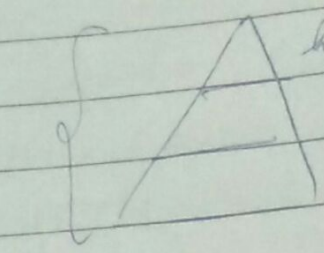
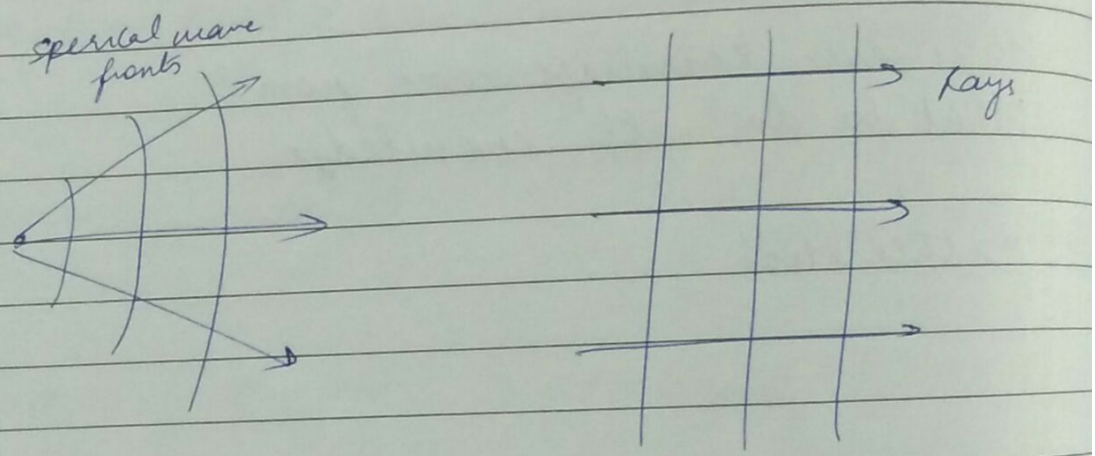
Engineering Management → ultimately to make



The need for management

Organisation :- like minded
A group of people coming together to perform
a particular function / goal is called
an organisation

OFC



Multiple rays are superimposed and seat in OF
* All rays don't enter at the same time
* All rays don't have the same speed & propa

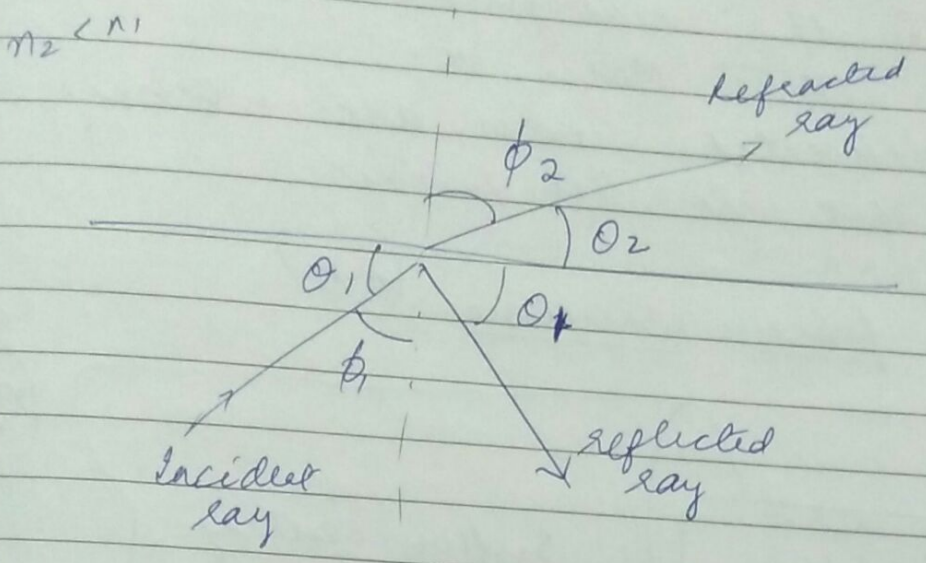
Basic optics

Basic optical laws and definitions
* Refractive index
* Reflection and refraction
* Polarization
* -"- scrasline materials

(another approach : EFT)

Refraction and reflection

'RAY OPTIC APPROACH'



'Law of reflection'

Snell's law $n_1 \sin\phi_1 = n_2 \sin\phi_2$

* Optical fibre modes and configurations

* Fibres types

* An optical fibre is a dielectric waveguide that operates at optical frequencies

* This fibre waveguide is normally cylindrical in form.

* It confines EM energy in the form of light to within surfaces and guides the light in the direction ||el to its axis

* Information carrying capacity

no of 'd' ∝ capacity of fibre

Ex: 1x, 2x, 3x - - -

* The propagation of light energy along a waveguide can be described in terms of a set of guided EM waves called the modes of the waveguide

Modes: TEM, TE Modes, etc.

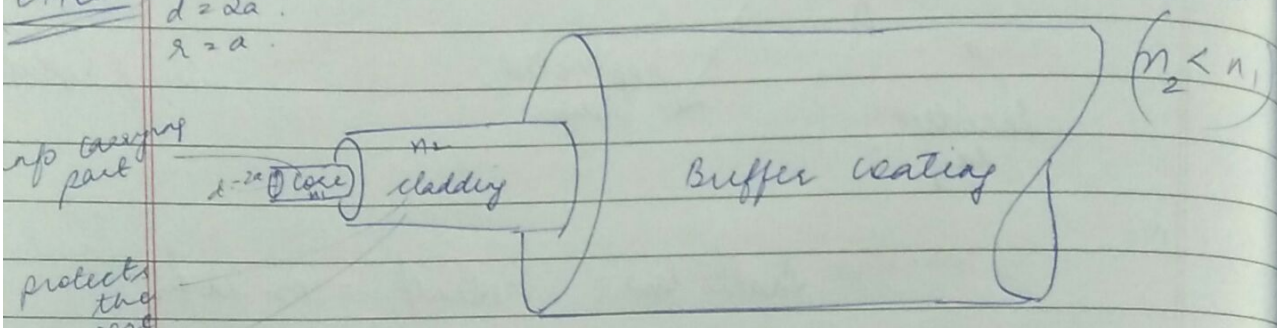
only dedicated modes are working here (Modes that are ⊥el to axis

* (**) Single fiber structure

EXPECTED

$d = 2a$

$r = a$



- These guided modes are referred to as the bound or trapped modes of the waveguide

- Radius, a and index of refraction n_1 of core

- Solid dielectric cladding having index of refraction n_2; $n_2 < n_1$

* ∪ Advantages of cladding

① Reduces scattering loss

② Mechanical strength to fibre

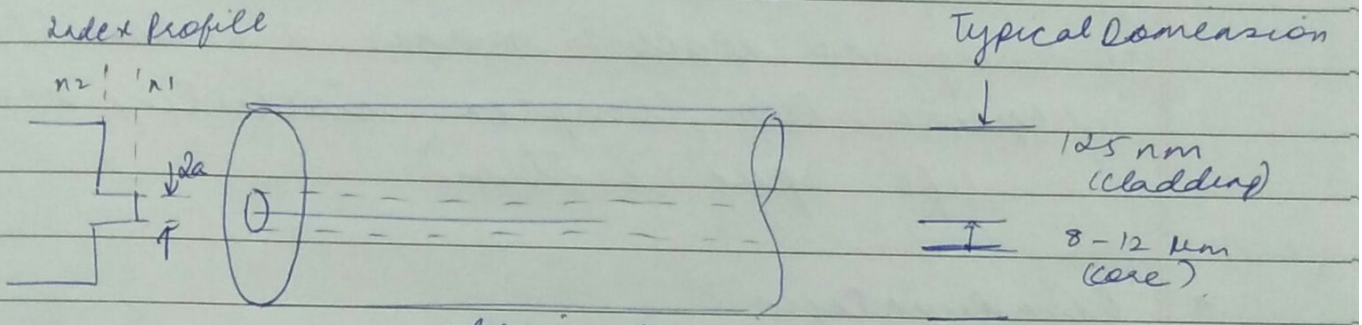
③ It protects the core from ~~absorption~~ absorbing surface contaminants.

1 nm 10^{-9} m

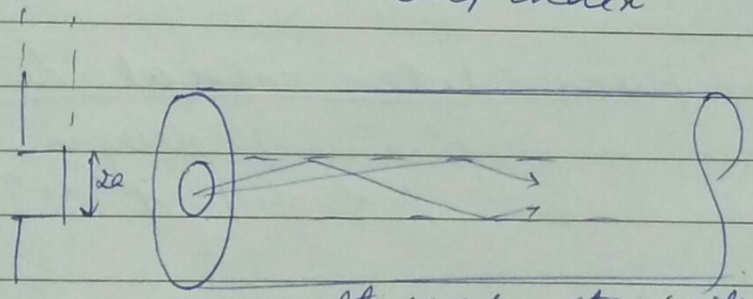
Variations in the material composition of the core gives rise to the two commonly used fibre types

* Fibre Types :- → Single mode
→ multi

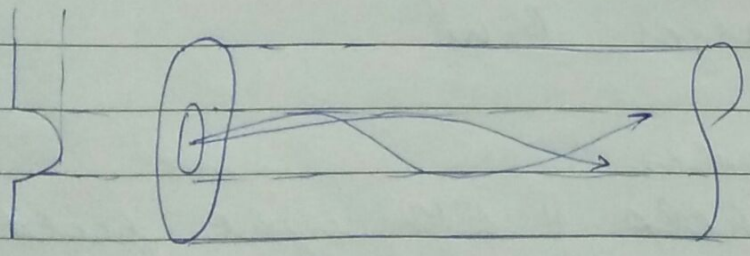
① Step index Fibre: Refractive index of the core is uniform throughout and undergoes an abrupt change (or step) at the cladding boundary



step index



multi mode step index



multi mode graded index

② Graded index fiber: the core refractive index is made to vary as a fn of the radial distance from the centre of the fibre

① Laser diode → single
② LED. → ps multimode

have further classification

Advantage of multimode fibre

① Larger core radii leads to launch better optical power and easily connecting together similar fibers.
② Light can be launched using LED source whereas in single mode, laser diode.
③ LED have less optical power when compared to laser diode
④ They are easier to make, are less expensive, require less complex circuiting and life span (better).

* Disadvantages :-

They suffer from later modal dispersion
because of delay in starting and diff speeds of pulse

It can be reduced in graded index fiber, because larger B.W.

* Rays and modes :
with the help of EM light field; along an optical fiber can be a superposition of bound or trapped modes
$e^{j(\omega t - \beta z)}$ EM means modely
For guided modes β can be ——

core $\lambda >> \lambda$

Ray-tracing approach provides a good approximation to the light acceptance and guiding properties of optical fibers
↳ when the ratio of the fiber radius to the wavelength is large

small λ limit

adv Direct phy interpretation of the light propagation characteristics in an optical fiber.

** (EXPECTED) Any plane wave can associate a light ray which is $\perp^r$ to the plane phase front of the wave, then family of plane waves corresponding to a particular mode forms a set rays called a "ray congruence".

Each of these ray travells along a fiber axis

* Step Index Fiber structure :-

Step index fiber the core of radius a has a refractive index n_1, which is typical close to 1.48

core surrounded by a cladding of slightly lower index n_2, where

$$n_2 = n_1(1-\Delta)$$

The parameter Δ is called the core-cladding index difference or index difference

n_2 chosen such that Δ is nominally 0.01

for multimode: 1 to 3 %.
single mode: 0.2 to 1.0 %.

Since core index n_1 > cladding index n_2

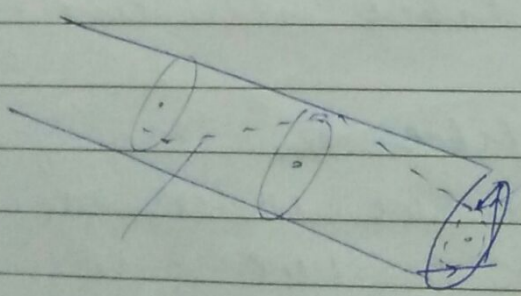
EM energy at optical freq is made to propagate along the fiber waveguide through internal reflection at the core-cladding interface

* Ray optics representation

2 types of rays that can propagate in a fiber are

① Meridional rays → carry info
② Skew rays → does not carry info
→ not passing center of axis → helical path

Skew rays :-



ray path projected on fiber end face

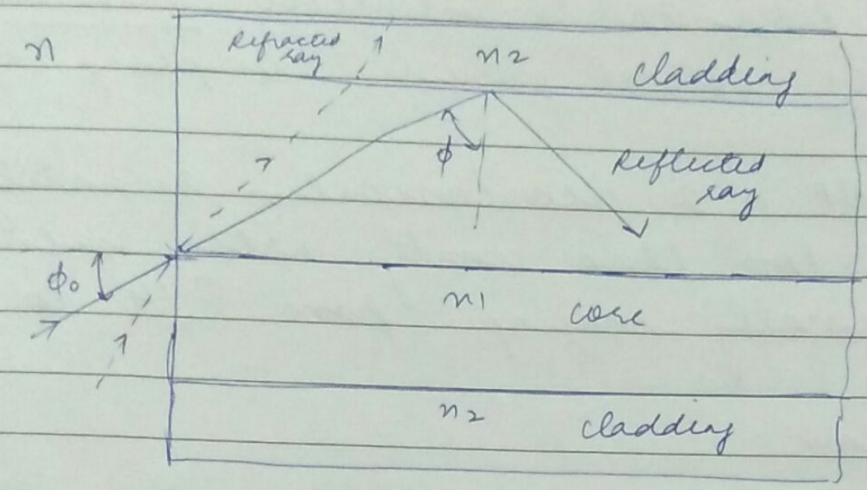
angle of incidence = b/w core & clad

acceptance = b/w outside & core space

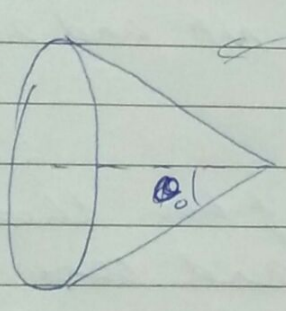
classmate Date Page

optical waveguide by TIR :-

Dielectric Slab waveguide



Propagation mechanism in an ideal step index optical waveguide



$\sin\phi_c = \frac{n_2}{n_1}$ (Snell's law, for total internal reflection)

θ_0 = angle of acceptance.

from fig, $n \sin\theta_{0max} = n \sin\theta_A$

$= n_1 \sin\theta_c$

$= (n_1^2 - n_2^2)^{1/2}$

$=$ (NA → Numerical aperture

where $\theta_c = \frac{\pi}{2} - \phi_c$ (assume)

$\therefore \boxed{NA = n \sin\theta_A}$

$n = 1$ (air)

$\therefore \boxed{NA = \sin\theta_A}$

$\boxed{NA \approx n_1\sqrt{2\Delta}}$

Air to fiber = air to core

* NA is related to the acceptance angle it is commonly used to describe the light acceptance or gathering capability of a fiber and to calculate source to fiber optical power coupling efficiencies

* The NA is a dimensionless quantity, which is less than unity with values normally ranging from 0.14 to 0.5.

Problems

① Consider a multimode Silica fiber that has a core refractive index $n_1 = 1.48$ and cladding index $n_2 = 1.46$. Find critical angle, NA and acceptance angle.

② Consider a multimode fiber that has a core R.I of 1.48 and core cladding index difference is 2%. Find NA, acceptance angle, critical angle.

1. Given
$n_1 = 1.48$ $n_2 = 1.46$

To find: critical angle, NA, θ_0

$$\phi_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = 80.57^\circ = \text{critical angle}$$

$$NA = n_1 \sin\theta_c = n_1 \sin(90 - \phi_c)$$
$$= 1.48 \sin(9.43^\circ)$$
$$= 0.242$$

or $NA = (n_1^2 - n_2^2)^{1/2} = \sqrt{(1.48^2 - 1.46^2)} = 0.242$

acceptance angle $= \theta_A$

WKT $N_A = n \sin\theta_A$

$n = 1$ (air)

$\therefore \theta_A = \sin^{-1}(N_A)$

$\boxed{\theta_A = 14}$

Given $n_1 = 1.48$

$\Delta = 2$

$N_A = n_1\sqrt{2\Delta}$

$= 1.48\sqrt{\frac{2(2)}{100}}$

$\boxed{N_A = 0.296}$

$n_2 = n_1(1-\Delta)$

$= 1.48\left(1-\frac{2}{100}\right)$

$\boxed{n_2 = 1.4504}$

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

$\boxed{\theta_c = 78.52^\circ}$

$N_A = \sqrt{n_1^2 - n_2^2}$

$\boxed{N_A = 0.296}$

$\theta_A = \sin^{-1}(NA)$

$\boxed{\theta_A = 17.218^\circ}$