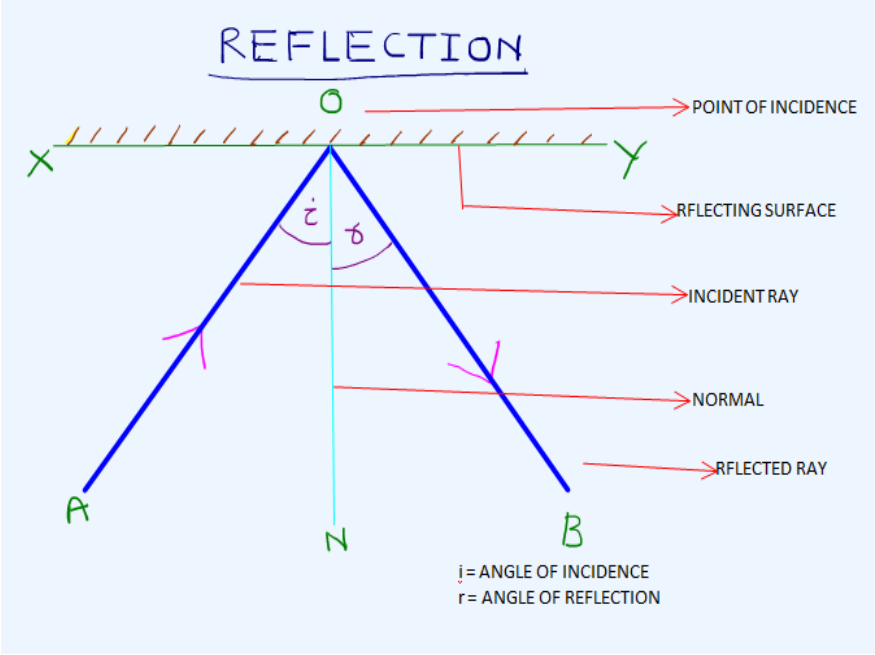
UNIT – 8

OPTICS

It is a branch of physics which deals with the study of the properties and behaviour light including its interaction with matter and the construction of instruments that use or detect it.

REFLECTION –:

It is a property of light in which a ray of light returns back to the same medium from which it is coming after being obstructed by the surface.

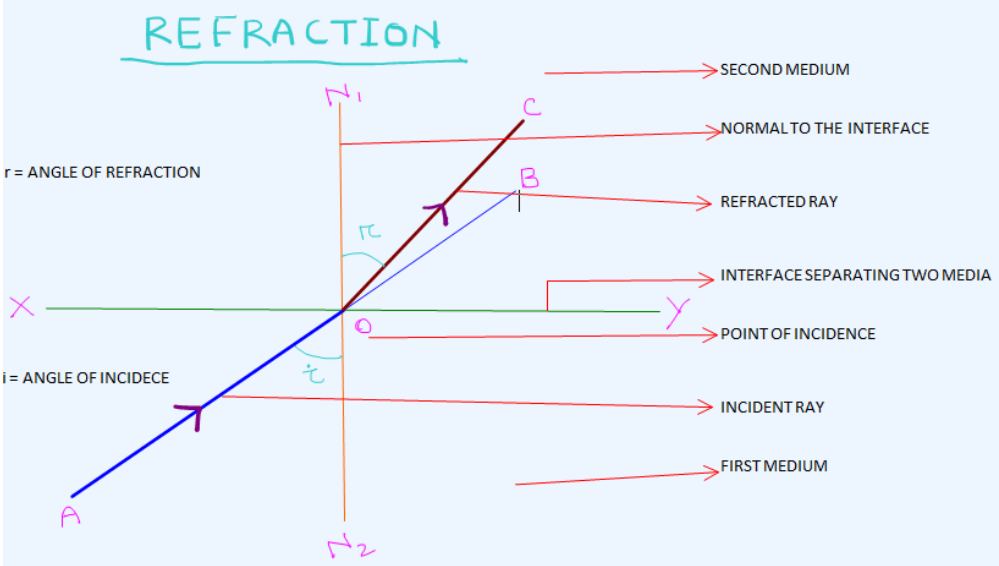


LAWS OF REFLECTION -:

1) The incident ray, reflected ray & the normal to the reflecting surface at the point of incidence are all lie in one plane and the plane is perpendicular to the surface.
2) The angle of incidence is equal to the angle of reflection.

REFRACTION -:

It is the phenomenon of light by virtue of which a ray of light deviates from its original path while travelling from one optical medium to another optical medium.



LAWS OF REFRACTION -:

1) The incident ray, the refracted ray & the normal to the interface at the point of incidence are all lie in one plane and the plane is perpendicular to the interface separating the two media.

SNELL'S LAW -:

2) The ratio between the value of sine of angle of incidence & the value of sine of angle of refraction is a constant.
   This constant is known as the refractive index.

- The ratio of sine of angle of incidence & the sine of angle of refraction is the refractive index of the medium in which the angle of refractions is situated with respect to the medium in which the angle of incidence is situated.
- So according to the diagram refractive index of 2nd medium with respect to the 1st medium can be written as ${}^{1}\mu_{2} = \frac{\sin i}{\sin r}$
- Refractive index has no unit and no dimension.

REFRACTIVE INDEX -:

1) Experimentally it has been found that refractive index of a given optical medium is the ratio of the velocity of light in vacuum (c) and the velocity of light in that optical medium (v).

$$\mu = \frac{c}{v}$$

It is known as absolute refractive index of the medium.

2) Refractive index of 2nd medium with respect to 1st medium is also defined as the ratio of the velocity of light in 1st medium (v_1) and the velocity of light in 2nd medium (v_2).
   ${}^1\mu_2 = \frac{v_1}{v_2}$
3) Refractive index of 2nd medium with respect to 1st medium can also be defined as the ratio of absolute refractive index of 2nd medium (μ_2) to the absolute refractive index of 1st medium (μ_1).
   ${}^1\mu_2 = \frac{\mu_2}{\mu_1}$

❖ Depending upon the values of refractive index of different medium, there are two types of optical medium.

1) **OPTICALLY DENSER MEDIUM -:** A medium having high value of refractive index is known as optically denser medium.
   As greater the value of refractive index, smaller is the velocity of light in this medium.
2) **OPTICALLY RARER MEDIUM -:** A medium having small value of refractive index is known as optically rarer medium.
   As smaller the value of refractive index, greater is the velocity of light in it.

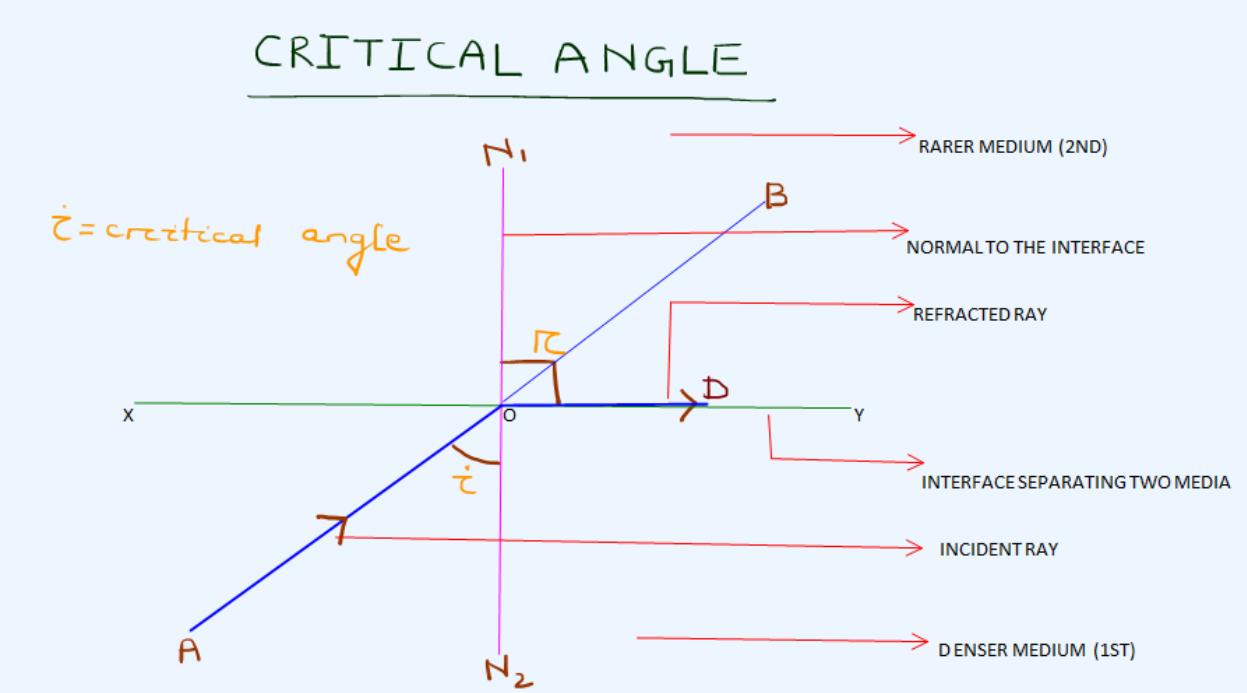
- **When a ray of light is travelling from a denser medium to a rarer medium it always bends away from the normal.**
- **In this case the angle of incidence is always smaller than the angle of refraction.**
- **When a ray of light is travelling from a rarer medium to a denser medium it always bends towards the normal.**
- **In this case the angle of incidence is always greater than the angle of refraction.**

REFRACTION THROUGH A PRISM -:

In case of a prism, refraction occurs twice. Once at the boundary separating air glass media, another at the boundary separating glass air media.

CRITICAL ANGLE -:

It is the angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90°.



RELATION BETWEEN CRITICAL ANGLE & REFRACTIVE INDEX -:

Let a ray of light is travelling from a denser medium (1st medium) to rarer medium (2nd medium).

$$i = angle\ of\ incidence$$

$$r = angle\ of\ refraction$$

According to Snell's law, refractive index of 2nd medium with respect to 1st medium

$${}^{1}\mu_2 = \frac{\sin i}{\sin r}$$

Here the light ray is incident at critical angle in the denser medium, $i = c$

And angle of refraction $r = 90°$

$${}^{1}\mu_2 = \frac{\sin c}{\sin 90}$$

$$\frac{\mu_2}{\mu_1} = \sin c$$

Here μ_1 & μ_2 are the absolute refractive index of 1st(denser) medium & 2nd (rarer) medium respectively.

If we take the rarer medium as air, then $\mu_2 = 1$

Substituting this in the above equation we get

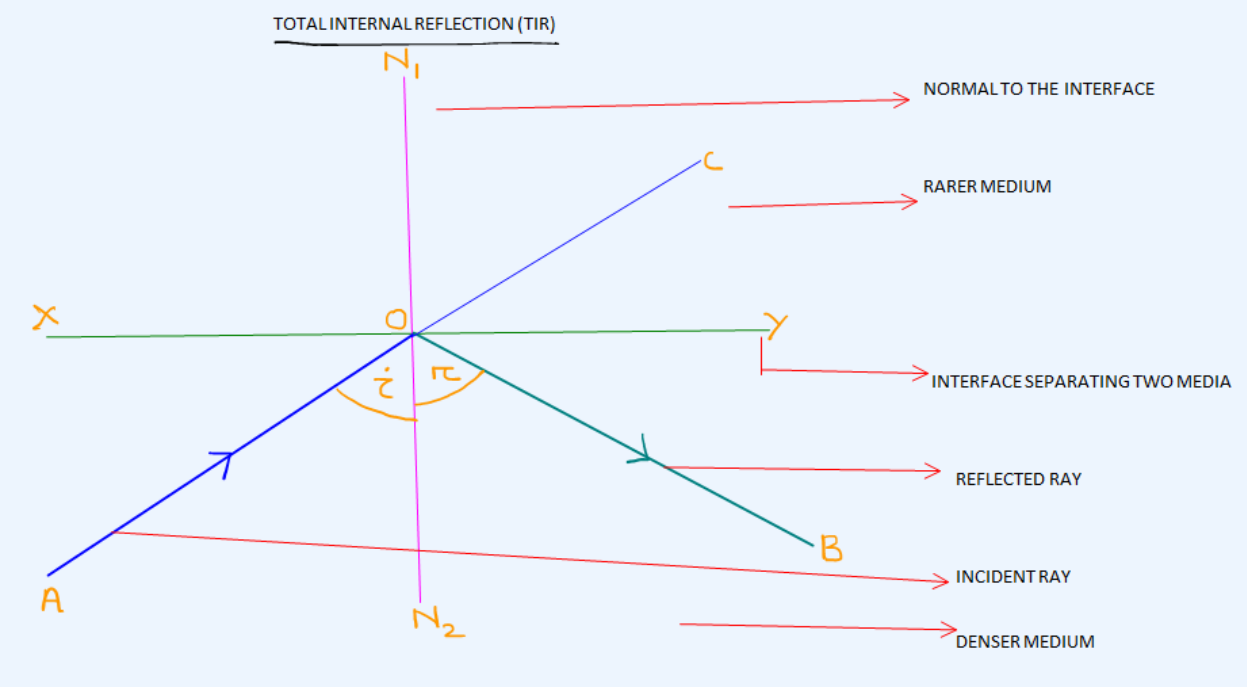
$$\frac{1}{\mu_1} = \sin c$$

$$\Rightarrow \quad \mu_1 = \frac{1}{\sin c}$$

So refractive index of a medium can also be defined as the reciprocal of sine of critical angle in that medium.

TOTAL INTERNAL REFLECTION (TIR) -:

It is the phenomenon of light by virtue of which a ray of light is sent back to the same medium while travelling from a denser medium to a rarer medium, provided it is incident on the interface at an angle greater than the critical angle.



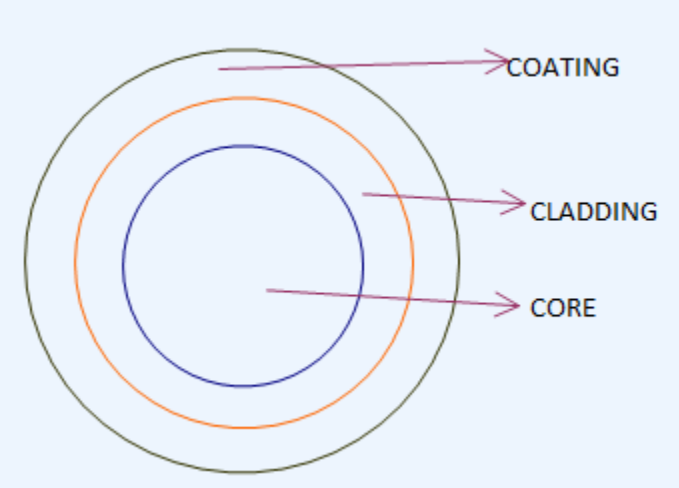
CONDITIONS FOR TIR -:

1) The light ray should travel from a denser medium to a rarer medium.
2) The angle of incidence in denser medium must be greater than the critical angle.

OPTICAL FIBRE -:

It is a technology related to the transportation of optical energy (light) in a specifically designed fibres made up of glass, plastic etc.

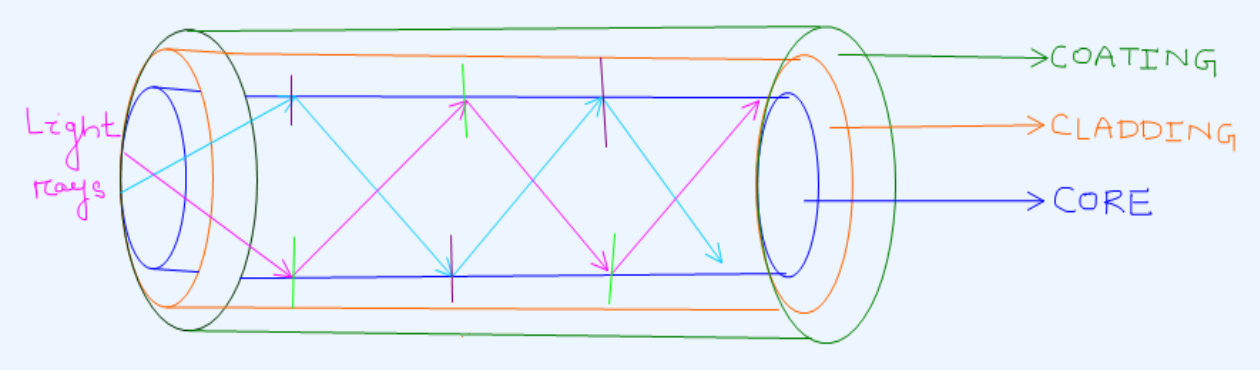
The main principle behind optical fibre is the principle of total internal reflection.



CONCEPT -:

It consists of three layers.

- The innermost layer of the fibre having high value of refractive index is called core.
- The second layer surrounding the core is known as cladding. The refractive index of cladding is smaller than that of core.
- The outermost layer surrounding the whole fibre is known as coating. The refractive index of coating is less than that of cladding.



The light ray enters at one end of the fibre, undergoes multiple successive total internal reflections as the angle of incidence at the core cladding interface is always greater than the critical angle.

APPLICATIONS -:

1) Optical fibres are used to illuminate the objects in some scientific instruments.
2) These are also used telecommunications.
3) These are also used in cable TV connections.
4) Due to high data security, these are also used in military sectors.
5) Optical fibres are also used in medicals as endoscope (fibrescope).