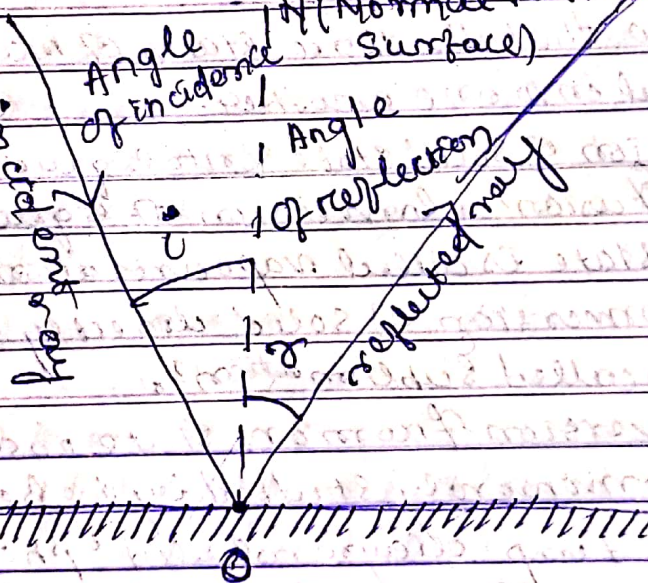
Unit -8 → Optics

Reflection :- # It is the property of light by virtue of which when a ray of light falls on a polished and shining surface of an object then it is sent back to the same medium from which it is being incidented.

The process of sending back the light rays after falling on the shining surface of an object is called reflection of light.

Laws of Reflection :-



phenomenon of Reflection is governed by two laws called laws of reflection given below ;

(i) The incident ray, the reflected ray and the normal to the reflecting surface at the point of incidence all lie in one plane and that plane is perpendicular to the reflecting surface.

(ii) The angle of incidence is equal to the angle of reflection. i.e., $\angle i = \angle r$.

Refraction:-

* It is the phenomenon by virtue of which a ray of light going from one medium to the other undergoes a change in its velocity.

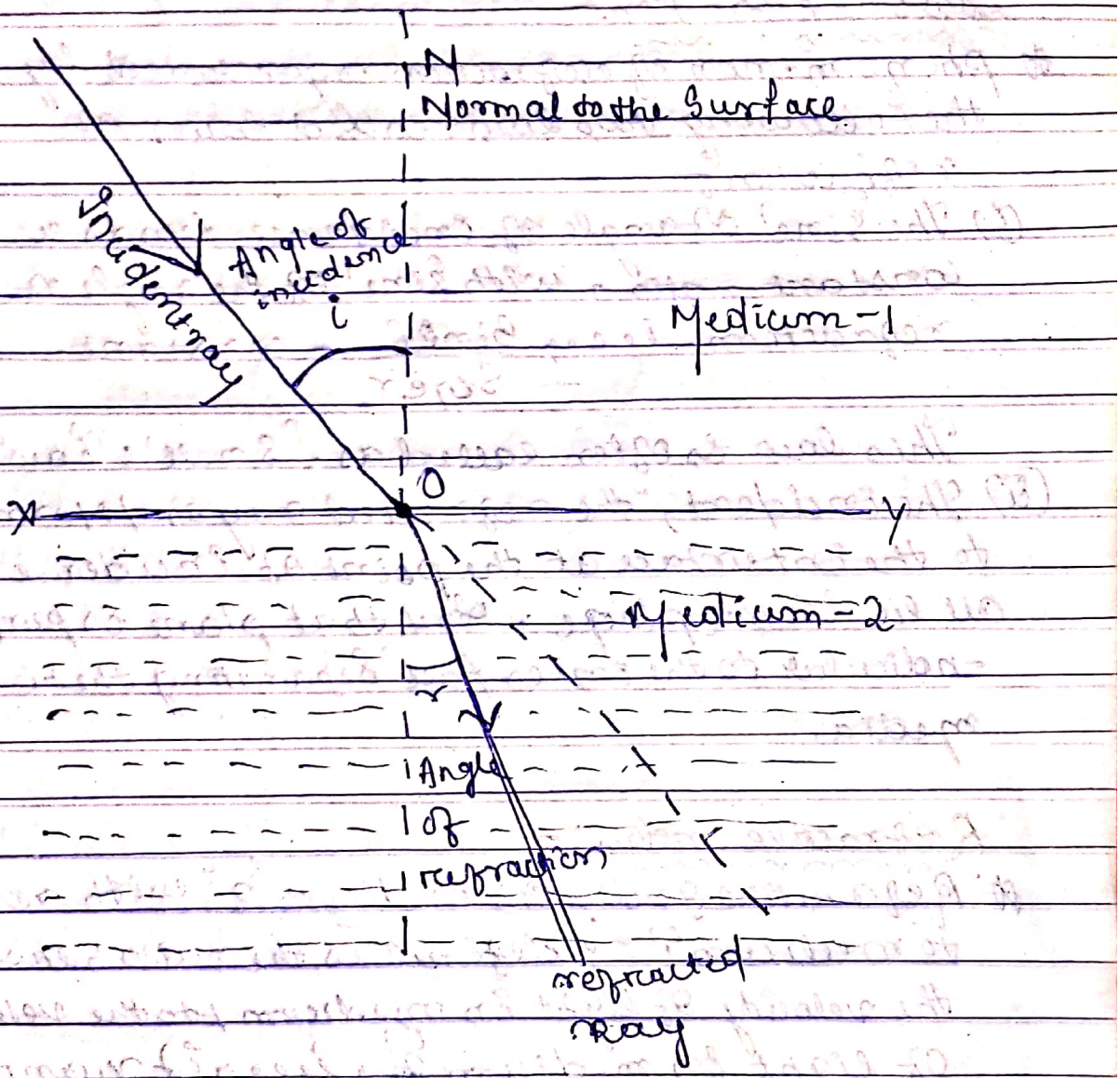


Fig:-2:- Refraction at a plane surface

* Velocity of light in different media is different as ray of light goes from medium 1 (velocity of light is v_1) to medium 2 (velocity of light v_2) its velocity changes on crossing the interface xy. This phenomenon is known as refraction.
* A ray of light travelling from rarer to denser medium bends towards the normal to the interface whereas that travelling from denser to rarer

medium bends away from the normal to the interface whereas that travelling from denser to rarer medium bends away from the normal.

Laws of Refraction:-

* Phenomenon of refraction is governed by the following two laws called laws of refraction:-

(i) The 'sine' of angle of incidence bears a constant ratio with 'sine' of the angle of refraction. i.e., $\frac{\sin i}{\sin r}$ = constant.

This law is often called as 'Snell's Law'.

(ii) The incident, the refracted ray and Normal to the interface at the point of incidence, all lie in one plane. And that plane is perpendicular to the interface separating the two media.

Refractive Index:-

* Refractive index of medium '2' with respect to medium '1' is defined as the ratio between the velocity of light in medium 1 to the velocity of light in medium 2. i.e., if v_1 and v_2 are the velocities of light in first and second medium, then,

$$\mu_2 = \frac{v_1}{v_2} \quad \text{---------(i)}$$

Where, μ_2 = Refractive index of second medium with respect to first.

* If the first medium is air or vacuum then

the refractive index is simply written as μ and is known as absolute refractive index.

$$\mu = \frac{c}{v} \quad \text{---(ii)}$$

Where, c = velocity of light in vacuum.
v = velocity of light in other medium.
$c = 3 \times 10^8$ m/sec.

* Refractive index of a medium with respect to another is defined as the ratio between 'sine' of the angle of incidence to the 'sine' of the angle of refraction.

$$\mu_2 = \frac{\sin i}{\sin r} \quad \text{---(iii)}$$

* Refractive index of denser medium is larger than that of rarer medium.

Air :- $\mu = 1$
water :- $\mu = 1.33$
Glass :- $\mu = 1.5$

Q.1. Find the velocity of light in glass if its refractive index is $\frac{3}{2}$.

Ans :- We know that,

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

$$\Rightarrow \frac{3}{2} = \frac{3 \times 10^8}{v}$$

$$\Rightarrow 3v = 6 \times 10^8$$

$$\Rightarrow v = 2 \times 10^8 \text{ m/sec}$$

Q.2 A ray of light is incident on water surface at an angle 50°. Calculate the angle of refraction in water given that refractive index of water is $\frac{4}{3}$.

Ans :- We know that,

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

$$\Rightarrow \frac{4}{3} = \frac{0.76}{\sin r}$$

$$\Rightarrow 4 \sin r = 2.28$$

$$\Rightarrow \sin r = \frac{2.28}{4} = 0.57$$

$$\Rightarrow r = \sin^{-1} 0.57$$

$$= 34.75$$

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Critical Angle (θ_c) :-

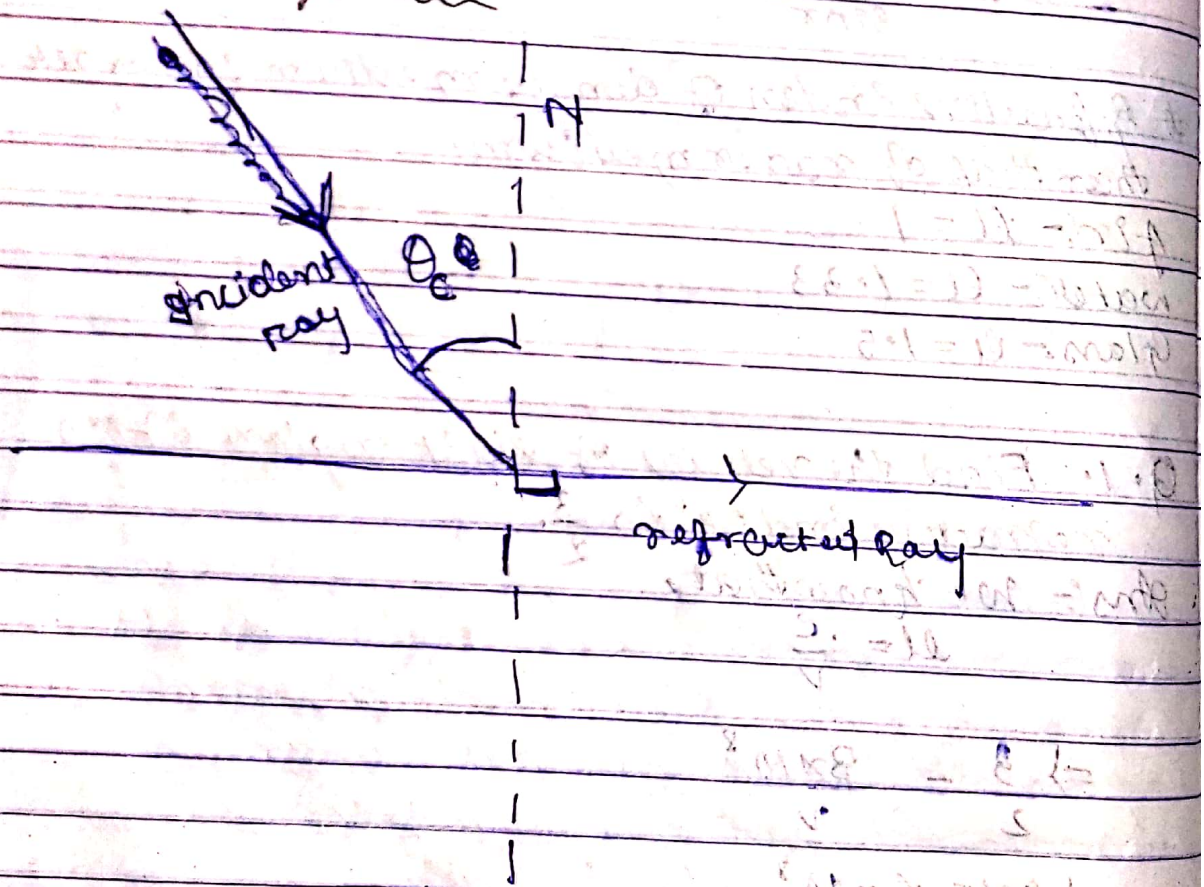


Fig :- 3

Critical angle is the angle of incidence of a ray of light in denser medium such that its angle of refraction in rarer medium is 90°. i.e., the refracted ray becomes

parallel to the interface.

$$\theta_c = \sin^{-1}\frac{\mu_2}{\mu_1} \quad \text{---(Eq)}.$$

Where, μ_2 and μ_1 are refractive indices of 2nd and 1st medium respectively.

Total Internal Reflection:-

* If the angle of incidence of the ray is increased further beyond the critical angle (θ_c) then it is reflected back to the same medium, the phenomenon is called total internal reflection.
* Total internal Reflection is the phenomenon by virtue of which a ray of light travelling from a denser to a rarer medium is sent back to the same medium provided it is incident on the interface at angle greater than the critical angle.
* For $i > \theta_c$, total internal reflection.

Q. The refractive indices of glycerin and water are 1.46 and 1.33 respectively. What is the critical angle when the ray passes from glycerin to water.

Ans:- $\mu_1 = 1.46$

$\mu_2 = 1.33$

Critical angle, $\theta_c = \sin^{-1}\frac{\mu_2}{\mu_1}$

$= \sin^{-1}\frac{1.33}{1.46}$

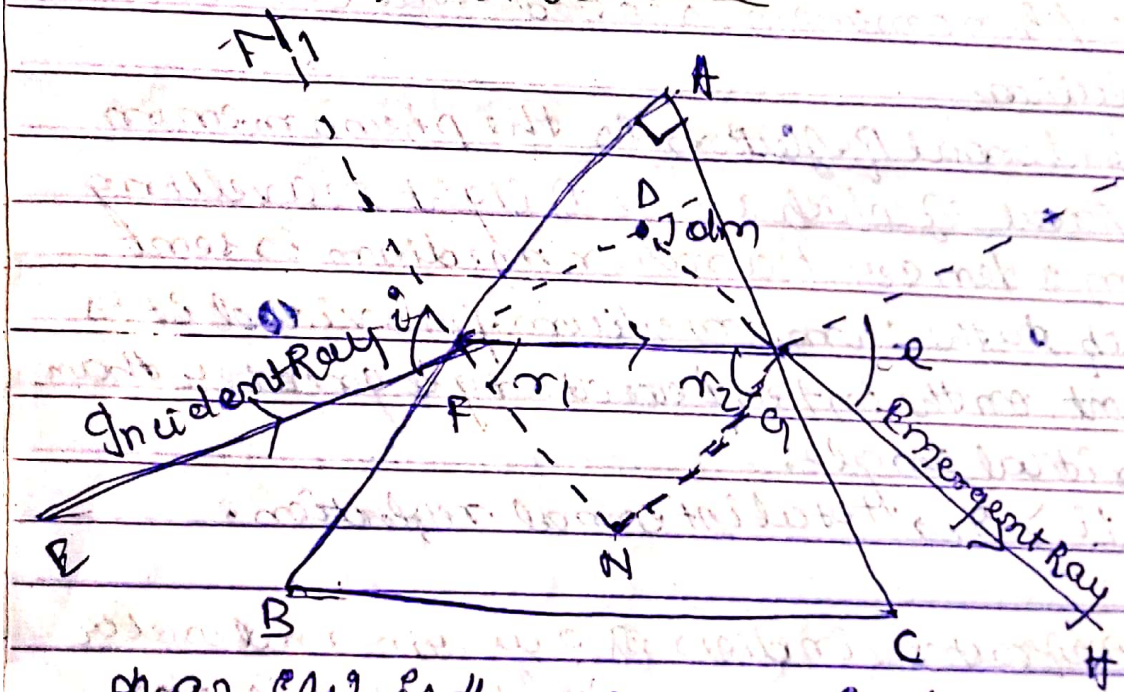
$= \sin^{-1}\frac{133}{146} = \sin^{-1} 0.91$

$= 65.50$

Refraction Through a prism:-

Prism is a wedge-shaped body made from a refractive medium bounded by two plane faces inclined to each other at some angle. The two plane faces are called the refracting faces and angle included betⁿ these two faces is called the angle of prism or the refracting angle.

Ray Diagram Of prism:-



If 'μ' is the refractive index of material of prism and 'δm' is the angle of minimum deviation then the relation between 'μ' and δm is given by,

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad \text{---(1)}$$

δm = Angle of minimum deviation.

A = Angle of prism.

Fibre Optics (Optical Fibre)

* The use of thin flexible fibres of glass or other transparent solids to transmit light signals mainly for telecommunication or for internal inspection of the body is called fibre optics.

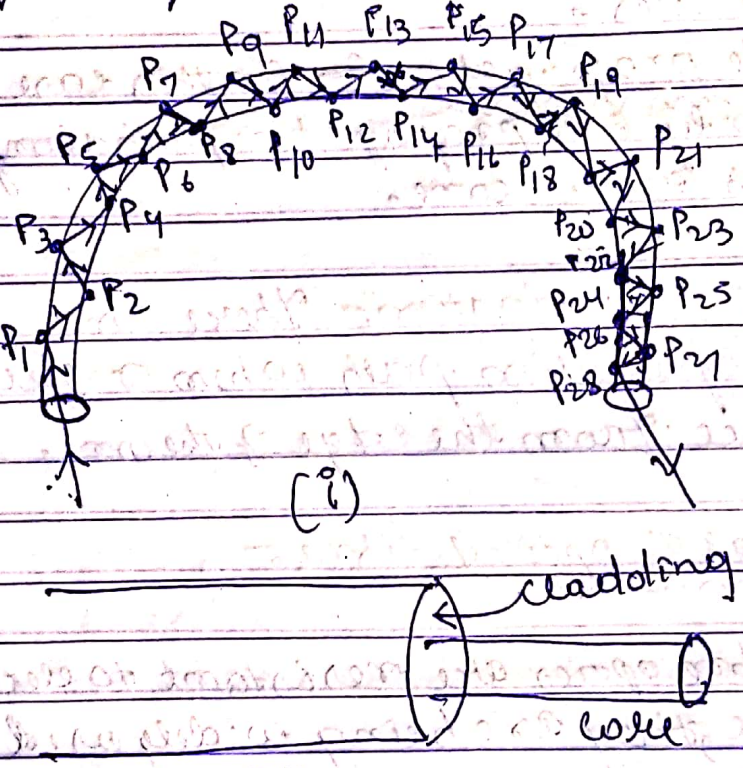


Fig :- 5 :- Optical fibre

* According to the properties of rectilinear propagation of light, light travels in a straight line. Making use of the phenomenon of total internal reflection it can be made to go in a curved path.
* Consider a curved rod 'AB' made up of a transparent material like glass or optical grade plastic. A ray light entering the pipe through face 'A' undergoes successive

T.I.R's at point's P_1, P_2, P_3 ..... and emerges out of the face B.

* An optical fibre consist of a glass or plastic core surrounded by a cladding made up of a similar material but with a lower refractive index.
* Light propagates through an optical fibre in two modes,

(i) Monomode propagation :- In this case light has only one propagation path along the length of the core.

(ii) Multimode propagation :- There are many propagation path when reflection takes place from the edge of the core.

Applications of optical fibre :-

(i) Since fibre optics are resistant to electro-ne noise, they are being widely used in the field of communications.
(ii) Fibre optics are used as light guides, imaging tools.
(iii) Lasers for surgeries.
(iv) Optical fibre bundle's are used to transmit light from a spectrometer to a substance which cannot be placed inside the spectrometer in order to analyse its composition.
(v) Broadcast or cable company use fibre optic cables for wiring, HDTV, internet, video and other applications.