01-05-2023

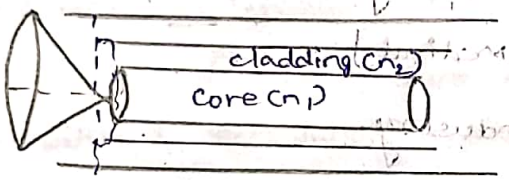
4. HOLOGRAPHY AND OPTICAL FIBERS.

* Optical Fibre :-

→ It is a 'silica metal' [obtained from sand].
→ It is 'Low cost'.
→ 'Bandwidth' is more.
→ It is 'high speed'.
→ We can send signals for 'longer distances'.
→ It contains 'Low loss' & 'No Radiation loss'.
→ It contains 'high security' than copper.
→ It is 'Atmospheric Ineffective'.

* Basic principle :-

→ The basic principle behinds optical Fibre is "Total Internal Reflection".

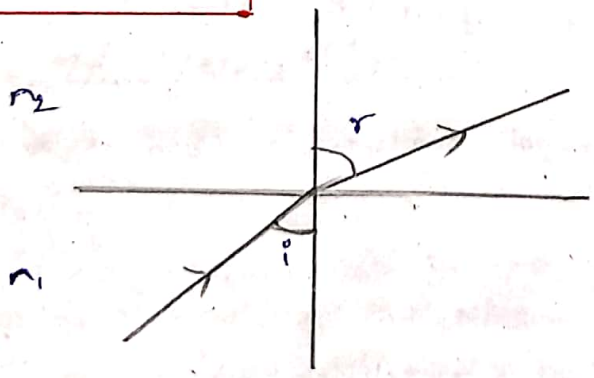


$n_{core} > n_{cladding}$

→ The Basic principle behind 'T.I.R' is 'Snell's Law'.

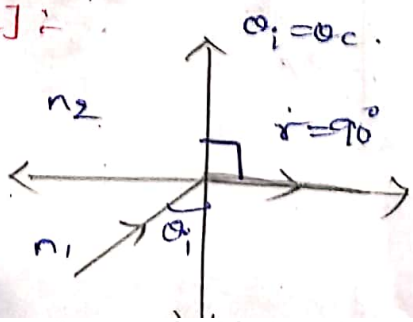
* Snell's Law :-

$$n_1 \sin i = n_2 \sin r.$$



* Total Internal Reflection [T.I.R] :-

→ Two conditions.
① 'Denser to Rarer'.
② '$\theta_i > \theta_{critical}$'



$\Rightarrow n_1 \sin\theta_i = n_2 \sin 90^\circ \quad [n_1 > n_2]$

$\Rightarrow \sin\theta_i = \frac{n_2}{n_1} \quad (1)$

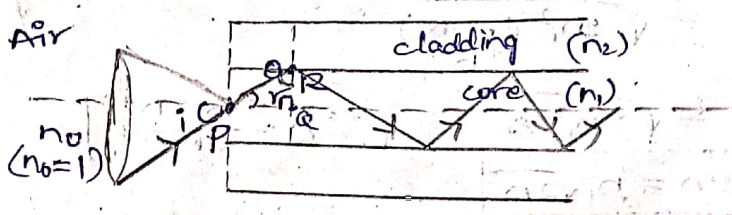
$\Rightarrow \boxed{\sin\theta_c = \frac{n_2}{n_1}}$

$\therefore \boxed{\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)}$

$\therefore \boxed{\text{critical angle} = \sin^{-1}\left(\frac{\text{cladding } (n_2)}{\text{core } (n_1)}\right)}$ $\frac{\text{lower value}}{\text{Higher value}}$

* Acceptance Angle :

→ The angle of which we are passing light must be inside the cone. [acceptance cone].



At P, No Total Internal Reflection occurs [Rarer to Denser].

Now, $n_0 \sin i = n_1 \sin r$

$\Rightarrow n_0 \sin i = n_1 \sin(90 - \theta_i)$

$\Rightarrow n_0 \sin i = n_1 \cos\theta_i$

$\Rightarrow n_0 \sin i = n_1 \sqrt{1 - \sin^2\theta_i}$

For maximum limit, "$i = i_{max}$", "$\theta_i = \theta_c$".

$\Rightarrow n_0 \sin i_{max} = n_1 \sqrt{1 - \sin^2\theta_c}$

$\Rightarrow n_0 \sin i_{max} = n_1 \sqrt{1 - \frac{n_2^2}{n_1^2}} \quad [\because \sin\theta_c = \frac{n_2}{n_1}]$

$\Rightarrow n_0 \sin i_{max} = n_1 \sqrt{\frac{n_1^2 - n_2^2}{n_1^2}}$

$\Rightarrow n_0 \sin i_{max} = \frac{n_1}{n_1}\sqrt{n_1^2 - n_2^2}$

$\Rightarrow \sin i_{max} = \frac{\sqrt{n_1^2 - n_2^2}}{n_0} = \sqrt{n_1^2 - n_2^2} \quad [\because \text{For air, } n_0 = 1]$

$\therefore \boxed{i_{max} = \sin^{-1}\sqrt{n_1^2 - n_2^2}}$, Acceptance angle.

* Numerical Aperture :-

→ The ability of the optical fiber cable to absorb the input [Light] is called "Numerical Aperture".

$$\therefore \boxed{NA = \sin i_{max} = \sqrt{n_1^2 - n_2^2}}$$

→ 'Numerical aperture' is different for different type of optical fibers.

→ We can also write the formula as,

$$NA = \sin i_{max} = \sqrt{n_1^2 - n_2^2}$$

$$= \sqrt{(n_1+n_2)(n_1-n_2)}$$

$$= \sqrt{(2n_1)(n_1-n_2)} \quad [\text{If } n_1 = n_2 \text{ only for addition.}]$$

$$= \sqrt{2n_1^2 \frac{(n_1-n_2)}{n_1}}$$

$$= \sqrt{2n_1^2 \Delta} \quad \left[\because \Delta = \frac{n_1-n_2}{n_1}\right]$$

$$\therefore \boxed{N.A = n_1\sqrt{2\Delta}}$$

* Mode :- optical fibre cable.

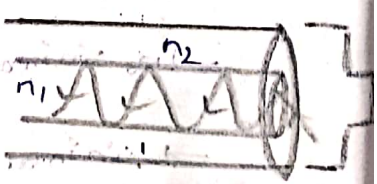
* Carrier :- Laser Light.

* Types of optical Fibers :-

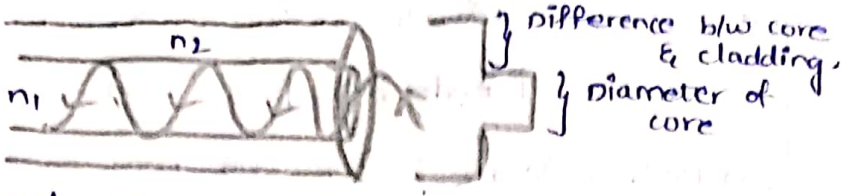
1. Single Mode step Index (SMSI)
2. Multi Mode step Index.
3. Graded Mode.

* step Index :-

1. It gives information about,
   - (i) Refractive Index difference.
   - (ii) Geometry of optical Fiber.
   - (iii) Uniformity.

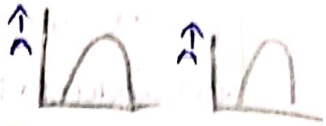


① Single Mode step Index :



→ We can send single signal.

→ The output signal is very Accurate.



→ Numerical aperture & appeptance angles are small.

→ Used for long distance communication.

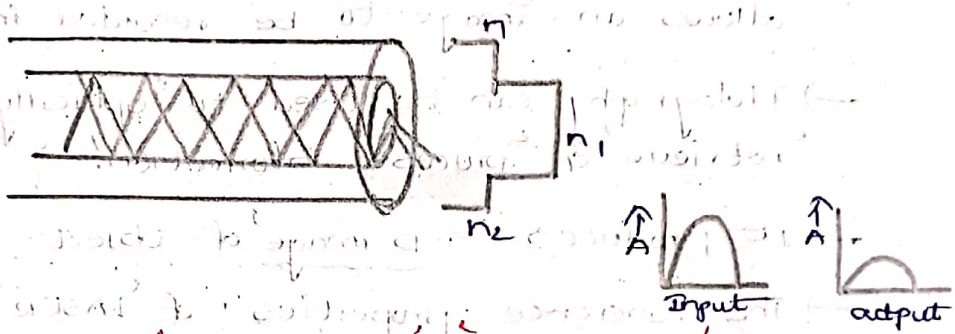
Demerits:

→ Diameter of core is small.

→ It is difficult to manufacture.

→ It is very costly.

② Multi Mode step Index :



→ We can send more signals / Multi signals.

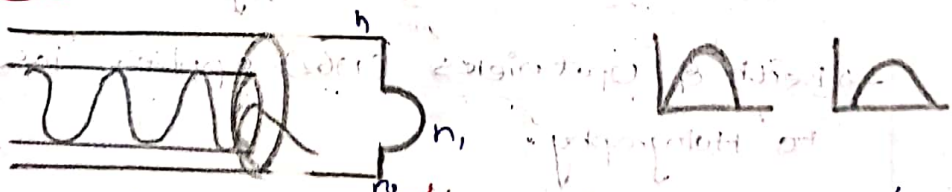
→ cost is very Low.

Demerits:

→ It sends signal for shorter distances only.

→ Due to Multi signals, it is not perfect. [Not Accurate

③ Graded Mode :



→ Cladding's refractive index is uniform but core's refractive index is not uniform.

→ It's wave is sinusoidal and parabolic shape.

→ It has very high speed.

* Applications of optical Fibers :

1. communications.
2. Medical [Endoscopy].
3. Researches
4. Decorations.
5. Industrial.
6. Used as sensors.

Holography

* Holography :-

→ It is a Greek word, (Whole + write).
'Holes - whole' and 'Gramma - message'.

→ It is an advanced form of photography that allows an Image to be recorded in 3-dimensions

→ Holography can be used to 'optically store', 'retrieve' & 'process information'.

→ It produces '3-D image' of object.

→ The coherence properties of 'LASER' are employed to record the image of an object in the form of 'Interference' pattern called 'Hologram'.

→ In holography, Both 'amplitude' & 'phase' information are recorded as hologram.

→ It was invented in 1948 by 'Dennis Gabor' for use in Electron microscopy, before 'Laser'.

→ 'Leith' & 'Upatnieks' (1962) applied 'laser light' to 'Holography'.

* Photography :-

→ 2-D version of a 3-D scene.

→ photograph lacks depth perception.

→ Film sensitive only to radiant energy.

→ Phase relation [Interference] are lost.

→ It has only amplitude information.

* Hologram :-

→ Freezes the intricate wave front of light that carries all visual information of the scene.

→ To view Hologram, wave front is reconstructed.

→ provides depth perception.

→ If any object is hidden just behind another object then observer can see the hidden object in viewing the Hologram.

→ Hologram is positive pattern whereas in conventional photography negative pattern produced.

* → Photography vs Holography :-

Photography	Holography
① Each region contains separate part of object.	① Each part of Hologram contains information about entire object.
② Information holding capacity is Low.	② Information holding capacity is High.
③ only one image can be recorded at one place	③ More than one image can be recorded in a single Hologram.
④ Destruction of any part of image results in complete loss of information	④ Destruction of any part of hologram doesn't lose information of object.
⑤ Single fragment is not enough to produce image.	⑤ Single fragment is enough to produce entire image.
⑥ Less Realistic.	⑥ More Realistic.

* Principle of Holography:-

→ It is based on phenomena of interference blw two beams i.e object beam & reference beam

→ Laser light splits into two :-

① Object beam :- reaches photographic plate after reflection.

② Reference beam :- Falls on a plane mirror which reflects it towards photographic plate.

→ Both reference & object beams having information of amplitude & phase of light wave interfere & produce a complete interference pattern

→ This pattern is recorded on photographic plate which is called Hologram.

→ one can produce 3-D image exactly as object from this Hologram.

* Hologram properties :-

→ We can observe different perspectives of object with different angles.

→ They look like sparkly pictures or smears of color.

→ Each part contains whole view of entire holographic image.

* Hologram construction :-

① Laser :- we can use Red Lasers, HeNe Lasers

② Beam splitter :- It uses mirrors & prisms to split one beam of light in to 2.

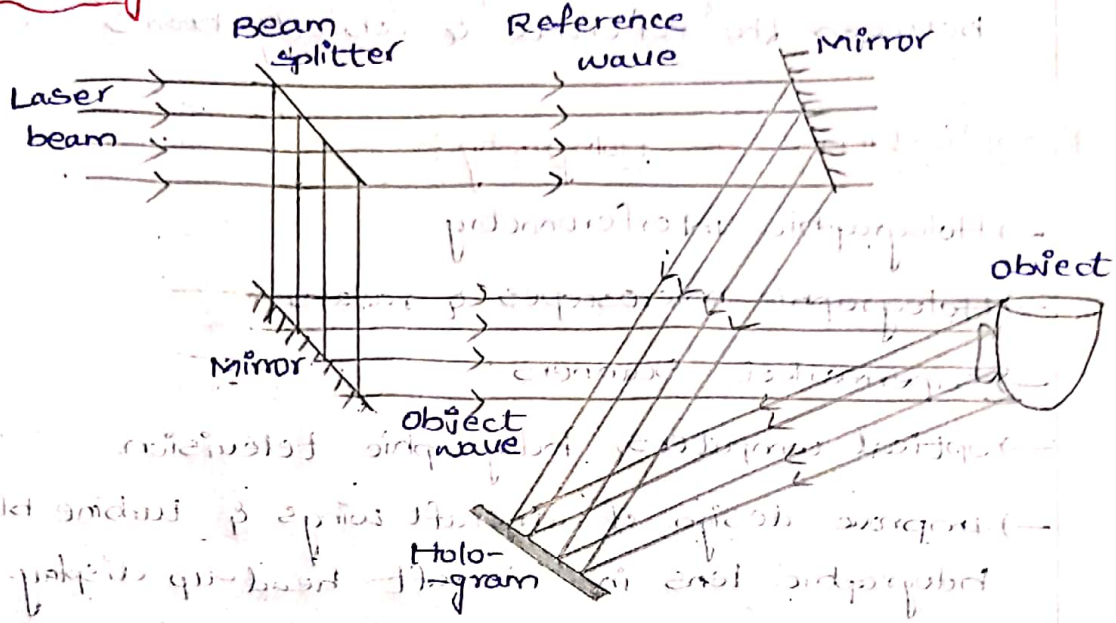
③ Mirrors :- Direct the beams to correct location

④ Holographic film :- It's a layer of light-sensitive compounds on a transparent surface like photographic film.

→ Need a 'Laser' [Highly coherent, & monochramatic], 'Lenses' 'mirror' 'photographic film' & 'object'.

*** → Same points as principle of Holography. ***

Working:-



*** Same points under as principle of Holography ***

* Reconstruction of image from Hologram

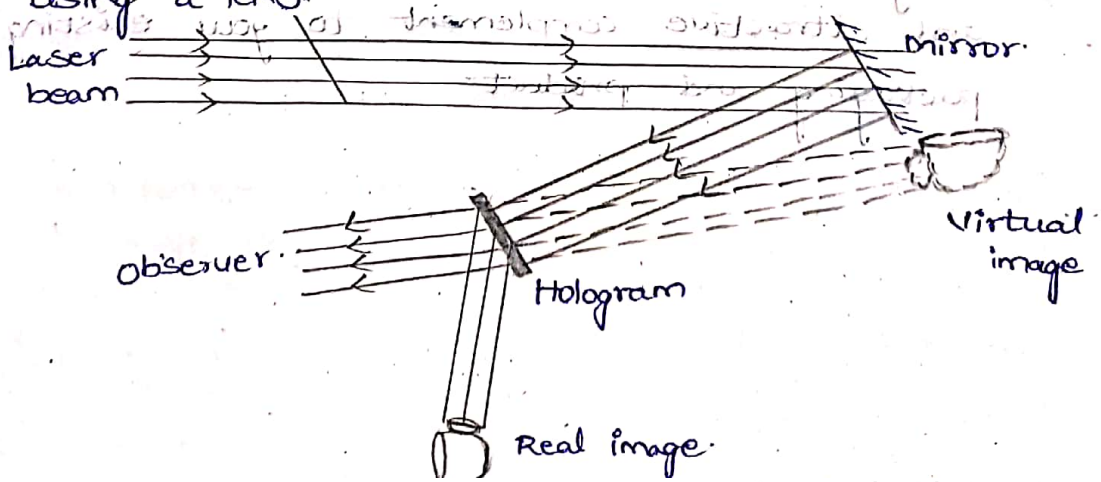
→ To view image, Hologram is again illuminated with another laser beam called "Reconstruction beam" which is at same angle as reference beam.

→ Hologram acts as diffraction grating.

→ This form a real image infront of Hologram & a virtual image behind Hologram.

→ The virtual image has all the characteristics of object.

The real image can be photographed directly without using a lens.



* Why we use Laser in Holography?

→ Lasers produce monochromatic light (it has one wavelength & one colour).

→ Because of the need for 'coherent interference' between the 'reference' & 'object beams'

* Applications of Holography:

→ Holographic Interferometry.

→ Holographic microscopes & radars.

→ supermarket scanners.

→ optical computers, holographic television.

→ Improve design of aircraft wings & turbine blades, holographic lens in aircraft head-up display.

→ Data storage.

→ Art

→ Medical applications or biomedicine.

→ Authentication

→ virtual Display.

* Why we use Hologram for Authentication?

→ Hologram stickers cannot be scanned or photocopied.

→ Hologram stickers can also create a unique and attractive complement to your existing packaging and product