UNIT-8 :- OPTICS :- Dt-8/11/19

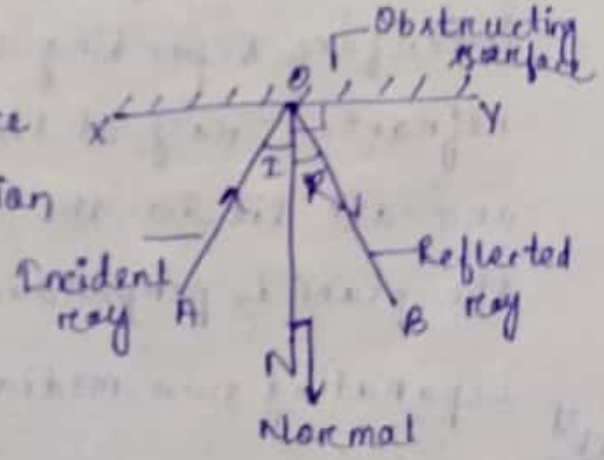
Optics

It is the branch of physics which deals with the study of behaviour and properties of light including it's interaction with matter and construction of instruments which detect/use it.

Reflection :-

It is the property of light by virtue of which a ray of light sends back to the same medium after being obstructed by the surface.

I = Angle of Incidence
R = Angle of Reflection



Laws of reflection :-

(i) The angle of incidence is equal to the angle of reflection.

(ii) The incident ray, normal to the surface and the reflected ray are all lie in same plane.

→ Refraction :-

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

i = Angle of Incidence
r = Angle of Refraction

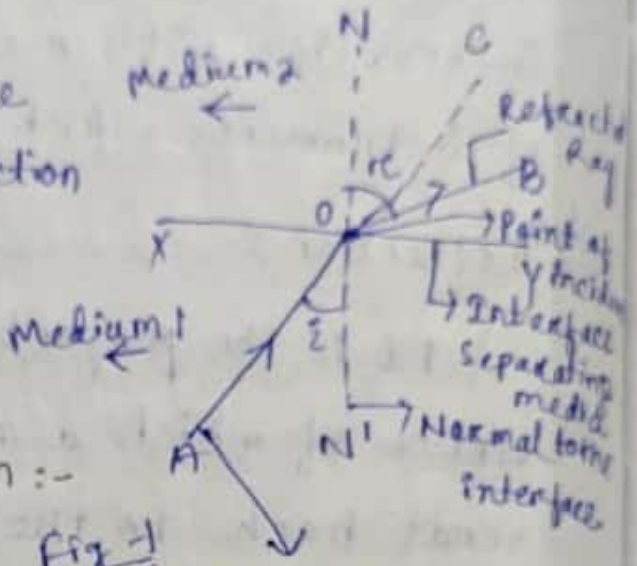


Fig - 1

Laws of Refraction :-

① The incident ray, the normal to the interface separating 2 media and the refracted ray at the point of incidence are all lie in the same plane and the plane is perpendicular to the interface separating two media.

② Snell's law :-

The ratio of sine of angle of incidence to the sine of angle of refraction is a constant and the constant is known as Refractive Index and is denoted by the symbol 'μ'.

According to the fig-1

$\mu = \frac{\sin i}{\sin r}$

refractive index of 2nd medium with respect to 1st medium i.e. $^1\mu_2 = \frac{\sin i}{\sin r}$

the ratio of the value of sine of angle of incidence and the value of sine of angle of refraction is known as the refractive index of that medium in which angle of refraction is situated with respect to that medium in which angle of incidence is situated.

→ Refractive index has no unit and no dimension.

Refractive Index :-

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

~~R.I. = Velo~~

i.e. $\boxed{\mu = \frac{c}{v}}$

$\boxed{c = 3 \times 10^8 \text{ m/s}}$

This is known as absolute refractive index.

② Refractive index of second medium with respect to first medium is defined as the ratio of velocity of light in first medium (v_1) and the velocity of light in 2nd medium (v_2).

i.e $\boxed{{}^1\mu_2 = \frac{v_1}{v_2}}$

③ Refractive index of second medium with respect to 1st medium can also be defined as the ratio of absolute refractive index of 2nd medium (μ_2) and the absolute refractive index of 1st medium (μ_1).

i.e $\boxed{{}^1\mu_2 = \frac{\mu_2}{\mu_1}}$

* Difference between denser medium and rarer medium.

Denser Medium	Rarer Medium
(i) The medium having high value of refractive index is known as denser medium.	(i) The medium having lower value of refractive index is known as rarer medium.
(ii) The value of refractive index in denser medium increases with decreasing the velocity of light.	(ii) The value of refractive index in rarer medium decreases with increasing the velocity of light.
(iii) As greater the value of ~~ref.~~ R.I smaller as the velocity of light in it.	(iii) As smaller the value of R.I greater as the velocity of light in it.
(iv) Example: glass	(iv) Example: air

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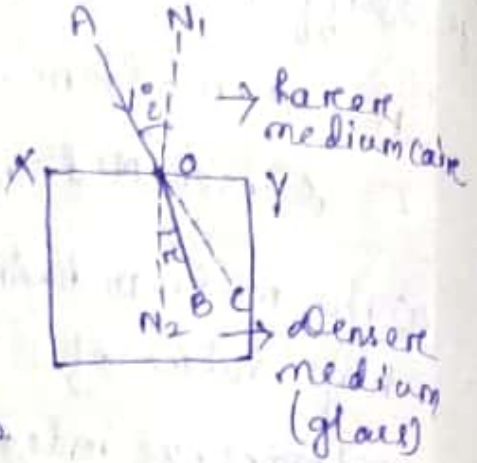
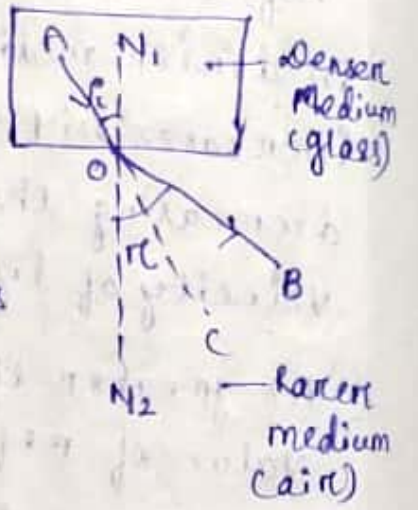


* When a ray of light is travelling from a rarer medium to a denser medium it always bends towards the normal. In this case the angle of incidence (i) is always greater than the angle of refraction (r).

$i > r$



* 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 (i) is always smaller than the angle of refraction (r).

$i < r$

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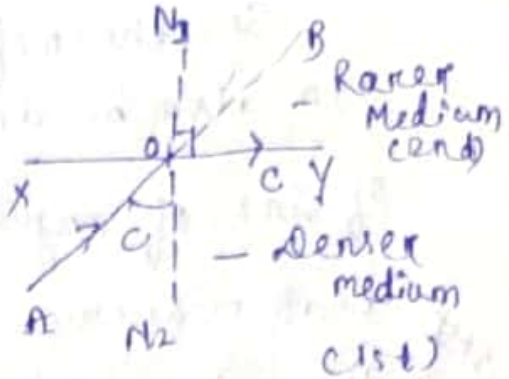
* Critical Angle(C):-

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

According to the ~~figure~~ Snell's Law



Refractive index of 2nd medium with respect to 1st medium

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

where, i = Angle of incidence

r = Angle of refraction

In this case, the angle of incidence is equal to the critical angle (c).

So, $\frac{\mu_2}{\mu_1} = \frac{\sin c}{\sin 90}$ [$\because$ μ_2 & μ_1 are the absolute refractive index of 2nd medium and 1st medium respectively]

$\Rightarrow \frac{\mu_2}{\mu_1} = \frac{\sin c}{1}$

If we will take the rarer medium as air, then, absolute refractive index of air is

$\mu_a = 1$

So, $\frac{\mu_a}{\mu_1} = \sin c$

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

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

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

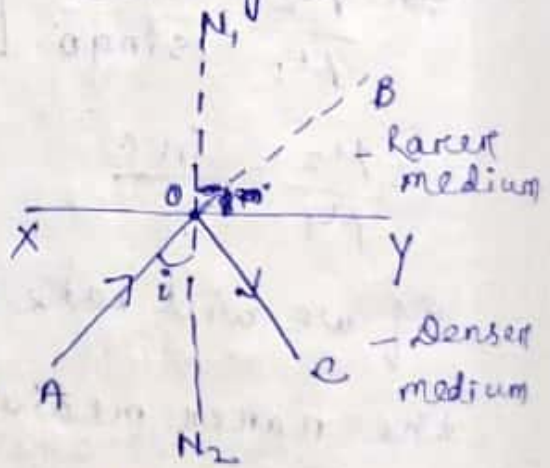
2nd

* Total Internal Reflection (T.I.R) :-

It is the phenomenon of light by virtue of which a ray of light sends 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.

→ Condition for T.I.R :-

① A ray of light should travel from a denser medium to a rarer medium.



② The angle of incidence must be greater than the critical angle. $i > C$

* Optical Fiber :-

It is a technology related to the transpotation of optical energy (light) through specifically design fibres.

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* It consist of three layers.
(i) Core (ii) Caladding (iii) Coating.

The upper (first) layer is known as core and is usually made of glass or plastic. It's refractive index is greater than the other layers. Then, the second layer is known as cladding. It's is smaller than the core. Then, the upper layer is known as coating. It's

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→ Applications :-

(i) they are used in the field of (tele) communication.
(ii) It is used in
(iii) It can be used to transmit high intensity laser light inside the body for medical purposes. (Endoscope)

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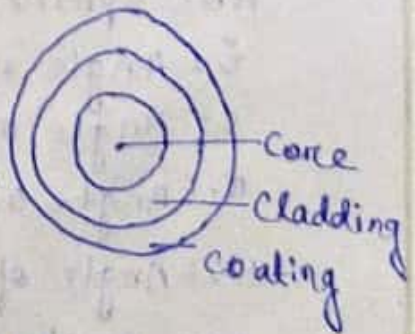
The main principal (optic) behind optical fibre is total internal reflection (TIR)

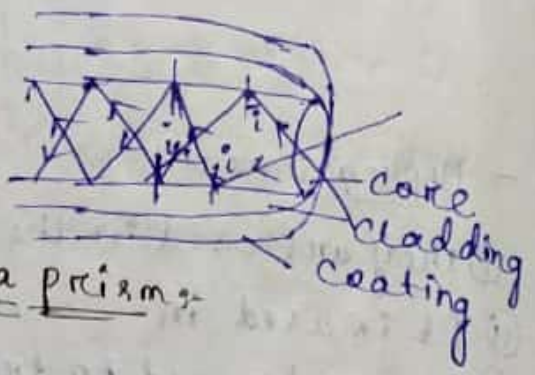
Concept :-

The innermost layer of the optical fibre is known as core which has highest refractive index.



The second layer surrounding the core is known as cladding whose

refractive index is ~~greater~~ smaller than that of core. The outer most layer surrounding the core fibre is known as coating whose refractive index is smaller than that of cladding. Light enters at one end of the fibre undergoes multiple successive total internal reflections as the angle of incidence is always greater than the critical angle.



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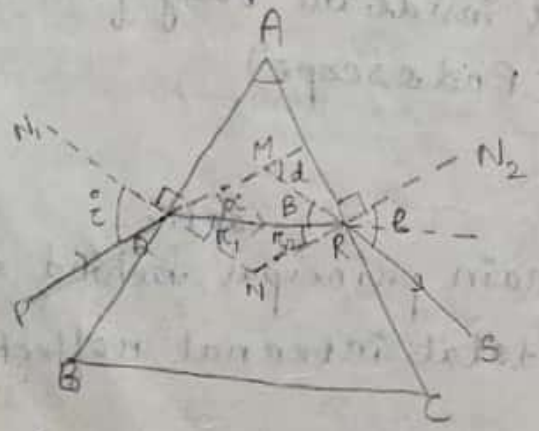
* Refraction through a prism:-



ABC = principal section of the prism
i = Angle of incidence
e = Angle of emergence
r_1 = Angle of refraction for the face AB.
r_2 = Angle of incidence for the face AC.
A = Angle of the prism
D = Deviation angle
μ = Refractive Index of the prism.

(*)

*continued...

Refractive Index of the prism is given by.

$$\mu = \frac{\sin\left(\frac{\angle A + dm}{2}\right)}{\sin\left(\frac{\angle A}{2}\right)}$$

where $\angle A$ = angle of prism

dm = angle of minimum deviation

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