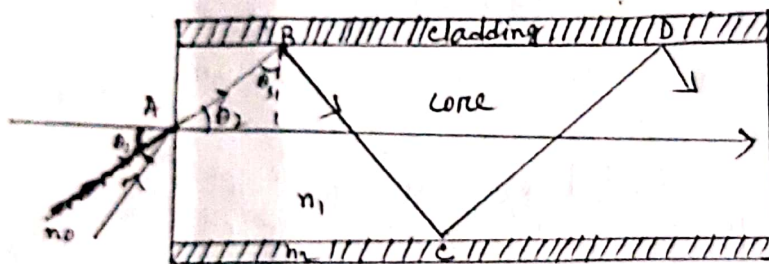


Name - Bishnupriya Jana
Dept - physics
Sem - VI
Paper - C137

Topic - Optical fibres

1. Determination of acceptance angle and numerical aperture :-

We consider a step index optical fibre. Let n_1, n_2 be the indices of the core and cladding respectively and n_0 be that of the outside medium.



Let a ray be incident on the entrance aperture of the fibre at an angle θ_1 with its axis and θ_2 be the corresponding angle of refraction.

$$\therefore n_0 \sin \theta_1 = n_1 \sin \theta_2 \quad \text{--- (i)}$$

To retain the ray inside the core, the angle of incidence θ_3 at the core cladding interface must not be less than the critical angle θ_c .

But,

$$\theta_3 = 90^\circ - \theta_2 \quad \text{--- (ii)}$$

2

A cone of light of semiangle θ_A is called the acceptance cone.
Acceptance angle is $2\theta_A$.
Now

$$n_0 \sin \theta_1 = n_1 \sin \theta_2 = n_1 \sin (90^\circ - \theta_3) = n_1 \cos \theta_3$$

$$\Rightarrow n_0 \sin \theta_A = n_1 \cos \theta_c$$

for $\theta_1 = (\theta_1)_{\max} = \theta_A$ and $\theta_3 = \theta_c$, the critical angle

$$\begin{aligned} \therefore n_0 \sin \theta_A &= n_1 \sqrt{1 - \sin^2 \theta_c} = n_1 \sqrt{1 - n_2^2 / n_1^2} \\ &= \sqrt{n_1^2 - n_2^2} \end{aligned}$$

$$\text{Since } \sin \theta_c = n_2 / n_1$$

The quantity $n_0 \sin \theta_A$ or $\sin \theta_A$ is defined as the numerical aperture (N.A).

$$\therefore N.A = \sqrt{n_1^2 - n_2^2}$$

2. Find the numerical aperture (N.A) of a step index fibre when the refractive index of the core is 1.51 and that of the material used for cladding is 1.47.

Solⁿ :=

$$\text{Here } n_1 = 1.51$$

$$n_2 = 1.47$$

$\therefore$ Numerical aperture is given by,

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

$$= \sqrt{(1.51)^2 - (1.47)^2}$$

$$= \sqrt{2.98 \times 0.04} = 0.3452$$

3. Calculate the angle of acceptance of the fibre referred³ when refractive index of the core is 1.51 and that of the material used for cladding is 1.47, it is placed in air.

Soln. = Let θ_A be the required angle of acceptance. Then we have $n_0 \sin \theta_A = \text{N.A.}$

$$\begin{aligned}\therefore \text{N.A.} &= \sqrt{n_1^2 - n_2^2} \\ &= \sqrt{(1.51)^2 - (1.47)^2} \\ &= \sqrt{2.98 \times 0.04} \\ &= 0.3452\end{aligned}$$

Here $n_0 = 1$.

$$\begin{aligned}\therefore \sin \theta_A &= 0.3452 \\ \Rightarrow \theta_A &= \sin^{-1}(0.3452) \\ &= 20.19^\circ\end{aligned}$$

4. The numerical aperture of an optical fibre is 0.5 and the core refractive index is 1.54. Find the refractive index of the cladding.

Ans. =

Refractive index of cladding, $n_2 = \sqrt{n_1^2 - (\text{N.A.})^2}$

$$\begin{aligned}&= \sqrt{(1.54)^2 - (0.5)^2} \\ &= 1.46\end{aligned}$$

5. Advantage of optical fibre communication :- 4

- i. It possesses far more information carrying capacity in comparison to the conventional radio and microwave carriers. Losses are extremely low and the clarity of the signals transmitted is much better.
- (ii) Because of the smaller size and light weight of the system, it is highly suitable in aeronautical and space applications.
- (iii) The cost of cables per unit length is much lower than that of the metallic counterpart, as fibre is made of glass whose raw material silica is both cheap and available in plenty.

6. Application of optical fibre :-

The most important application of fibre optics is to transmit communication signals through light pipes. Other applications are given below.

- i. The optical fibre system is widely used in defence services as high privacy can be maintained. The military applications include communication, command, and control links on ships and aircrafts, data links for satellite earth stations etc. Digital data generated by computers are most suited for transmission by the fibre system. It is also used in signalling.

(ii) Its applications in science and industry are numerous.

Fibre-optic sensors measure temperature, Pressure, liquid levels, rotary and linear positions etc.

It is also used in cable television, space vehicles, ships and submarine cables. Optical fibres are also widely used in security and alarm systems, electronic instrumentation systems, industrial automation and process control.

(iii) The other important application is in the medical field for diagnostic purpose - the endoscopy.