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Subject : Optical Communication

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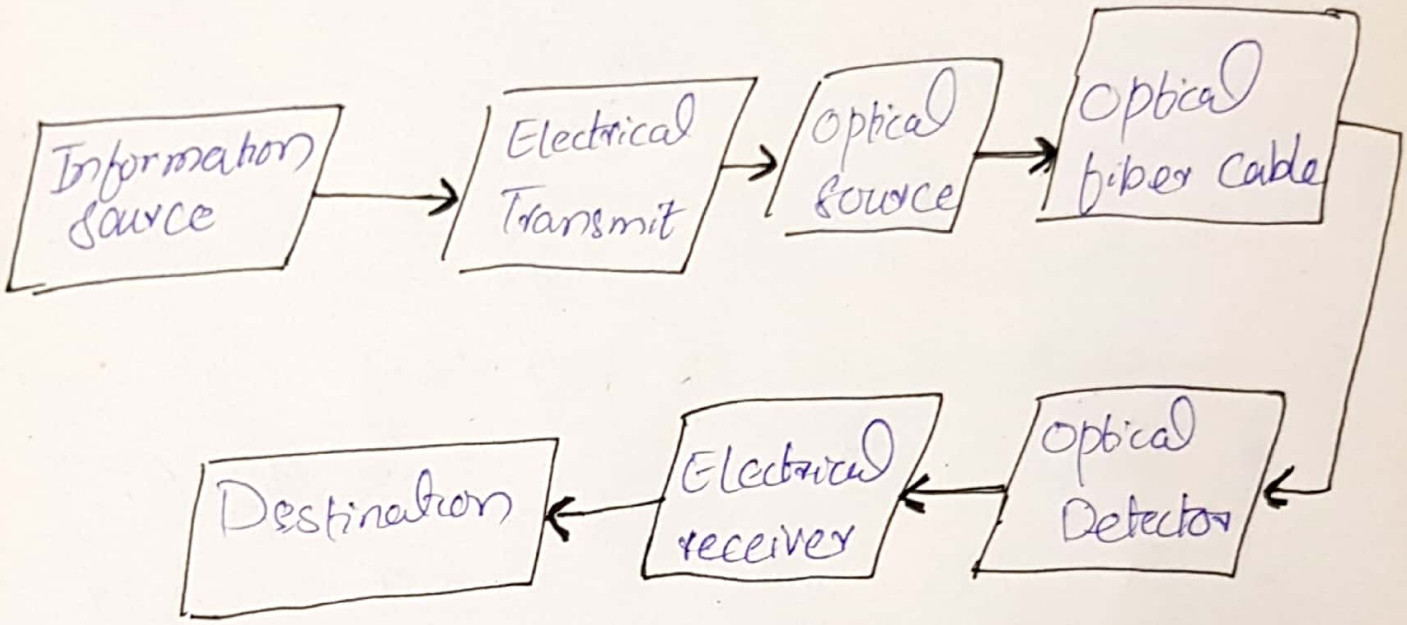
(Q1)

(A) Why fiber optic communication? Explain in detail the basic of fiber optic communication system.

(Ans) * Need for ultra-high speed communication.
* Rapid access to very large data base.
* High definition image transmission.
* Tv cables with a massive number of channels.
* "Information super-high" communications.
* Optical fiber has very high bandwidth (~30THz)
* Optical fiber has very low loss.
* Suitable for long distance transmission.

cont

Block Diagram of optical fiber



= Electrical transmitter:- is to convert the electrical signal into optical form.

= Optical source:- A device that convert an electrical signal into an optical signal.

= Optical Detector:- optical detector is a detector that convert an optical signal into an electrical signal.

= Electrical Receiver:- Is to convert the optical form into electrical signal.

(Q1)

(B) Describe and Differentiate between LED and LD. Explain its principle of action and types of LD.

(Ans) * LED: (Light emitting Diode)

⇒ A light emitting diode is a semiconductor light source that emits light when current flows through it.

* LD:- (Laser Diode)

A laser diode is a semiconductor device similar to a light emitting diode in which a diode pumped directly with electrical current can create lasing condition at the diod's junction.

cont

Difference between LED and LASER.

LED	LASER
= Non-coherent	- coherent Beam
= Few MHz	- Up to 10 GHz
= Eye safe	- Classes I, II, III
- Preferred for indoor	- All practical outdoor.
= Application	- FSO system require.
= Optical power output	- LASER.

★ LASER Diode Principle:-

⇒ Consider a p-n junction.

⇒ In order to design a Laser diode, the p-n junction must be heavily doped.

⇒ In other word, the p and n materials must be degenerated doped.

⇒ The principle of Laser is based on the stimulated emission of light.

cont

* Types of LASER Diode :-

There are several types of laser.

(1) Multi-Longitudinal mode (MLM) or Fabery-Perot Laser.

(2) Single Longitudinal mode laser (SLM).

(3) SLM with distributed feedback-laser called DFB LASER.

(4) vertical-cavity surface-emitting laser (VCSEL)

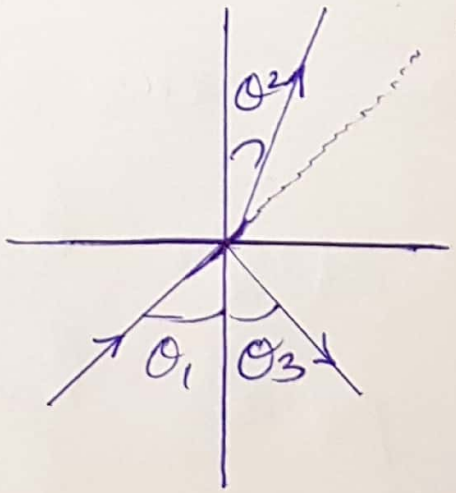
(Q2)

(a) Explain the phenomena of total Internal Reflection. support your ans with help of diagram.

(Ans) Total Internal reflection:-

when the light travel from a denser medium to a rarer medium if the angle of incident is greater than the critical angle. There is no refracted light (The light return the denser medium are known TIR

Diagram



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θ_1 = angle of incident.

θ_2 = angle of refracted.

θ_3 = angle of reflected.

In this phenomena we use Snell's Law

$$\theta_1 = \theta_3 \rightarrow (1)$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightarrow (2)$$

Q2

(B)

What is cable loss factor? Explain the relation $P_{out} = P_{in} \times 10^{-AL/10}$

(Ans) As we know that

$$A\left(\frac{dB}{km}\right) = \frac{-10 \log_{10}\left(\frac{P_{out}}{P_{in}}\right)}{L\ (km)}$$

by cross Multiplication

$$\frac{-10 \log_{10} \frac{P_{out}}{P_{in}}}{-10} = \frac{A\left(\frac{dB}{km}\right) L(km)}{-10}$$

$$= \log\left(\frac{P_{out}}{P_{in}}\right) = -\frac{A\left(\frac{dB}{km}\right) L(km)}{10}$$

$$\frac{P_{out}}{P_{in}} = 10^{-AL/10}$$

$$\boxed{P_{out} = P_{in}\, 10^{-A/10}}$$

* Cable loss factor

(a) Macro bending.
(b) Micro bending
(c) Scattering
(d) Absorption.

Q3

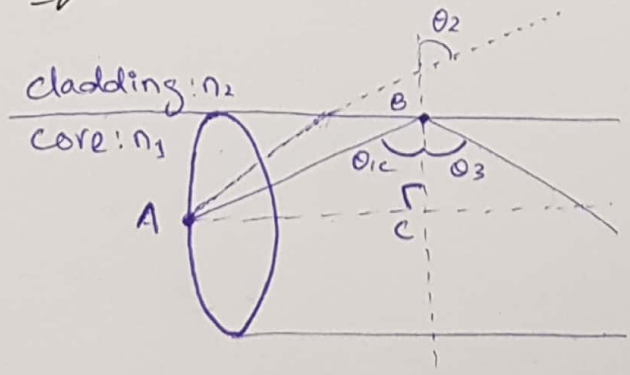
(A) The refractive indexes of the core and cladding of a silica fiber are 1.48 and 1.46 respectively. Find.

(Part(a)) Critical inciden angle, show critical incident angle using figure;

(Ans) ⇒ The angle the beam makes with line perpendicular to optical boundary between core and cladding is called critical incident angle.

⇒ It is denoted by θ_{1c}.

Figure:



Q3 (B) critical propagation angle, also Explain why is critical propagation angle so important?

(Ans) Critical Propagation angle:-

The angle the beam makes with center line of fiber optic is known as critical propagation angle.

★ Why it is so important:-
we need to direct the rays inside the core at critical propagation angle or even lesser angle.

★ θ_{1c} is not use instead we use α_c.

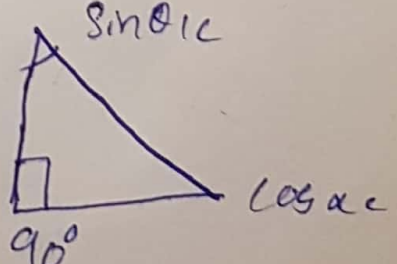
$n_1 = 1.48$ (core)
$n_2 = 1.46$ (cladding)

As we know that

$\sin\theta_{1c} = n_2/n_1$

Here we have

$\alpha_c = 90° - \theta_{1c}$



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$\sin\theta_{1c} = \cos\alpha_c$

$$\boxed{n_2/n_1 = \cos\alpha_c}$$

we can say that

$\sin\alpha_c = \sqrt{1 - \cos^2\alpha_c}$ $\because \sin^2\alpha_c + \cos^2\alpha_c = 1$

$\sin\alpha_c = \sqrt{1 - \cos^2\alpha_c}$

$\sin\alpha_c = \sqrt{1 - (n_2/n_1)^2}$

$\alpha_c = \sin^{-1}\sqrt{1 - \left(\frac{1.46}{1.48}\right)^2}$

$= \sin^{-1}\sqrt{1 - (0.9864)^2}$

$= \sin^{-1}(0.162)$

$$\boxed{\alpha_c = 9.43}$$

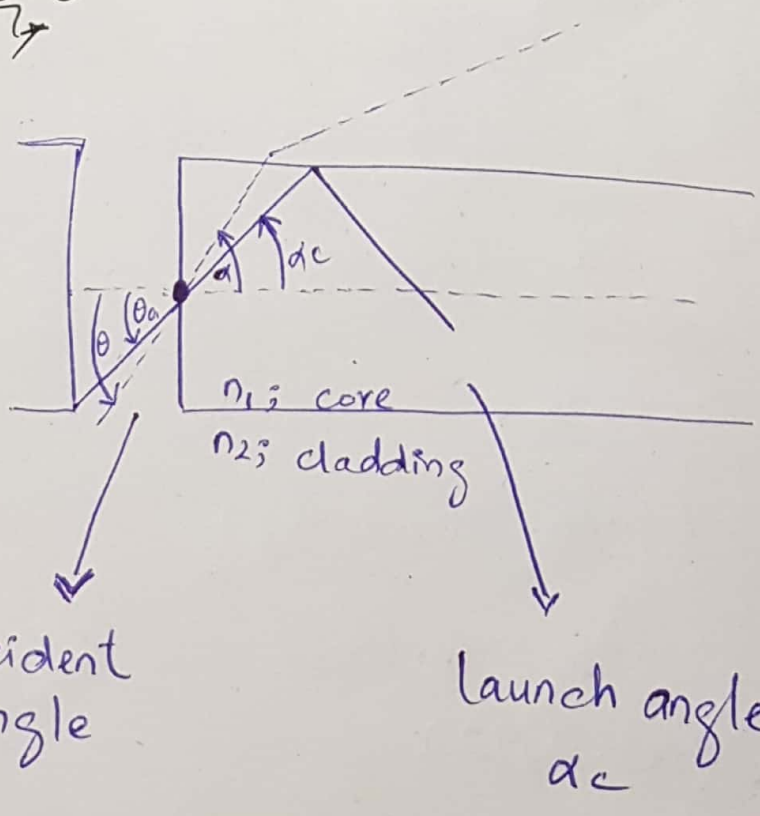
Ans)

Q3 (c) Acceptance angle, what is the relation between spatial angle and acceptance angle?

Ans Acceptance Angle:- (launching the light)

Acceptance angle is the maximum angle at which a light ray enters into core and propagate through it. in zig zag path.

Figure:



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⇒ So the relation between acceptance angle and spatial angle.

Using Snell's Law

$n_a \sin\theta_a = n_1 \sin\alpha_c$

As $n_a = 1.0003$

$\sin\theta_a = n_1 \sin\alpha_c$ → θ_a = Spatial angle

- So the light will save inside the fiber if it comes out from bended so the acceptance angle is $2\theta_a$

$n_1 = 1.46$, $\alpha_c = 9.43$, $n_a = 1.0003$

Sol:

$1 \sin\theta_a = n_1 \sin\alpha_c$

$\theta_a = \sin^{-1}(1.46 \sin 9.43)$

$\theta_a = \sin^{-1}(1.46 \times 0.1638$

$= \sin^{-1}(0.2392)$

$\theta_a = 13.84$

$2\theta_a = 13.84 \times 2$

$\boxed{2\theta_a = 27.67}$ Acceptan

Ans.

Q3

1) Numerical Aperture and explain the relation $\theta_{1c} \rightarrow \alpha_c \rightarrow \theta_a \rightarrow NA$.

(Ans) Numerical Aperture

⇒ NA is the light gathering ability.

⇒ The numerical aperture is define as

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

Relation $\theta_{1c} \rightarrow \alpha_c \rightarrow \theta_a \rightarrow NA$

⇒ NA which describe the ability of an optical fiber to gather light from a source and then preserve.

⇒ The formula expressing this statement

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