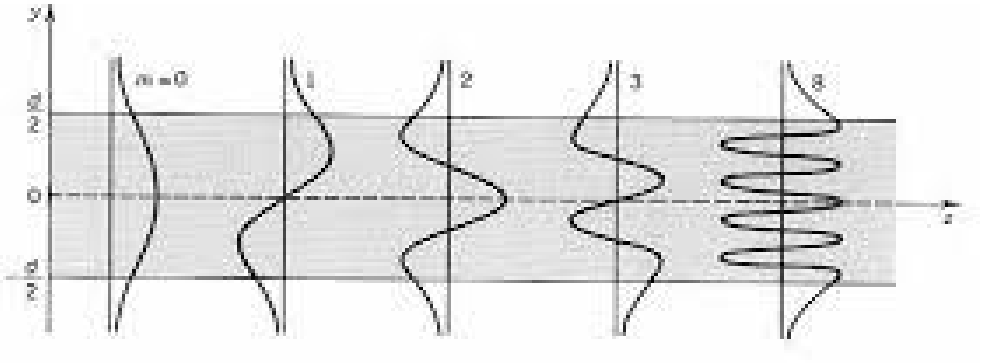
OPTICAL FIBERS **WAVEGUIDE-I**

Guided Modes in a Planar Waveguide



m: Mode order

Only discrete values of are allowed in a waveguide

Optical Fiber Waveguide

- To understand transmission mechanisms of optical fibers with dimensions approximating to those of a human hair;
  - Necessary to consider the optical waveguiding of a cylindrical glass fiber.

- Fiber acts as an open optical waveguide – may be analyzed using simple ray theory – **Geometric Optics**
  - Not sufficient when considering all types of optical fibers

- **Electromagnetic Mode Theory** for Complete Picture

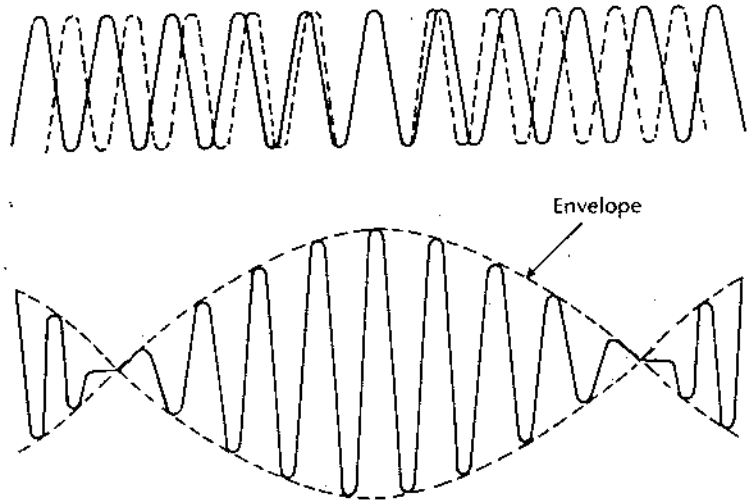
Phase and Group Velocity

- **Phase Velocity**: For plane wave, there are points of constant phase, these constant phase points forms a surface, referred to as a **wavefront**.
  - ➢ As light wave propagate along a waveguide in the z-direction, wavefront travel at a phase velocity ; $v_p = \omega/\beta$

- Non-monochromaticity leads to group of waves with closely similar frequencies – **Wave Packet**

  Wave packet observed to move at a group velocity, $v_g = \delta\omega/\delta\beta$

❖ **V_g is of great importance in study of TCs of optical fibers as it relates to the propagation characteristics of observable wave groups**



Formation of wave packet from combination of two waves of nearly equal frequencies

Group Velocity

- Considering propagation in an infinite medium of R.I. n_1,

Propagation constant : $$\beta = n_1 k = n_1 \frac{2\pi}{\lambda} = n_1 \frac{\omega}{c}$$

Phase velocity : $$v_p = \frac{c}{n_1}$$

Group velocity : $$v_g = \frac{c}{\left(n_1 - \lambda \frac{dn_1}{d\lambda} \right)} = \frac{c}{N_g}$$

- Parameter N_g is known as the ***group index*** of the guide

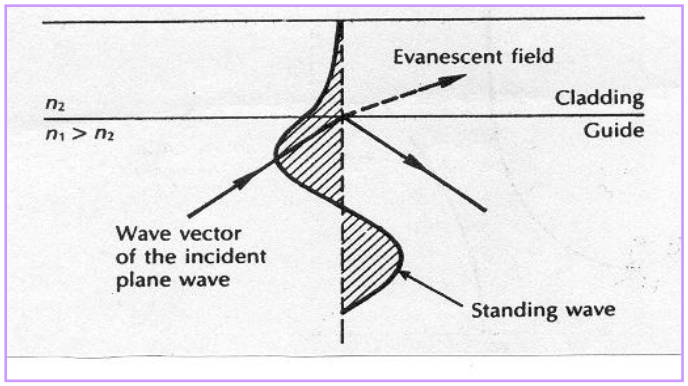
Evanescent Field

- Another phenomenon of interest under conditions of TIR is the form of the electric field in the cladding of the guide.

The transmitted wave field in the cladding is of the form

$$B = B_0 \exp(-\xi_2 x)\exp j(\omega t - \beta z)$$

The amplitude of the field in the cladding is observed to decay exponentially in the x-direction.- ***Evanescent Field***



Exponentially decaying evanescent field in the cladding

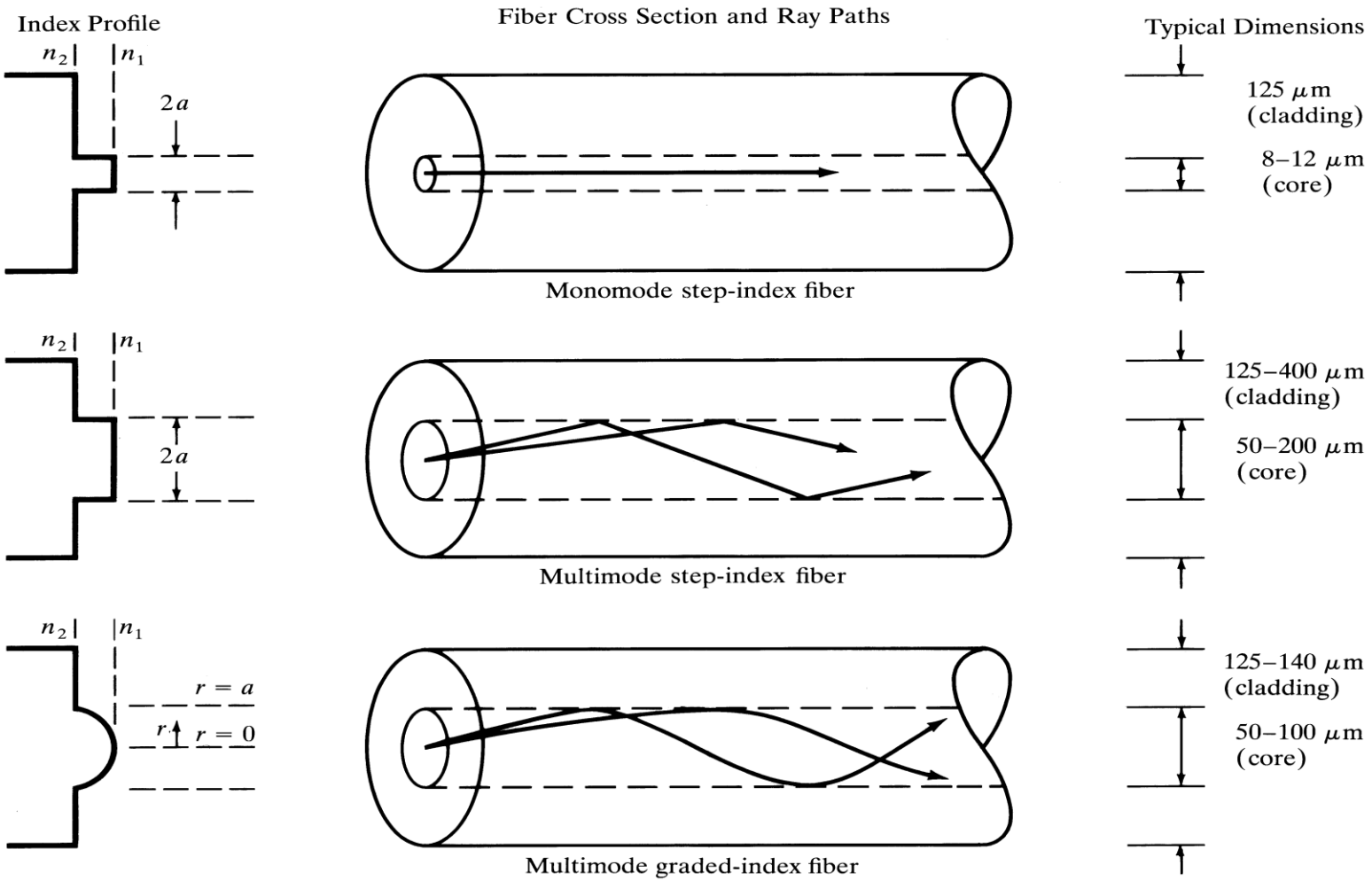
- A field of this type stores energy and transports it in the direction of propagation (z) but does not transport energy in the transverse direction (x).
- Indicates that optical energy is transmitted into the cladding.

Cladding Material

- **The evanescent field gives rise to the following requirements for the choice of cladding material**
  - The cladding should be transparent to light at the wavelengths over which the guide is to operate.
  - Ideally, the cladding should consist of a solid material in order to avoid both damage to the guide and the accumulation of foreign matter on the guide walls.
  - The cladding thickness must be sufficient to allow the evanescent field to decay to a low value or losses from the penetrating energy may be encountered.

- Therefore, the most widely used optical fibers consist of a core and cladding, both made of glass. Although, it give a lower NA for fiber, but provides a far more practical solution.

Step Index / Graded Index fiber



THANK YOU