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classmate
Date
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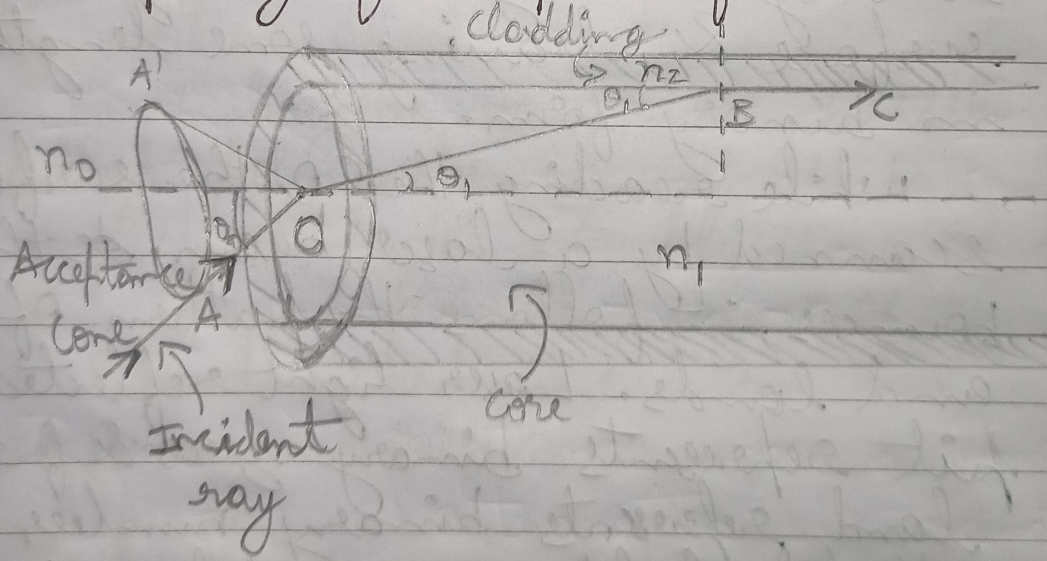
Assignment - 5

1. With a neat diagram derive an expression for numerical aperture of an optical fiber.

Ans→ Sine of the acceptance angle θ_0, $\sin\theta_0$ is called the numerical aperture of the fiber. It represents the light gathering capacity of the optical fiber.



Consider an optical fiber into which light is launched at one end from a medium of RI n_0. Let n_1 be the RI of core and n_2 be that of the cladding. Assume that a ray of light enters the fiber at an angle θ_0 known as

acceptance angle with respect to the axis of the fiber. The light ray refracts at an angle θ_1 & strikes the core-cladding interface at an angle of $(90-\theta_1)$ which is equal to the critical angle for the core-cladding interface.

Applying Snell's law at 'O'

$$\frac{\sin\theta_0}{\sin\theta_1} = \frac{n_1}{n_0}$$

$$\sin\theta_0 = \frac{n_1}{n_0}(\sin\theta_1)$$

$$\sin\theta_0 = \frac{n_1}{n_0}\left(\sqrt{1-\cos^2\theta_1}\right) \rightarrow (1)$$

Applying Snell's law at 'B'

$$n_1 \sin(90-\theta_1) = n_2 \sin 90$$

$$\cos\theta_1 = \frac{n_2}{n_1} \rightarrow (2)$$

Substituting (2) in (1) we get

$$\sin\theta_0 = \frac{n_1}{n_0}\left(\sqrt{1-\left(\frac{n_2}{n_1}\right)^2}\right)$$

$$\sin\theta_0 = \frac{n_1}{n_0}\left(\sqrt{\frac{n_1^2 - n_2^2}{n_1^2}}\right)$$

$$\sin\theta_0 = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}$$

By definition, sine of the angle of acceptance is known as Numerical aperture (N.A)

$$N.A = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}$$

If the medium surrounding the fiber is air, then $n_0 = 1$

$$N.A = \sin\theta_0 = \sqrt{n_1^2 - n_2^2}$$

2. Define a) acceptance angle, b) Numerical aperture, c) attenuation, d) Franctional Index change (Δ).

Ans → a) Acceptance angle – It is the maximum angle that a light ray can have relative to the axis of the fiber & propagates down the fiber.

a) Numerical aperture – It is the maximum angle that a light ray can have relative to the axis of the fiber and propagates down the fiber.

b) Numerical aperture – Sine of the acceptance angle θ_0, $\sin\theta_0$ is called Numerical aperture.

c) attenuation – The loss of power suffered by the optical signal as it propagates through the fiber is called attenuation.

d) Fractional Index change (Δ) – It is the ratio of the RI difference b/w the core and cladding to the RI of core of an optical fiber.

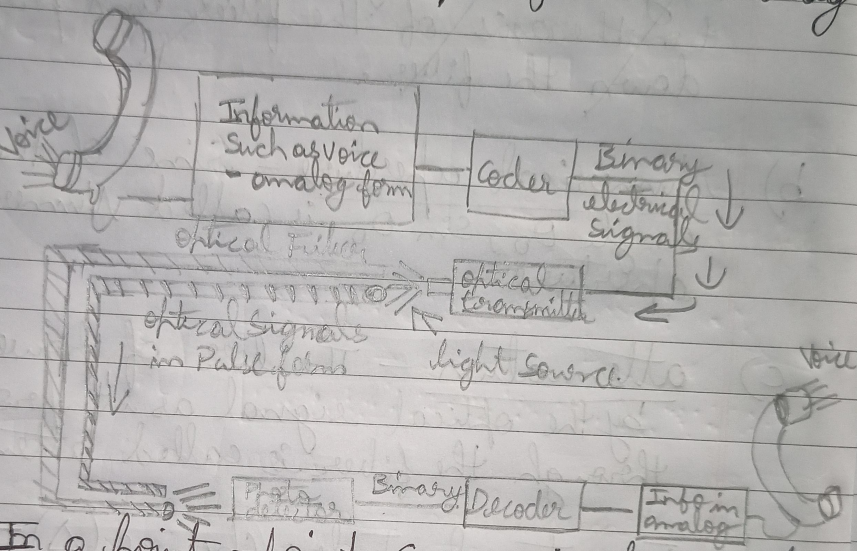
$$\Delta = \frac{n_1 - n_2}{n_1}$$

$n_1 \rightarrow$ RI of core

$n_2 \Rightarrow$ RI of cladding

3. Describe the point-point communication system, with the help of a block diagram.

Ans ⇒



In a point-point communication, we have analog information such as voice of a telephone user. The voice gives to electrical signals in analog from coming out of the transmitter section of the telephone. With the help of a coder, the analog signal is converted into binary data. The binary data in the form of a stream of a electrical pulses are converted into pulses of optical power by modulating the light emitted by an optical source such as a laser diode.

4.

This unit is called optical transmitter, from which the optical power is launched into the fiber.

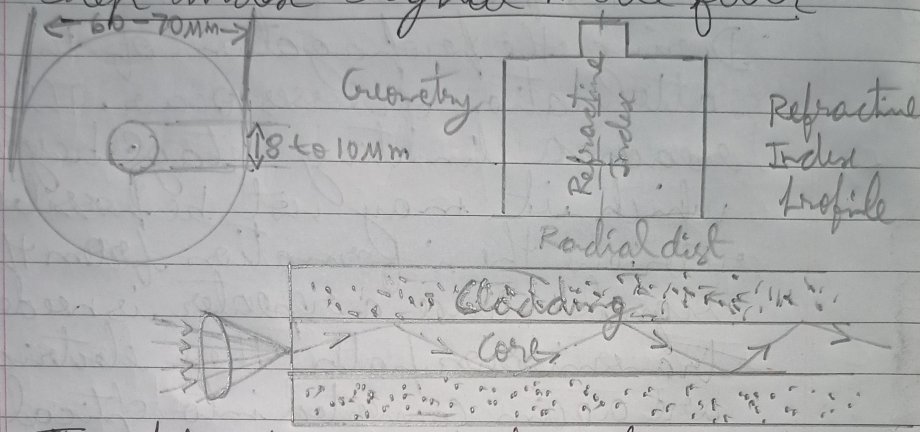
During the propagation of the signal, attenuation or losses occur. This may reach a limiting stage beyond which it may not be possible to retrieve the information from the light signal. Hence a repeater is needed in the transmission path. These electrical signals are again converted into optical fiber.

At the receiving end the optical signal from the fiber is fed into a photo detector. Hence signal is coverted to pulses of electric current. This is then fed to a decoder which converts the the binary data into a analog signal, which will be the same information such as voice, which was there at the transmitting end.

4. Discuss the types of optical fibers with neat diagrams.

Ans→ There are 3 types of optical fibers

1. Step index Signal mode fiber -

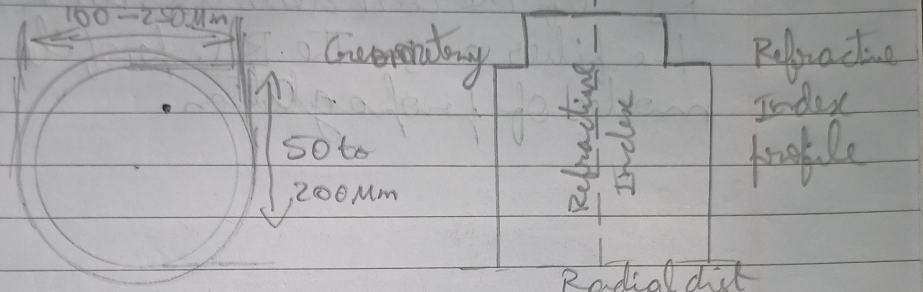


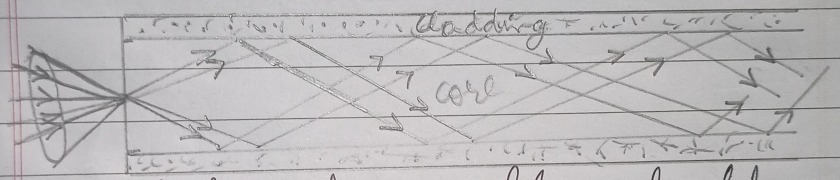
This fiber has a core diameter of about 8 to 10 μm & external diameter of cladding is 60 to 70 μm. The RI of the core & cladding region remains constant. But, there is a sudden/abrupt decrease in the RI at the core-cladding interface

2. Step index multi mode fiber -

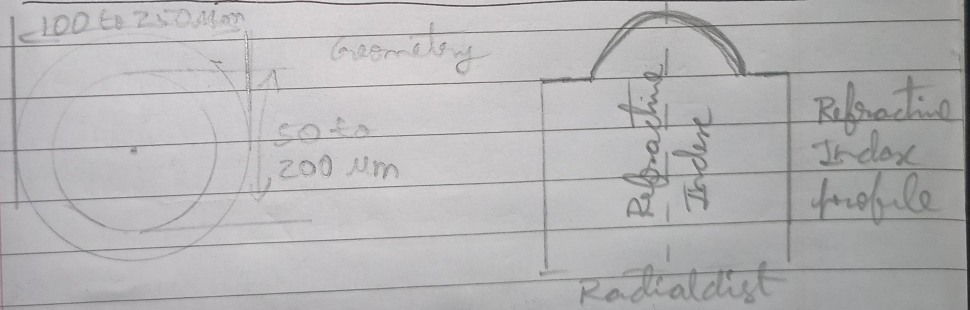
This fiber has a core diameter of about 100 μm. The RI remains uniform in the core & cladding region. But the RI changes abruptly at the core-

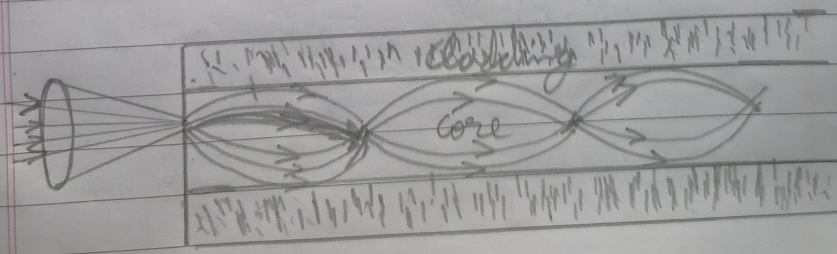
cladding interface. Because of larger diameter, this fiber allows many modes to propagate through it.





3. Graded Index multimode fiber –





It is a multimode fiber with a core consisting of concentric layers of different refractive indices. Therefore RI of the core decreases with distance the fiber axis. The RI profile & the modes of propagation.