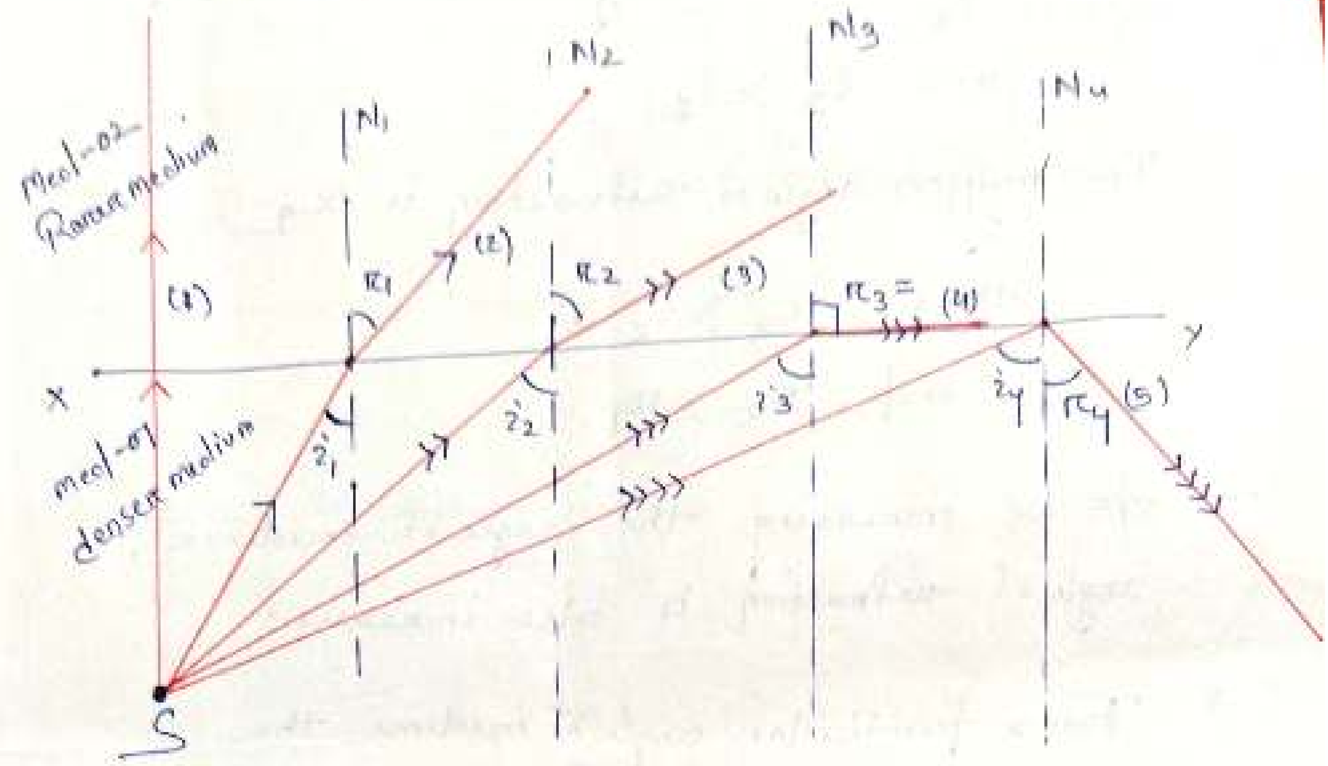
UNIT-08

01

Total Internal Reflection (TIR)



Consider a refracting surface xy which separated by 2 medium. The source 'S' is in dencer medium and the light ray which travels from dencer to Rarer medium are emitted by source 'S'.

→ The light ray which striaks the refracting surface perpendicularly goes undeviated.

→ The ray (01) strikes the surface at an angle of incidence $\angle i_1$ and deviated from its path and showing refracting angle r_1.

Here $r_1 > i_1$ ($\because$ Ray travel dencer to Rarer)

A

→ Again we consider the ray(3). Ray-03 incident on the refracting surface at an angle of i_2.

Here $i_2 > i_1$

For ray(03) angle of refraction is r_2.

Here $r_2 > i_2$

And $r_2 > r_1$

→ As we increasing the angle of incidence, angle of refraction is also increases.

→ For a particular angle of incidence the angle of refraction is 90°. This is known as Critical angle.

for this Condition μ_1 = refractive index of $\simeq \mu$ denser medium.

μ_2 = refractive index of air(say) = 1 rarer medium.

Angle of incidence $i_3 = C$, critical Angle

$r_3 = 90°$

so, Applying Snell's law

$$\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} \Rightarrow \frac{\sin C}{\sin(90)} = \frac{1}{\mu}$$

$$\Rightarrow \boxed{\mu = \frac{1}{\sin C}}$$

If we further increasing the angle of incidence beyond critical angle then instead of being refracted the ray is bounced back to the same medium showing all the laws of ~~refraction~~ reflection.

This phenomenon is known as total internal reflection.

For this Angle of incidence i_4 is equal to the angle of reflection r_4

$$\boxed{i_4 = r_4}$$

Def^n

Critical Angle: —

Critical Angle is defined as the angle of incidence in denser medium for which the angle of refraction in rarer medium is 90°, when a ray of light is travelling from denser to rarer medium.

Total internal Reflection: —

Total internal reflection is a phenomenon by virtue of which a ray of light which travelling from denser to rarer medium at an angle of incidence greater than Critical angle instead of being refracted, reflected back to the same medium and obey laws of reflection.

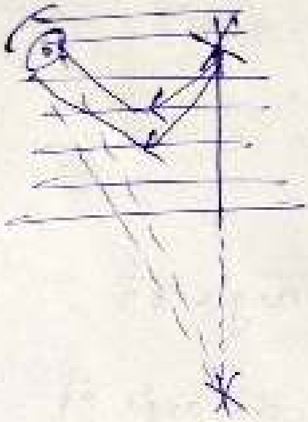
* Mirage :—

Mirage is an optical illusion produced due to the total internal reflection phenomenon.

(1) Inferior Mirage (2) Superior Mirage or looming.

A. Inferior Mirage :—

In deserts, sometimes we see the presence of water at distance place which is actually an optical illusion termed as Inferior Mirage.



Atmosphere of deserts is very hot so, density of air in lower region is lesser than higher region. So, beam of light starting from tree moves from denser to rarer medium and suffers total internal reflection and create a virtual image of of tree at our eye. Due to the disturbance in air, the mirage is wavy in nature so it gives illusion of presence of water.

B. Superior Mirage :—

In cold region the temprature of air in lower region is less then ~~upper~~ upper region. so density of air in lower region greater than upper region.

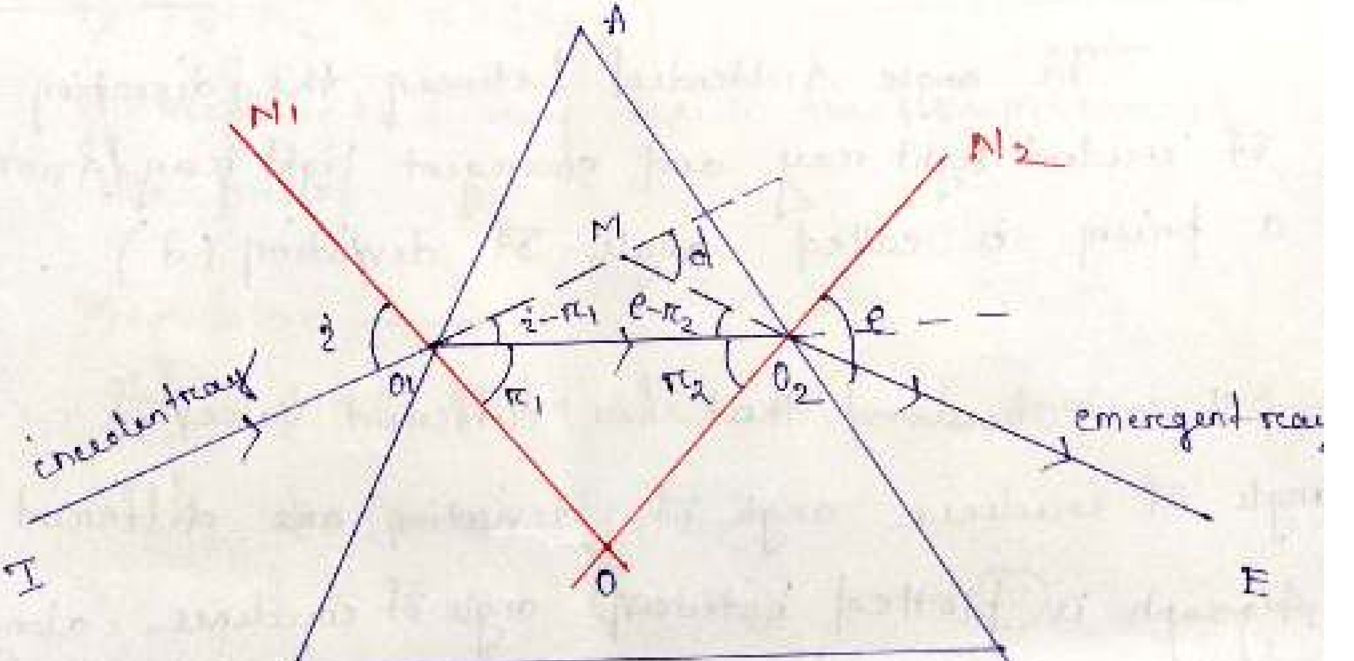
So a beam of light comming from ship travel denser to rarer medium and

Dispersion :—

The splitting of white light into its constituent colours in the sequence of "VIBGYOR" on passing through a prism is called dispersion of light.

Refraction through prism

Consider a glass prism ABC. A light of single wave length incident on prism.



IO_1 is the incident ray, incident on refracting surface of prism (AB)

$\angle i$ is the angle of incidence.

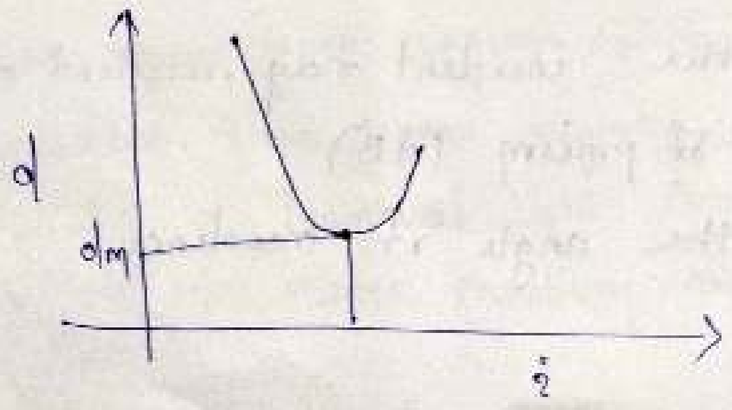
O_1O_2 be the refracted ray inside the prism.
At the refracting surface AC, this ray O_1O_2 again suffer refraction and gives emergent ray O_2E.
$\angle e$ is the angle of emergent for prism.

lets extend the incident ray in forward direction and the emmergent ray in backward direction. They meet at the point M. The angle between these two ray is called angle of deviation and it denoted by d.

Angle of deviation —

The angle subtended between the direction of incident light ray and emergent light ray from a prism is called angle of deviation (d).

→ It was observed that for different values of angle of incidence angle of deviation are different.
A graph is plotted between angle of incidence along x-axis and angle of deviation along y-axis.



From graph it is clear that the angle of deviation decreases with increasing the value of angle of incidence. But after a particular angle of incidence the angle of deviation is also increases with increasing the angle of incidence.

That particular value of angle of incidence for which we get the angle of deviation as minimum is called angle of minimum deviation.

Condition for minimum deviation ———

1) $i = e$

2) $r_1 = r_2 = r$ (say)

3) refracted ray inside the prism equally bisects the prism.

Derivation ———

In ΔMO_1O_2, d is the external angle.

$$d = (i - r_1) + (e - r_2)$$

$$d = i + e - (r_1 + r_2) \quad \text{——— (1)}$$

In ΔOO_1O_2,

$$\angle O + \angle r_1 + \angle r_2 = 180 \quad \text{——— (2)}$$

$$\Rightarrow \angle r_1 + \angle r_2 = 180 - \angle O$$

In $\square AO_1O_2O$

$$\angle A + \angle O = 180 \quad \text{——— (3)}$$

$$\Rightarrow \angle A = 180 - \angle O$$

Comparing (2) & (3)

$$\angle A = \angle r_1 + \angle r_2 \quad \text{——— (4)}$$

Using eq^n(4) in eq^n(1)

$$d = i + e - A$$

$$\Rightarrow d + A = i + e \quad \text{——— (5)}$$

Using condition for minimum deviation

$$A + d_m = i + i$$

$$\Rightarrow i = \frac{A + d_m}{2}$$

And $A = r_1 + r_2$

$$A = r + r = 2r$$

$$\Rightarrow r = A/2$$

According to Snell's law

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

$$\mu = \frac{\sin\left(\frac{A + d_m}{2}\right)}{\sin\left(A/2\right)} \quad \text{——— (6)}$$

This is the representation of refractive index of material of the prism.

Refraction through a prism for small angle of incedence —

for surface AB,

$$\mu = \frac{\sin i}{\sin r_1}$$

for i and r_1 very very small

$\sin i \approx i$
$\sin r_1 \approx r_1$ (Small angle Approximation)

$$\mu = \frac{i}{r_1} \Rightarrow i = \mu r_1 \quad \text{--- (1)}$$

Similarly $e = \mu r_2$ — (2)

so, $i + e = \mu(r_1 + r_2)$
$= \mu A$.

Again $i + e = A + d$

$\mu A = A + d$

$$\Rightarrow \boxed{d = A(\mu - 1)} \quad \text{--- (3)}$$

Mirage: —

Suffers total internal reflection, so the ray entering in the eye appear to come from S' and create a impression that the ship floating in a