14	6.5	35	6.85	0.000154
15	7	33	7.33	0.000000806
16	7.5	25	7.75	0.000000003
17	8	18	8.18	0
18	8.5	10	8.6	0

From Observation Table :→

$I_{max} = 0.161114465$ (μA)

Sjohri

Experiment No:-> 06



For, radius of spot (r) :-> We find from Graph

$$\frac{I_{max}}{2.71} = \frac{0.161114465}{2.71} = 0.059451832$$

Drawing Horizontal line ‖ to X axis comes out to lie 4.3mm and 5.9mm

$2r = 5.9mm - 4.3mm \ (5.9mm - 4.3mm)$

$r = \left(\frac{1.6}{2}\right)mm$

$r = 0.8mm$ = Radius of the spot.

$d = 4mm$ (Distance between the fiber and the detector)

Numerical Aperture (NA)

$$= \sin\theta = \frac{r}{\sqrt{r^2+d^2}} = \frac{0.8}{\sqrt{(0.8)^2+(4)^2}} = \frac{0.8}{4.079215611}$$

$\Rightarrow NA = 0.196116135$ = Numerical Aperture

$\theta = \sin^{-1}(0.196116135)$

$\theta = (11.30993247)^\circ$ = Acceptance Angle

Jyotshna

Result :-

→ Numerical Aperture of the optic fiber is =

$NA = 0.196116135$.

Angle of acceptance = (11.30993247°)

Ans

Signature

Experiment Name / No.: Camlin Page No. Date / /

5.) Result:-> Numerical Aperture of the optic fiber is NA = 0.196116135 Ans

Angle of Acceptance = $(11.30993247)^\circ$ Ans

6.) Precautions and sources of errors.

☆ Mounting & coupling should be done carefully

☆ Glass optical fibres are thin & delicate & should be handed carefully

☆ Laser Light shouldn't fall directly in eyes

☆ Connections should be proper & tight

—o—X—o—

Teacher's Signature: