Optical Fibres

Q1. Explain the phenomenon of Total internal reflection.

Ans. When a ray of light suffers refraction at a boundary while travelling from a rarer medium to a denser medium , it bends towards the normal . Similarly , if a ray of light travels from a denser medium to a rarer medium , it bends away from the normal .

Two diagrams

In both the cases angle of refraction increases with increase in the angle of incidence. When angle of incidence is increased in case two then for a particular angle of incidence $\mathbf{I_c}$ the angle of refraction becomes 90° that angle is called angle of critical incidence .

Diagram left

When the angle of incidence increases the angle of critical angle the refracted ray does not enter the rarer medium and is reflected back to the denser medium .

Thus the phenomenon of light reflecting back into the denser medium , when incident a boundary of rarer medium with angle greater than critical angle , is called **Total Internal Reflection** .

Q2. Write a note on optical fibres.

Ans. Optical fibres are long thin hair like cables made of plastic or glass to electric light along their length.

An Optical fibre generally has three co-axial regions.

1.**Core:** The innermost region of nearly 50µm in diameter which is optically dense as compared to cladding is called core.

2.**Cladding:** The region surrounding the core with 125µm diameter which is rarer as compared to core is called cladding.

3.**Sheath:** The outermost skin of optical fire to protect it from external damage is called sheath.

One diagram left

Q3. Why is cladding required when light travels through core only ?

Ans. Cladding is required as :

1. It enhances the mechanical strength of fibre.
2. Protects core from surface contamination.
3. Reduces scattering loss at the core.

Q4. Derive expression for acceptance angle of an optical fibre.

Ans. The maximum angle of incidence for which the light incident on the core propagates successfully through the fibre is called acceptance angle (θ_0).

Consider a step index optical fibre with core of refractive index μ_1 and cladding of refractive index μ_2.

Diagram

$$\boldsymbol{\mu_1^0 = \frac{\mu_1}{\mu_0} = \frac{\sin\theta_i}{\sin\theta_r} = \frac{\sin\theta_i}{\sin(90-\emptyset)} = \frac{\sin\theta_i}{\cos\emptyset}}$$

Where θ_{imax} then θ_{rmax} and $\emptyset_{min} = \emptyset_{critical}$

Therefore, $\frac{\sin\theta_{imax}}{\cos\emptyset_c} = \frac{\mu_1}{\mu_0}$ - equation 1

$$\boldsymbol{\theta_{imax} = \theta_0, \mu_0 = 1}$$

When at cladding core interface

$\boldsymbol{\mu_2^1 = \frac{\mu_2}{\mu_1} = \frac{\sin\emptyset_c}{\sin 90} = \sin\emptyset_c}$ - equation 2

$$\boldsymbol{\sin\emptyset_c{}^2 + \cos\emptyset_c{}^2 = \frac{\mu_2{}^2}{\mu_1{}^2} + \frac{\sin\theta_0{}^2}{\mu_1{}^2} = 1}$$

$$\boldsymbol{\frac{\sin\theta_0{}^2}{\mu_1{}^2} = 1 - \frac{\mu_2{}^2}{\mu_1{}^2}}$$

$$\boldsymbol{\sin\theta_0{}^2 = \mu_1{}^2 - \mu_2{}^2}$$

$$\boldsymbol{\sin\theta_0 = \sqrt{\mu_1{}^2 - \mu_2{}^2}}$$

$$\boldsymbol{\theta_0 = \sin^{-1}(\sqrt{\mu_1{}^2 - \mu_2{}^2}\ )}$$

Expression for acceptance angle: The solid angle made by acceptance angle in all directions is called acceptance cone all light incident in this cone propagates through the fibre successfully.

One diagram

Q5. Describe fibre optic communication system.

Ans. Principle Elements of typical optical communication system are :

Diagram

1. Telephone (mike) i/p
2. Wire pairs (electrical voice)
3. Encoder
4. Optical transmitter
5. Optical fibre
6. Optical receiver
7. Decoder
8. Wire pair (Electrical)
9. Telephone (speaker) o/p