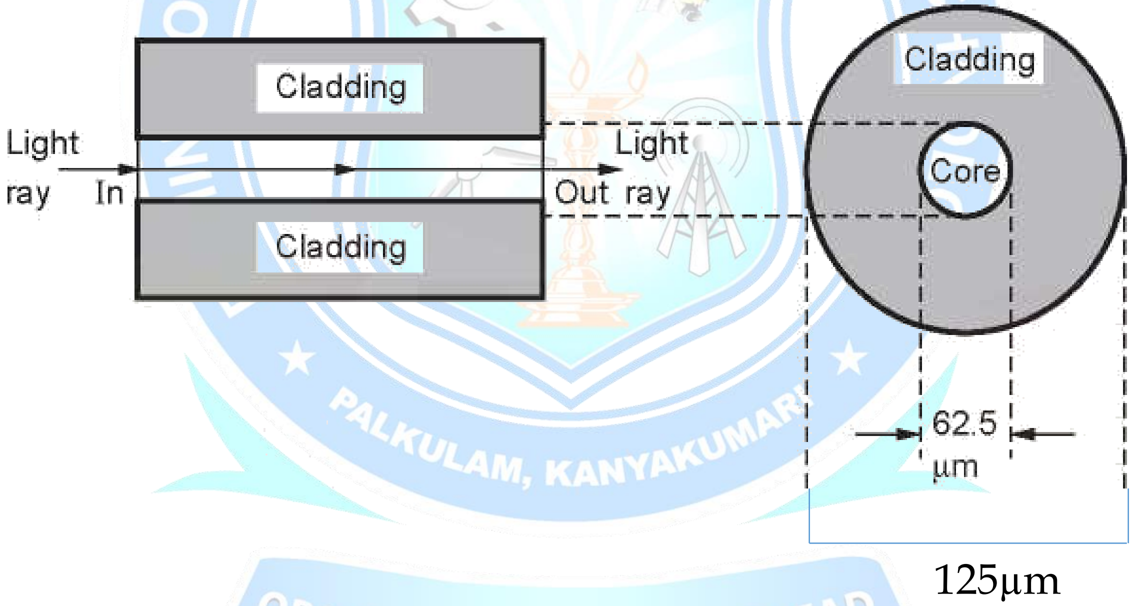
1.4 Mode Analysis for Optical Propagation Through Fibers

- To understand the general nature of light wave propagation in optical fiber. We first consider the construction of optical fiber.
- The innermost is the glass core of very thin diameter with refractive index of n_1.
- The glass core is surrounded by a cladding material with a slight lower refractive index n_2 .
- The light wave can propagate along such a optical fiber.
- A single mode propagation is illustrated in Figure along with standard size of fiber.
- Single mode fibers are capable of carrying only one signal of a specific wavelength.
- In multimode propagation the light propagates along the fiber in zigzag fashion, provided it can undergo Total Internal Reflection (TIR) at the core cladding boundaries.
- Total internal reflection at the fiber wall can occur only if two conditions are satisfied.



Condition 1 :

- The index of refraction of glass fiber must be slightly greater than the index of refraction of material surrounding the fiber (cladding).

  If refractive index of glass fiber = n_1

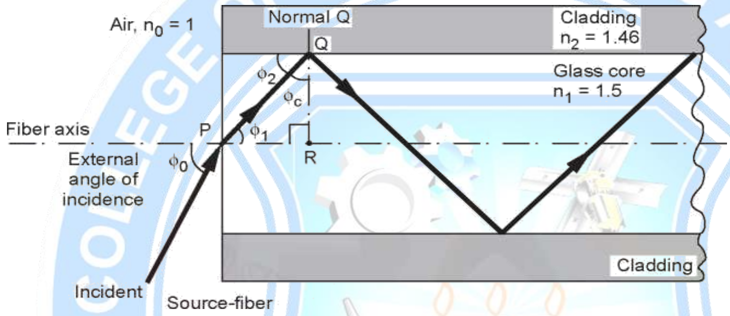
  and refractive index of cladding = n_2

  then $n_1 > n_2$

Condition 2 : The angle of incidence (φ_1) of light ray must be greater than critical angle (φ_c).

- A light beam is focused at one end of cable. The light enters the fibers at different angles.

- Figure shows the condition exist at the launching end of optic fiber. The light source is surrounded by air and the refractive index of air is n_0= 1.
- Let the incident ray makes an angle φ_0 with fiber axis.
- The ray enters into glass fiber at point P making refracted angle φ_1 to the fiber axis, the ray is then propagated diagonally down the core and reflect from the core wall at point Q.
- When the light ray reflects off the inner surface, the angle of incidence is equal to the angle of reflection, which is greater than critical angle.



- In order for a ray of light to propagate down the cable, it must strike the core cladding interface at an angle that is greater than critical angle (φ_c)

Accepting Angle (φ_0)

- Applying Snell's law to external incidence angle.

$$n_0 \sin \emptyset_0 = n_1 \sin \emptyset_1$$

- The maximum value of external incidence angle for which light will propagate in the fiber.

$$\emptyset_0(max) = sin^{-1}[\frac{\sqrt{n_1^2 - n_2^2}}{n_0}]$$