VIVEKANAND EDUCATION SOCIETY'S POLYTECHNIC

Study Material

Program Code: Common to all 1st semester

Semester: 1

Course Name: Basic Science (Physics)

Course Code: 22102

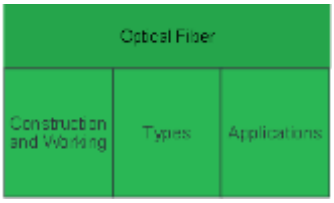
Topic Name: Heat and Optics

UO3f: Describe light propagation in given types of optical fiber. .

LO6: Students will be able to explain construction,working and applications of optical fiber

Course Expert: Mrs. Deepa Gupte	**Date: 21/9/2020**

Concept Map:

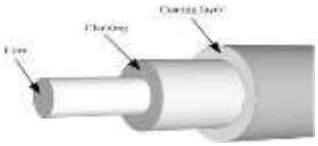


Key words: core,cladding, Acceptance angle, Numerical aperture

Key Questions:How light propagates through optical fiber?

Key Definition/Formula: **TIR, Acceptance angle, Acceptance cone, Numerical aperture**

Diagram /Picture:



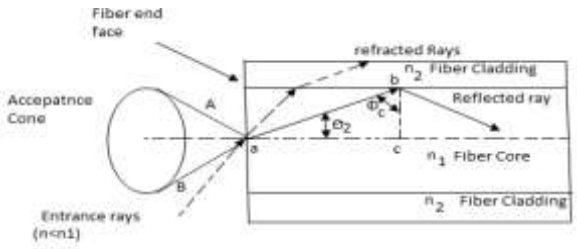


Figure 1.3: Numerical Aperture Rays

UO1b.1: Notes

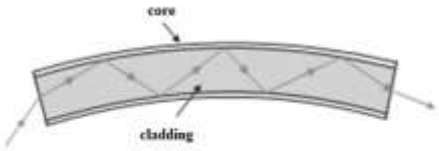
Optical fibre:

Now-a-days optical fibres are extensively used in communication for transmitting audio and video signals through long distances. Optical fibres make use of the phenomenon of total internal reflection.

Principle: The optical fibre works on the principle of total internal reflection (T.I.R)which states that whenever a ray of light passes from a denser medium to a rarer medium at an angle greater than the critical angle, all the rays are totally reflected back to a dense medium.

Structure: An optical fibre consists of a large number of extremely thin fibres of high quality composite glass or quartz. Each fibre has a cylindrical shape and consists of a core and cladding. The core is the innermost part and has a refractive index more than that of the cladding, the outermost part of the fibre.

Propagation of light: When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflections along the length of the fibre and finally comes out at the other end Since light undergoes total internal reflection at each stage, there is no significant loss in the light signal. Optical fibre is made-up in such a way that light reflected at one side of the inner surface strikes the other at an angle larger than the critical angle. Even if the fibre is bent, light can easily travel along its length. Thus, an optical fibre can be used to act as an optical pipe.



Acceptance angle (θa): It is the maximum angle made by the light ray with the fibre axis,so that light can propagate through the fibre after total internal reflection.

Acceptance cone: It is the cone in which the light incident at acceptance angle or less than the acceptance angle and then the light can propagate through the fibre after total internal reflection. The light rays contained within the cone having a full angle 2θa are accepted and transmitted along the fibre. Therefore the cone is called the 'Acceptance cone'.

Numerical Aperture (NA): Numerical aperture is a measure of the amount of light ray that can be accepted by an optical fibre. The numerical aperture is defined as the sine of the acceptance angle.

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

There are three main types of optical fibers.

1. Single-mode optical fiber
2. Multimode optical fiber with stepped index
3. Multimode optical fiber with graded-index

Single-mode optical fiber

As the name suggests, this type of optical fiber transmits only one mode of light. To put it another way, it can carry only one wavelength of light across its length. These cables can carry only one mode, physically, by having a tiny core. Since the light travels in a straight direction, there are fewer losses, and it can be used in applications requiring longer distance connections.

Multimode optical fiber

- As the name implies, these types of optical fibers allow multiple modes of light to travel along their axis.
- To explain physically, they can do this by having a thicker core diameter.

There are two types of multimode optical fibers:

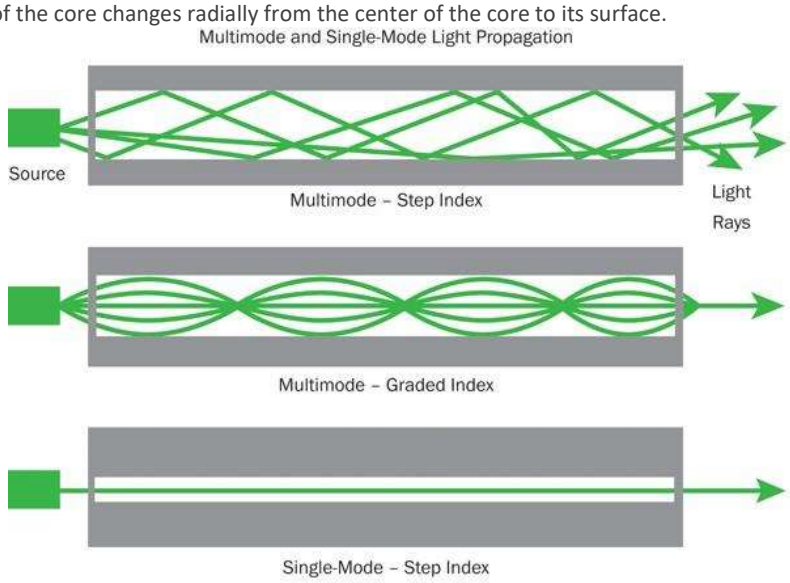
- stepped index multimode optical fiber and
- graded-index multimode optical fiber.

Stepped index multimode fiber

The refractive index of the core of the multimode is uniform throughout the cable.

Graded-index multimode fiber

The refractive index of the core changes radially from the center of the core to its surface.



Applications

Bundle of optical fibre can be used for several purpose, some of the uses are as follows:

1. Optical fibres are widely used in communications for transmitting and receiving electrical signals which are converted to light by suitable transducers.

2. They can also be used for medical examination by transmission of optical signals. For example, the 'light pipe' is used to have visual check of internal organs like esophagus, stomach and intestines of human body.

3. When a decorative lamp with fine plastic fibres at the free ends in form of fountain like structure is switched on, the light travels from the bottom of each fibre and appears at the tip of its free end as a dot of light. The fibres in such decorative lamps are optical fibers

Advantages of optical fibre: Complete input/output electrical isolation.

No electromagnetic **interference** (EMI) susceptibility or radiation along the transmission media.

Broad **bandwidth** over a long distance.

Light-**weight**, small-diameter cables **Thinner and Sturdier.**

More Flexibility for the Future

Faster Speeds

Lower Total Cost of Ownership: Although some fibre optic cables may have a higher initial cost than copper, the durability and reliability of fibre can make the total cost of ownership (TCO) lower.

Link to YouTube/ OER/ video/e-book:httpswww.youtube://.com/watch?v=9seDKvbaoHU&t=1441s

https://www.youtube.com/watch?v=aqazAcE19vw

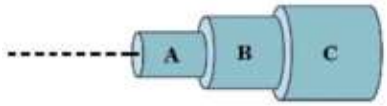
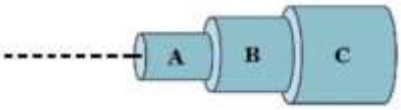
Key Take away: TIR, core ,cladding, Acceptance angle, Acceptance cone, Numerical aperture

Formative Assessments

<22102>: < Common to all 1st semester>: <Common to all>: <Heat and Optics>: <UO3f: Describe the properties of given good and bad conductors of heat>: <Assessments>: <Formative>

<Mrs. Deepa Gupte>

Assessment Type: Formative Assessments:

Set 1: Question No 1	Set 1: Question No 2	Set 1: Question No 3
In the following diagram of optical fibre, label B is 	In the following diagram of optical fibre, label A is 	For a glass optical fiber, calculate the critical angle if refractive index core is 1.5 & refractive index cladding is 1.3
a) core	a) core	a) 55.23°
b) cladding	b)cladding	b) 64.25°
c) jacket	c)jacket	c) 57.83°
d) shield	d)shield	d) 60.07°
Ans: <b>	Ans: <a>	Ans: <d>

Set 2: Question No 1	Set 2: Question No 2	Set 2: Question No 3
In the structure of fiber optic cable, the refractive index of core is always _____the refractive index of cladding.	Angle between incident ray and normal is known as _____.	The numerical aperture of a fiber if the angle of acceptance is 15 °, is _____.
a) Less than	a) angle of abnormality	a) 0.17
b) Equal to	b) angle of refraction	b) 0.26
c) Greater than	c) angle of incidence	c) 0.5
d) None of the above	d) angle of reflection	d) 0.75
Ans: <c>	Ans: <d>	Ans: <b>

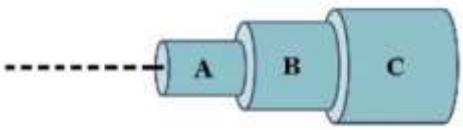
Practice Worksheet

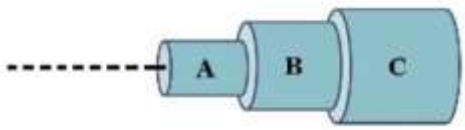
Practice Worksheets

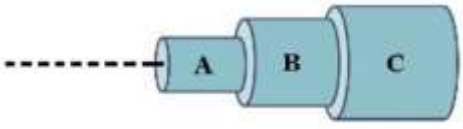
<22102> : <Common to all 1st Semester> : < Common to all 1st Semester>: <Heat and optics>: <UO1f> : <Assessments> : <Worksheet>

< Mrs. Deepa Gupte >

Assessment Type: Practice Worksheets:

<table>
<tr>
<td>A) In the following diagram of optical fibre, label A is
 

a. Core
b. Cladding
c. Jacket
d. shield</td>
<td>B) In the following diagram of optical fibre, label B is
 

a. Core
b. Cladding
c. Jacket
d. shield</td>
</tr>
<tr>
<td>Ans A: a</td>
<td>Ans B: b</td>
</tr>
<tr>
<td>C) In the following diagram of optical fibre, label C is
 

a. Core
b. Cladding
c. Jacket
d. shield</td>
<td>D) Thin flexible glass rods to transfer data from one region to another are known as
a. glass cables
b. reflection fibers
c. optical fibers
d. copper fibers</td>
</tr>
<tr>
<td>Ans C: c</td>
<td>Ans D: c</td>
</tr>
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