Chapter- 10

Light → Reflection and refraction

Light ⇒ Light is an electromagnetic wave which help us seeing the world around us.

Properties Of light ⇒

(1) The speed of light in vacuum is maximum which is 3×10^8 m/s

2. Light does not require any medium for its propagation.

3. Light is having transverse in nature.

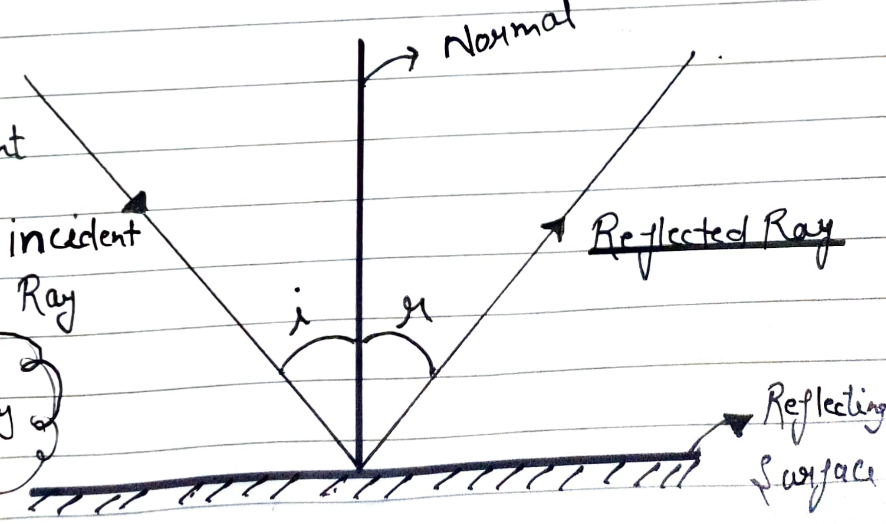
4. Light is having dual nature that is both particle nature and wave nature.

5. Light is having both electric field component and magnetic field component.

Reflection Of light ⇒ The phenomenon of bouncing back of light in the same medium in which initially it was travelling is known as reflection of light.

i = Angle of incident

r = Angle of Reflection



Angle of incident or reflection is always measured b/w incident or reflected Ray and the normal

Laws Of Reflection

(1) Angle of incident is equal to angle of reflection
{$\angle i = \angle r$}

(2) Incident ray, reflected ray and the normal all lies in the same plane.

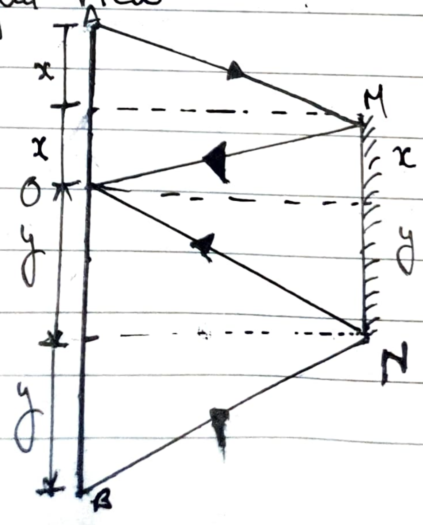
Plane Mirror

Plane Mirror is a reflecting surface whose focal length is infinity and power is zero.

Properties Of Image formed by plane Mirror

(1) The image formed by plane mirror is virtual.
(2) The distance of object from the mirror is equal to distance of image from the mirror
(3) Height or size of object is equal to size of image.
(4) The image is laterally inversed.

Minimum Height of Mirror is Required to see one's full view.



Size Of Mirror = $x+y$
height of Man (AB) = $2(x+y)$

Position of eye = O

So in oder to see one's full size in the mirror the size of mirror must be half of size of that person.

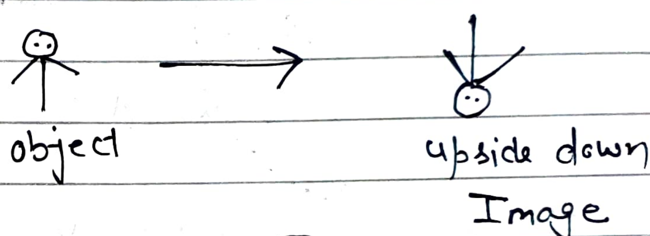
Terms Related to Image

Real Image ⇒ These are the image which are formed by actual ~~m~~ intersection of ray of light.
They can be formed on screen.

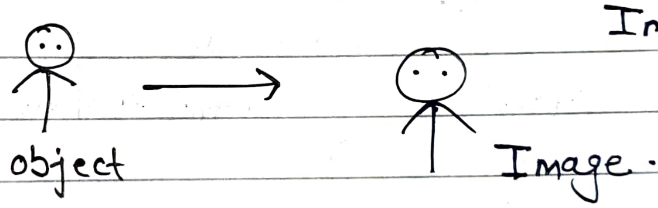
Virtual Image ⇒ These are images which are formed when rays appears to meet each other.

They can not be formed on a screen.

Inverted Image →



Erect Image →



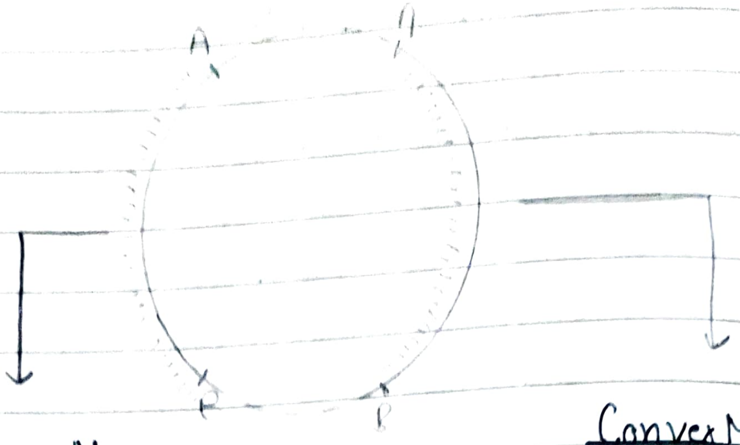
Spherical Reflecting Surface

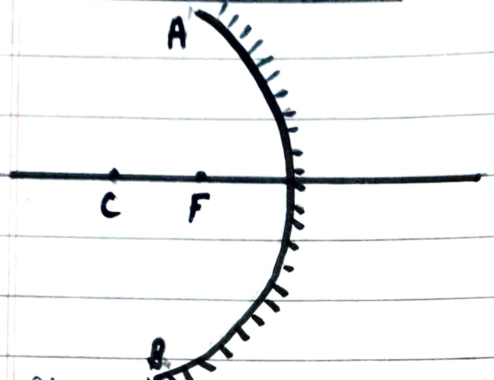
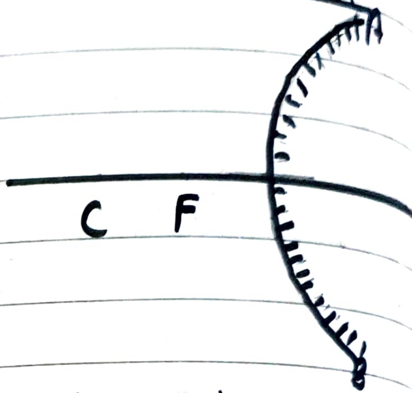
A spherical reflecting surface is basically hollow spherical glass capable of reflecting light falling on it.

Spherical Reflecting surface is basically of two type

(1) Concave

(2) Convex



Concave Mirror	Convex Mirror
	
(1) It is the mirror whose reflecting surface is towards the center of sphere from which mirror is made.	It is the mirror whose reflecting surface is away from the centre of sphere from which mirror is made.
(2) It is known as conversing mirror.	It is known as diversing mirror.
(3) It can form both real and virtual image	It will always form virtual image.
(4) The height of Image may be smaller or larger than the object.	The height of object is always ~~small~~ greater than height of image.
5) It has real focus.	It has virtual focus.

Application Of Concave Mirror.

1. They are used in solar cooker.
2. They are used in search light.
3. It is used as a dentist mirror.
4. It is used as a shaving mirror.

Application Of Convex Mirror

1. They are used as a plateform mirror.
2. Rear view mirror in car.
3. In CCTV Camera to increase the field of view.
4. It is used in parking lot.

TERMS RELATED TO SPHERICAL MIRROR

1. **Center Of Curvature** ⇒ It is the center of that sphere of which mirror is a part.

2. **Radius Of Curvature** ⇒ It is the radius of that sphere of which mirror is a part.

3. **Pole** ⇒ The centre of the spherical mirror is known as pole.

4. **Principal Axis** ⇒ It is an imaginary line which is passing through pole and centre of curvature.

Focus ⇒ It is the point on the principal axis at which rays coming parallel to each other and parallel to principal axis after reflection meet.

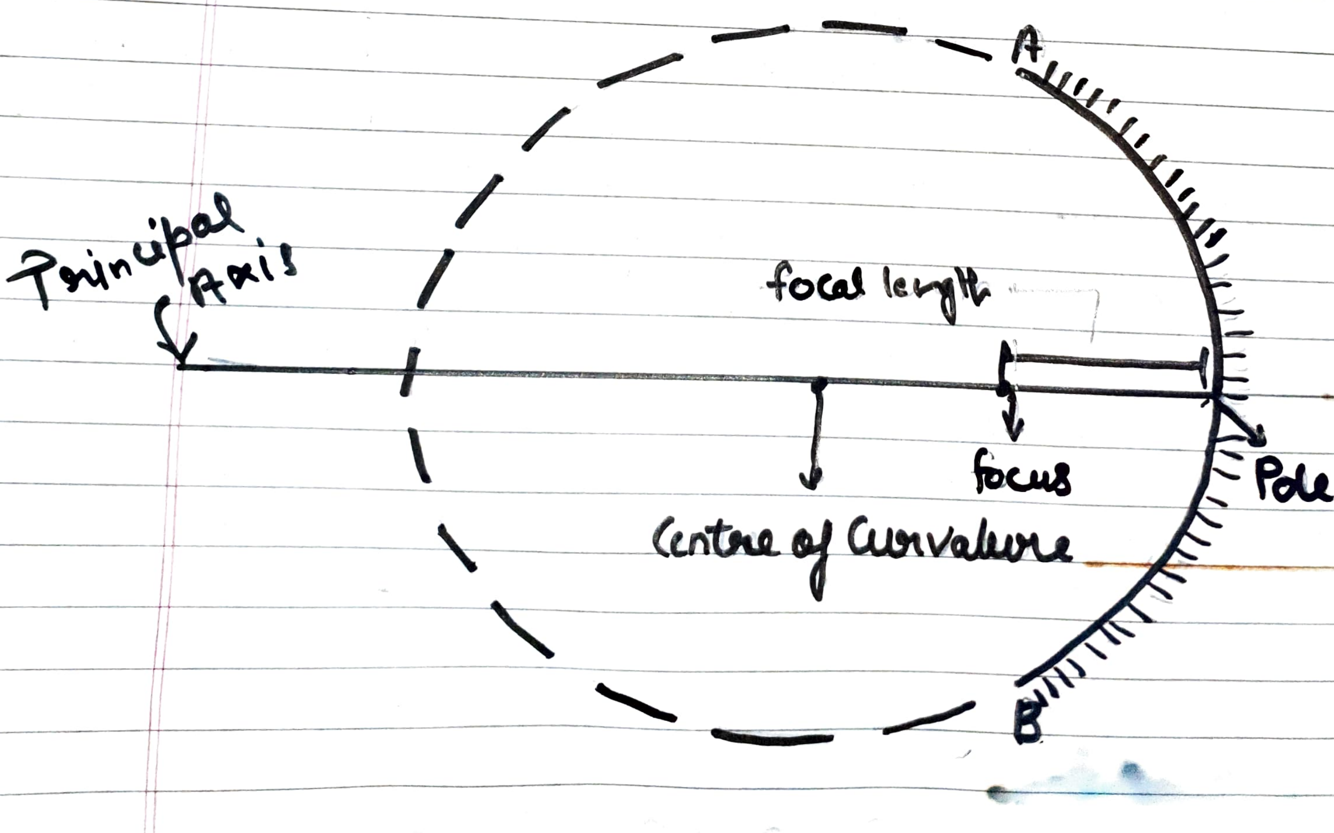
Focus

Real focus — In this rays after reflection actually meet.

Virtual focus — In this rays after reflection appears to meet.

6 Focal length ⇒ The distance b/w pole and focus is known as focal length.

7 Aperture ⇒ The maximum reflecting surface of mirror is called its aperture.



Relationship b/w focal length and radius of Curvature

$$f = \frac{R}{2}$$

MIRROR FORMULA

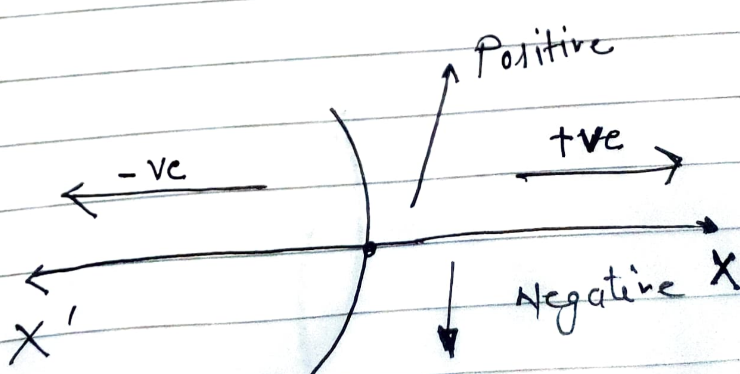
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

f = focal length
u = Distance of the object from the pole
v = Distance of image from pole of the mirror

Magnification → The ratio of height of image to the height of the object is called magnification

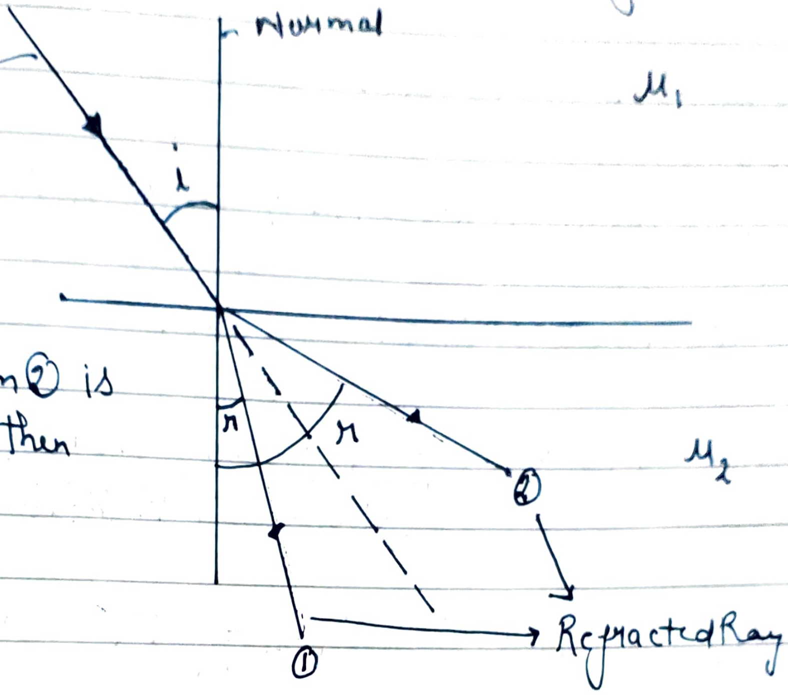
$$m = \frac{h'}{h} = \frac{\text{Height of image}}{\text{Height of Object}}$$

$$m = \frac{-v}{u}$$



Refraction Of Light

The phenomenon of change in path of light as it goes from one medium to another medium is called refraction



Case-1 ⇒ Medium ② is denser then medium ①

{$\angle i > \angle r$}

{$\mu_2 > \mu_1$}

Case-2 Medium ① is denser then medium ②

{$\angle i < \angle r$} {$\mu_2 < \mu_1$}

Laws Of Refraction

* Incident ray, refracted and the normal at the point of incidence all lies in the same plane.

* The ratio of sine angle of incidence to the sine angle of refraction is constant and is known as refractive index.

This law is also known as snell's law

$$\mu_{21} = \frac{\sin i}{\sin r}$$

$$\mu_{12} = \frac{\sin r}{\sin i}$$

Date
Page

Refractive Index ⇒ It is a dimensionless number which tells us how fast a light can propagate in a medium.

It is of two type

(i) **Absolute Refractive Index** ⇒ It is defined as the ratio of speed of light in vacuum to speed of light in medium.

$$\mu = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} = \frac{c}{v}$$

(ii) **Relative Refractive Index** ⇒ The relative refractive index of a medium one is defined as the ratio of speed of light in medium ② to the speed of light in medium ①

$$\mu_{21} = \frac{V_1}{V_2} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}}$$

Refractive index of medium ② w.r.t medium ①

$$\mu_{12} = \frac{V_2}{V_1} = \frac{\text{Speed in medium 2}}{\text{Speed of light in medium ①}}$$

$= {}_1\mu_2$

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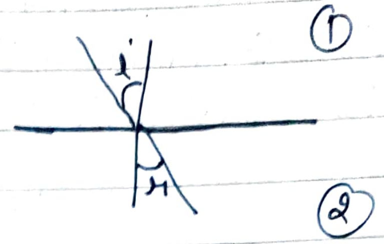
Date
Page

~~Angle~~ Relative Refractive index Interms of

(I) Angle

$$\mu_{21} = \frac{\sin i}{\sin r}$$



$$\mu_{12} = \frac{\sin r}{\sin i}$$

(II) In terms of wave length

$$\mu_{21} = \frac{V_1}{V_2} = \frac{\nu\lambda_1}{\nu\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

$$\mu_{21} = \frac{\lambda_1}{\lambda_2} \qquad \mu_{12} = \frac{\lambda_2}{\lambda_1}$$

(III) In terms of Absolute refractive index

$$\mu_{12} = \frac{\text{Absolute refractive index of medium (1)}}{\text{Absolute refractive index of medium (2)}} = \frac{\mu_1}{\mu_2}$$

$$\mu_{12} = \frac{\mu_1}{\mu_2} \qquad \mu_{21} = \frac{\mu_2}{\mu_1}$$

The value of relative Refractive index depends upon

- ★ The nature of pair of pair of medium
- ★ The wave length of light (or Colour)

Refractive index of medium is greater for voilet colour then red colour

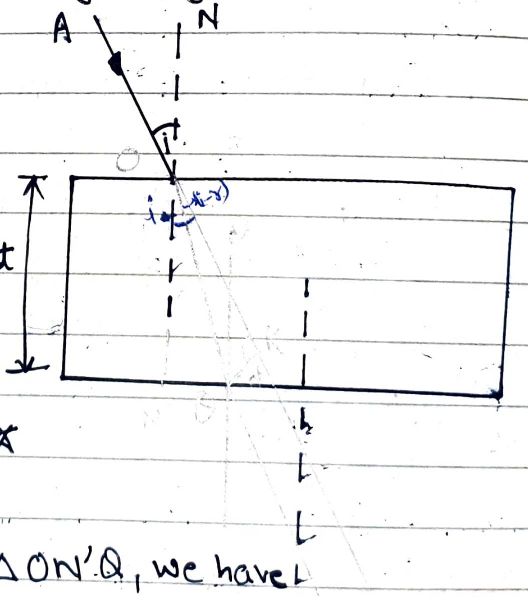
Properties Of light After Refraction

(i) Speed of light may increase or decrease
(ii) Frequency of light remains unchanged
(iii) Wave length of light is changed

$$\mu = \frac{\lambda_v}{\lambda_m} \quad = \quad \lambda_m = \frac{\lambda_v}{\mu}$$

Lateral Shift

The perpendicular distance b/w The incident ray and the emergent ray, when the light is incident obliquely on a parallel sided refracting slab is called lateral shift.



In right angled ΔOKQ

$\angle KOQ = i - r$

$$\sin(i-r) = \frac{QK}{OQ} = \frac{d}{OQ}$$

$$d = OQ \sin(i-r) \quad — \quad (*)$$

From right angled $\Delta ON'Q$, we have

$$\cos r = \frac{ON'}{OQ} = \frac{t}{OQ} \Rightarrow OQ = \frac{t}{\cos r}$$

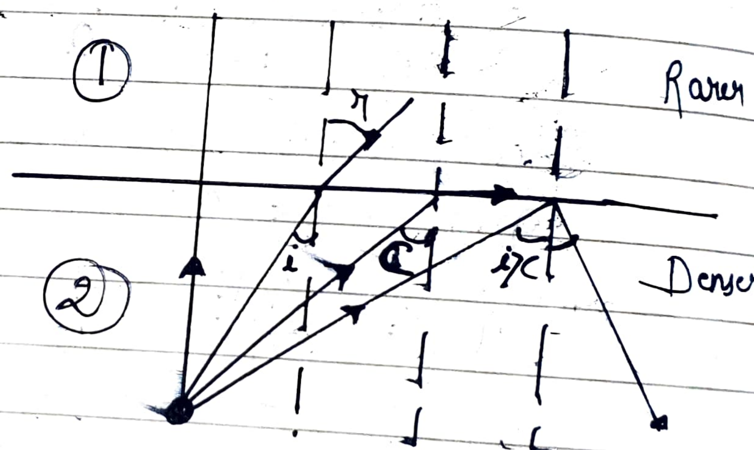
Substituting The value of OQ in equation (*)

$$d = \frac{t}{\cos r} \sin(i-r)$$

(i) Twinkling of Star
(ii) Bending of an immersed object
(iii) Apparent shift in position of sun at sunrise and sunset

Total Internal Reflection

Critical Angle ⇒ It is the angle of incidence at which angle of refraction becomes 90°



$${}^{2}\mu_{1} = \frac{\sin i}{\sin r}$$

when $i = C$

$r = 90°$

$$\mu_{12} \text{ or } {}^{2}\mu_{1} = \frac{\sin c}{\sin 90°}$$

$$\mu_{12} = \sin C$$

$$\mu_{21} = \frac{1}{\sin c}$$

Total Internal Reflection ⇒ When the light is travelling from denser medium to rarer medium and angle of incidence is greater then critical angle then light returns back in the denser medium

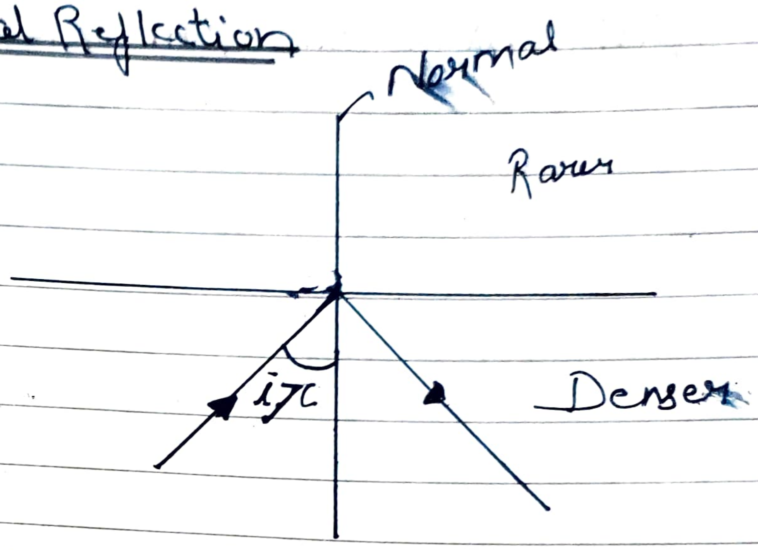
{When TIR take place angle of incidence is equal to angle of Reflection}

after reflection and this phenomenon is known as total internal reflection

Condition for Total internal Reflection

(1) Light must travell from denser to rarer medium

(2) Angle of Incidence must be greater then critical angle



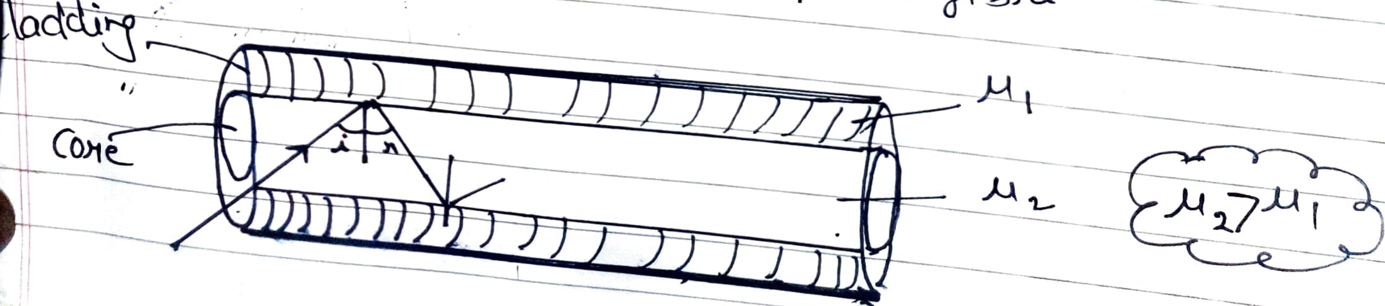
Application Of total Internal Reflection:

(i) Sparkling Of Diamond
(ii) Shining of air bubble in water
(iii) Mirage Formation.
(iv) Optical Fibre ⇒ It is a device used to transmit light signal.

Principle ⇒ It is based upon the principle of TIR

Construction ⇒ It consist of extremely thin long strand of quality glass or quartz surrounded by a glass coating of slightly lower refractive index.

- Jacket is used to protect the optical fibre



Refraction By Spherical Lenses

Lens ⇒ A transparent material bounded by two surfaces of which one or both surface are spherical, forms a lens.

There many types of lens but in our syllabus we are only restricted to concave and convex lens

Convex lens

It is a spherical lens in which both spherical surfaces are bulging outwards.

It is thick at the centre and thin at the edges.

It is known as converging lens.

It's focus is real

It may form real and virtual image

Concave lens

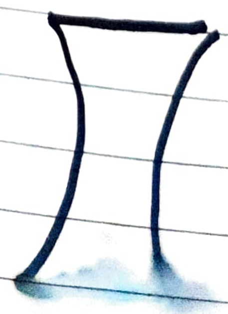
It is a spherical lens in which both spherical surfaces are bulging inwards.

It is thin in the middle and thick at the edges.

It is known as diverging lens.

It's focus is virtual.

It always form virtual image.



Application of Convex lens.

1. Camera
2. Microscope
3. Telescope
4. Spectacles

Application of Concave lens

1. Spectacles
2. Lasers
(3) STREET LIGHT
(4) REFLECTORS
5. LASERS

LENS FORMULA

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

where f = focal length
u = Distance of object from optical Centre
v = Distance of image from optical centre

Magnification ⇒ The ratio of height of image to the height of object is called magnification.

$$m = \frac{h'}{h}$$

$$m = \frac{v}{u}$$

Power Of a lens ⇒ The ability of a lens to converse or diverse the rays of light falling on it is called power of lens.

OR

The reciprocal of focal length of lens is called its power.

$$P = \frac{1}{f(m)}$$

SI unit of Power is dioptre (D)

Combination Of lens ⇒ When two or more lenses combined together then their effective power is given by

$$P = P_1 + P_2 + P_3 + \cdots + P_n$$

Power for convex lens = +ve
Power for concave lens = -ve

Q ⇒ Two lens having power 6 D and -3 dioptre combined together. What is effective power, focal length nature of combination

Ans:- Power = $P_1 + P_2$

$P = 6 - 3 = 3$

$P = 3D$

$f = \frac{1}{P} = \frac{1}{3} \Rightarrow f = \frac{1}{3}$

Sign Convention

Focal length

Concave Mirror | lens ⇒ -ve
Convex Mirror | lens ⇒ +ve

Distance of object

object $u = -ve$

Magnification

Real Image: -ve

Virtual Image: +ve

Height Of Image

Real Image: -ve

Virtual Image: +ve

Types Of Mirror

m = -ve
Concave
(Real)

M = +ve
- Concave: if $m > 1$
- Convex: if $m < 1$

h' = -ve
Concave

h' = +ve
- $h' > 1$: Concave
- $h' < 1$: Convex

Types Of lens

(i) Based upond Power

$P = +ve$
Convex lens

$P = -ve$
Concave lens

(ii) Based upon magnification

$m = -ve$
Convex lens

$m = +ve$
Concave lens $(m<1)$
Convex lens $(m>1)$

(iii) Based upon Height of Image

$h' = -ve$
Convex lens

$h' = +ve$
Concave lens $\left(\frac{h'}{h}<1\right)$
Convex lens $\left(\frac{h'}{h}>1\right)$