PHY110 – ENGINEERING PHYSICS

UNIT 1. Electromagnetic theory *CA1- Lab@Home*

UNIT 2. Lasers and Applications

Class test 1 (CA2)

UNIT 3. Fiber optics

MTE- MCQ (Unit 1 to 3)

UNIT 4. Quantum mechanics

UNIT 5. Solid State Physics

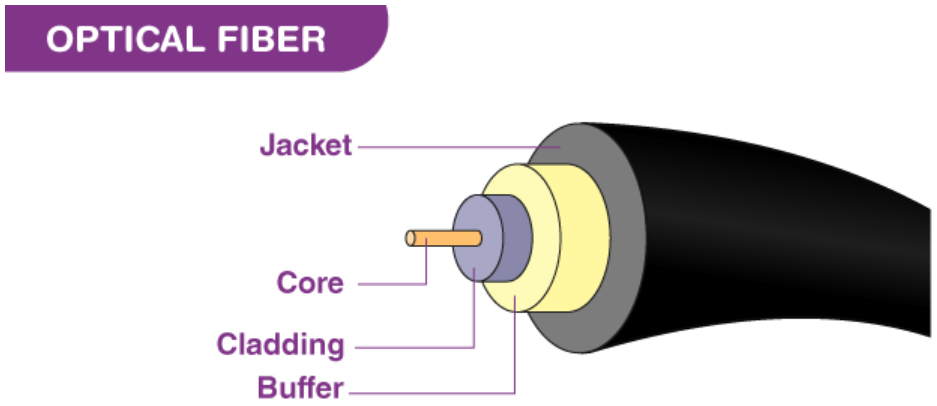
Class test 2 (CA3)

UNIT 6. Introduction to engineering materials

ETE- MCQ

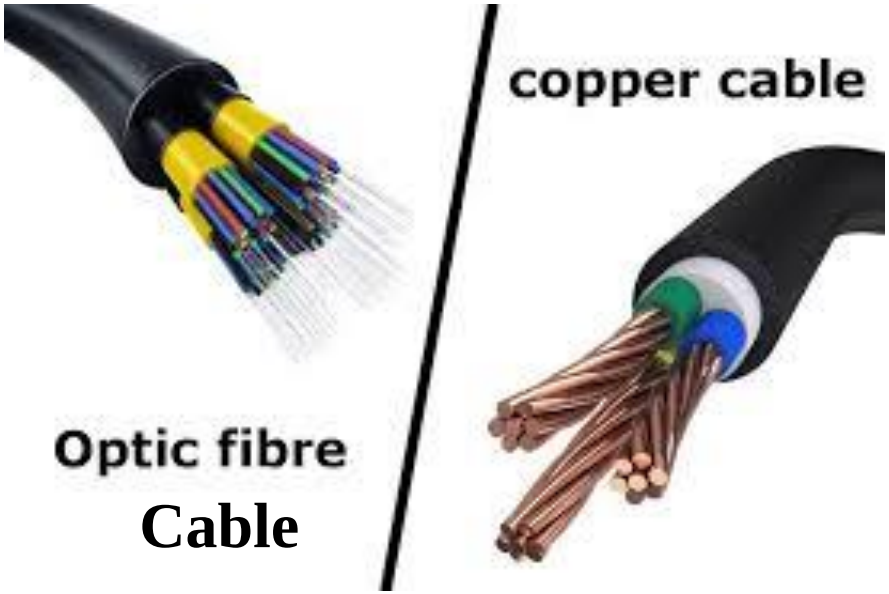
Unit 3: Fiber optics

Fiber optics introduction, optical fiber as a dielectric wave guide, total internal reflection, acceptance angle, numerical aperture, relative refractive index, V-number, step index and graded index fibers, losses associated with optical fibers.



PHY109 UNIT III: Fiber optics

LECTURE 1



1926-2020

The term '**fiber optics'** was coined by Indian-American physicist **Narinder Singh Kapany**, who is widely acknowledged as the father of fiber optics. He was awarded India's Second highest civilian award the **Padma Vibhushan in 2021**.

FIBER OPTICS

We can't live without the **INTERNET**, and hence we can't avoid **OPTICAL FIBER** ☺

How many km of fiber optic cables are used in LPU for networking ??

Do You Know

Lovely Professional University has 70 Km of fibre optic cable throughout the campus which acts as a backbone for the network.

Understand fiber optics and why they are important- We will learn in this UNIT III

https://www.youtube.com/watch?v=x3c1ih2NJEg

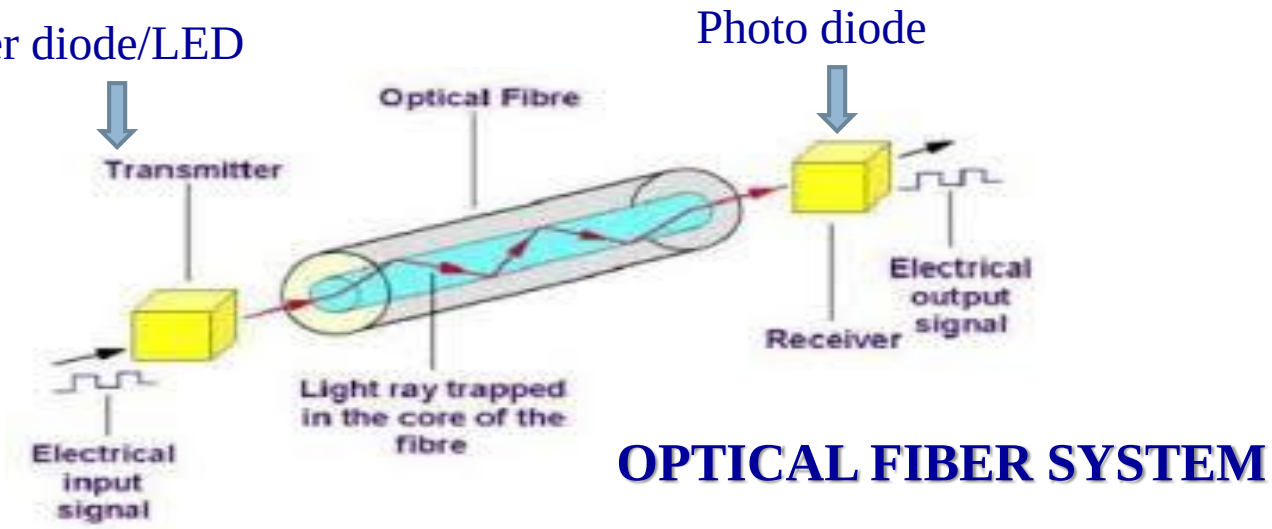
FIBER OPTICS

"Fiber optics is a technology in which electrical signal is converted to optical signals and transmitted through fibers and reconverted back into electrical signals"

1977- Commercial communication system based on Optical fibers came into existence based on the proposed information transmission over glass fiber by Charles Kao (**2009 Nobel Prize winner)** and George Hockham.

- LASER diode and LED revolutionized the communication sector, which was dominated by Microwave and Radio waves as the carrier waves for sending information..
- Use of light as carrier wave improved the bandwidth considerably

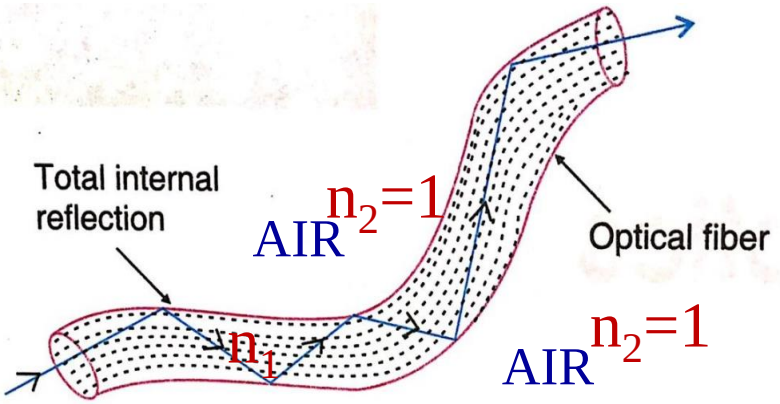
Optical Fiber System



"Fiber optics is a technology in which electrical signal is converted to optical signals and transmitted through fibers and reconverted back into electrical signals"

Optical Fiber

An **optical fiber** is a thin strand of **dielectric** material (glass or plastic) that can carry light from one end to the other,



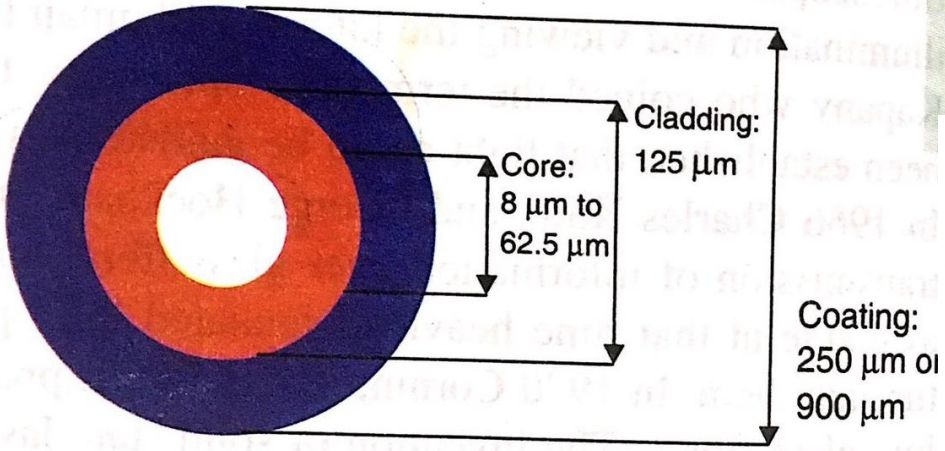
- Light undergoes total internal reflection ($n_1>n_2$)
- Zig-Zag path
- Launching /acceptance angle
- Small attenuation
- Will travel over the bends as well

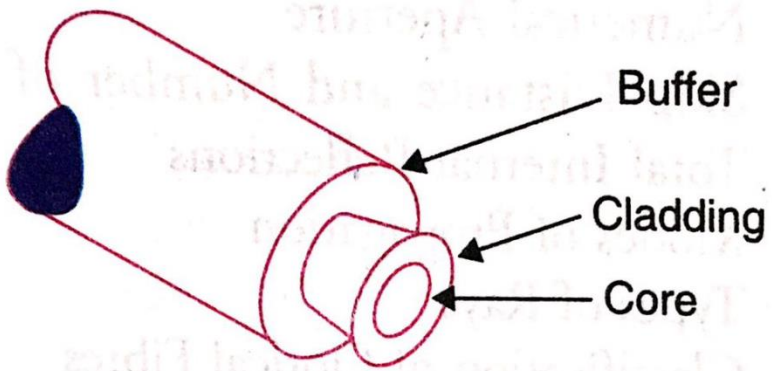
Thin strand of **dielectric** material we call fiber (*transmission of light*) *where as* if it is of **metal** we call it a wire (*transmission of electrical signal*)

Optical Fiber

Structure:

Human hair thickness ~ 100µm





1. Core - *Light guiding region*
2. Cladding- *confine the light to the core*
3. Buffer or Sheath - *protect the fiber from physical and environmental damage*

Functions of *'Cladding'* in Optical fiber

Why cladding is necessary?

i. *To maintain the uniformity along the length of the fiber*
   a) *Make the diameter of the core remain constant and ensure same medium around the core*

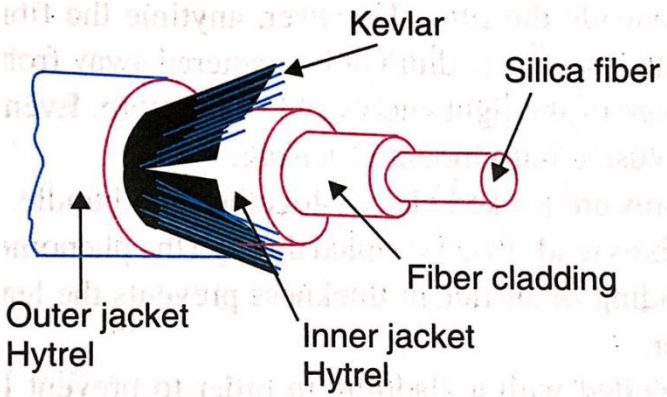
ii. *To protect the outer surface of the core*
   a) *Ensure a scratch and dust free core surface along with immunity for environmental changes and physical damage (chipping).. Loss reduced*
   b) *Easier to add other protective layers over the fiber*

iii. *To reduce the cone of the light*
   a) *Ensure higher bit rate of transmission*

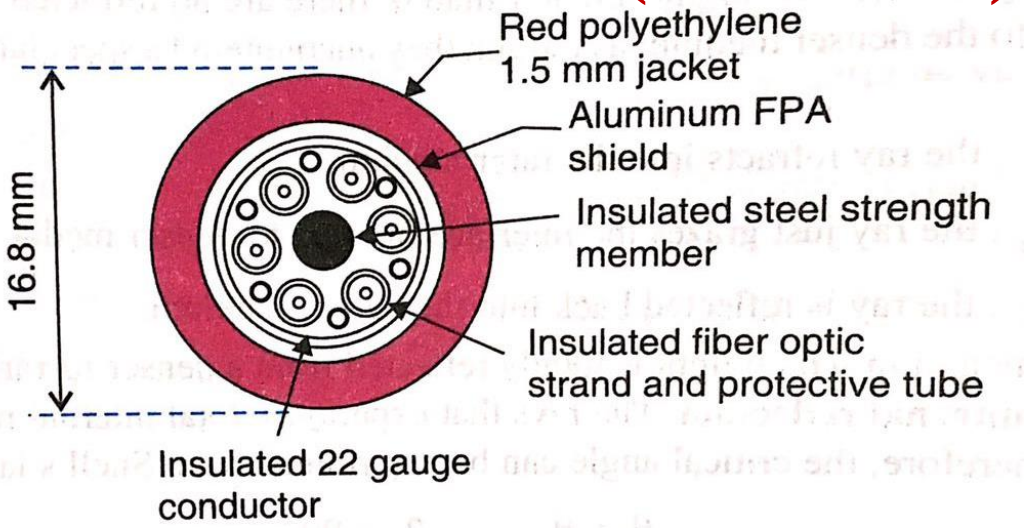
iv. *To confine light to the core*
   a) *Make sure the condition for total internal reflection always met along the length; maintain the signal strength*
   b) *Allows to pack the fibers in bundles by insulating it from other fibers in close proximity.*

OPTICAL FIBER CABLE

Single Fiber cable (side view)



Multi Fiber cable (cross section)

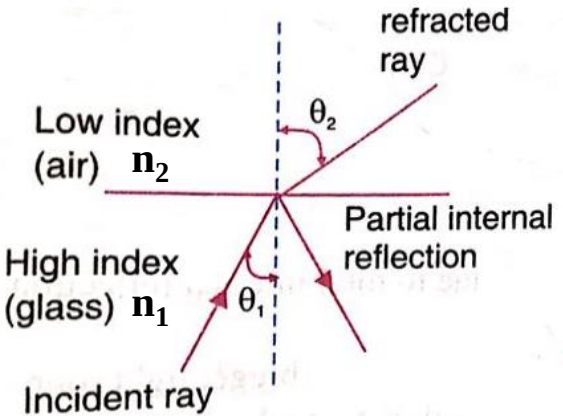


A Fiber optic telephone transmission can handle more than thousands of voice channels. True or false?

(a) True
(b) False

Ans: A

Total Internal Reflection



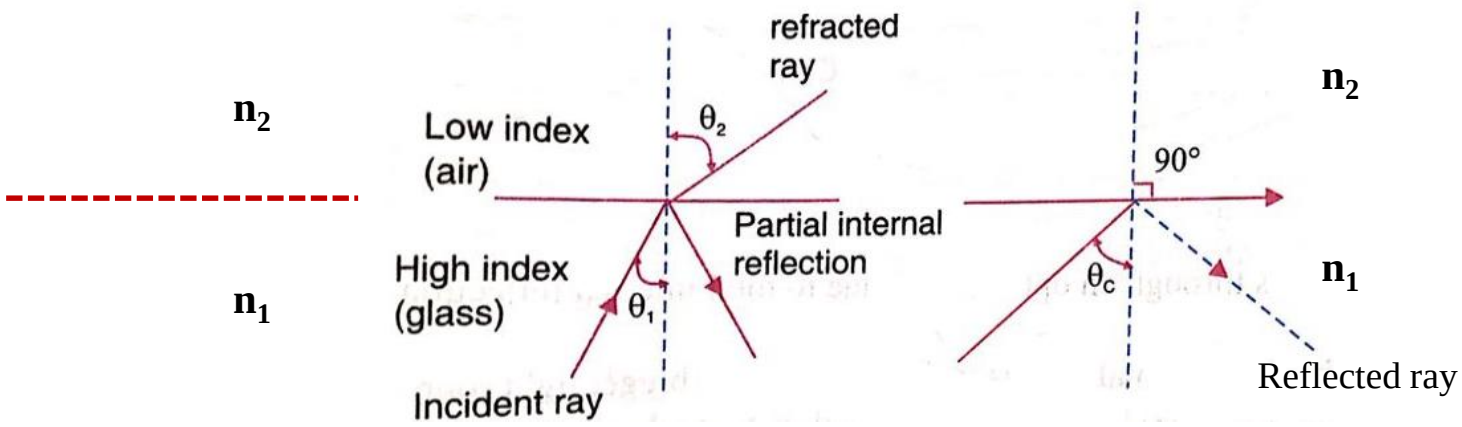
Rarer medium $n_2 < n_1$

Denser medium $n_1 > n_2$

$$\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$$ ---------- Eq.1

When a ray of light incident on the interface from a denser medium, the refracted ray bend away from the normal in the rarer medium. In that case the angle of incidence and refraction are related to refractive indices n_1 (denser medium) and n_2 (rarer medium) **through Snell's law**

Total Internal Reflection

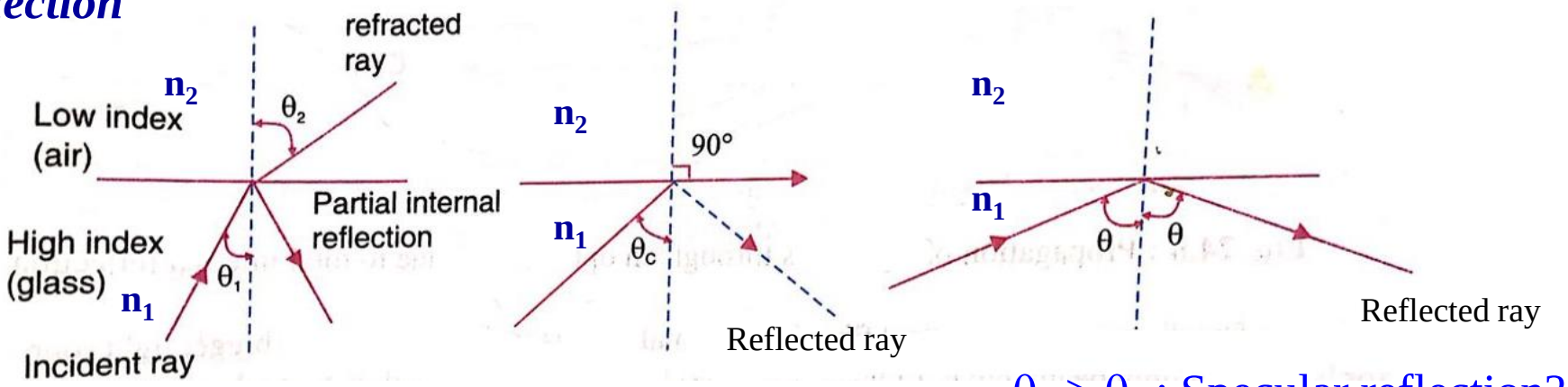


According to Eq.1, as incident angle (θ_1) increases refracted angle (θ_2) also increases

- ✓ Means refracted ray move more and more away from the normal
- ✓ When θ_1 becomes θ_c, (critical angle)refracted ray just glide the interface θ_2 =90°

Total Internal Reflection

In the third case, when incident angle $\theta_1 > \theta_c$ there is no refracted ray into rarer medium. The ray is reflected back to denser medium as if it encountered ***specular reflection***



$\theta_1 > \theta_c$; Specular reflection?

To summarize

i. $\theta_1 < \theta_c$, Ray of light refract to rarer medium

ii. $\theta_1 = \theta_c$ Ray of light grazes the interface of rare-denser medium

iii. $\theta_1 > \theta_c$, Ray of light totally reflect back into denser medium


Core
Cladding

What is the principle of fiber optical communication?

a) Frequency modulation
b) Population inversion
c) Total internal reflection
d) Doppler Effect

Ans: C

Snell's law describes

a) Interference
b) Diffraction
c) Refraction
d) Reflection

Ans: C

The core of an optical fiber has a

a. Lower refracted index than air
b. Lower refractive index than the cladding
c. Higher refractive index than the cladding
d. Similar refractive index with the cladding

Ans: C