

It is the branch of physics that deals with the scientific study of lights.

There are 3 types of Optics

- ① Ray optics — Geometric optics ✓
- ② wave optics — physical optics ✓
- ③ Quantum optics ✓

light : light is the radiant energy which give us sensation of vision when falls on our eyes.

⇒ Some properties of light

- ① light is an electromagnetic wave and having wave length of $400\text{ nm} - 750\text{ nm}$
- ② Velocity of light is also constant unless medium is change.
Velocity of light in air ($3 \times 10^8 \text{ m/s}$)
- ③ Rectilinear propagation (i.e. light always travels in straight path)

Ray Optics :- It is also considered as geometric optics which is the study of simple properties of light.

- ① Reflection
- ② Refraction
- ③ Dispersion

[Under the assumption that light acts as Ray]

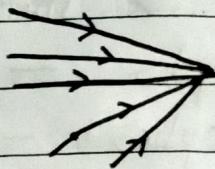
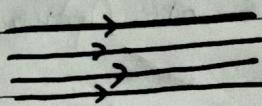
Ray & Beam of light :- The path along which a light travel in a homogenous medium is known as ray of light.

It is represented by straight line with the arrow in the middle, in the direction of propagation of light.

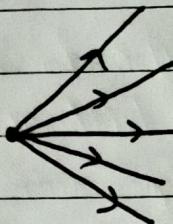
A collection of rays of light is known as beam of light.

⇒ Types of beam of light

- ① Parallel beam of light. ② Convergent beam of light



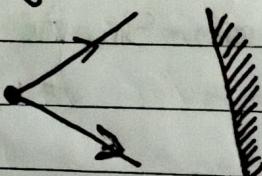
- ③ Divergent beam of light.



Object & Image.

① Object :- An object is a source of incident rays for an optical element - an object can be luminous or non-luminous. there are two types of objects.

② Real object :- An object is said to be real if the incident rays are diverging in nature



③ Virtual object :- An object is said to be a virtual if the incident rays are appeared to converge at a point.

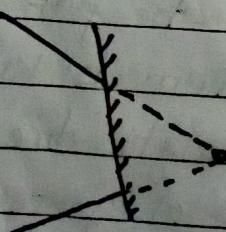
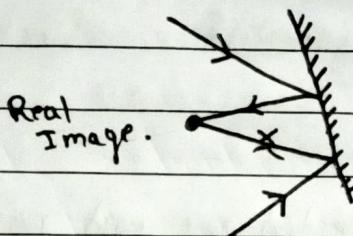
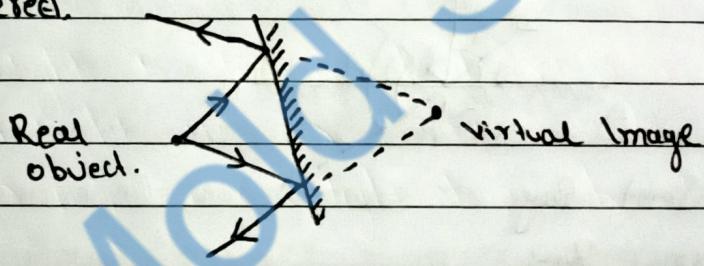


Image :- An ^{Image} object is formed due to intersection of reflected ray or refracted ray. There are two types of image:-

① Real Image :- An image is said to be real, if the reflected rays are converges at a point. This types of image can be obtained in screen. the nature of this image is inverted.



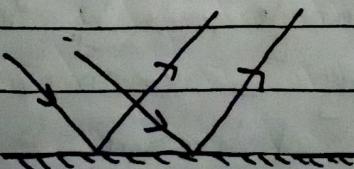
② Virtual Image :- An image is said to virtual, if the reflected rays are appeared to diverges from a point. This image can't be obtained on Screen. the nature of this image is erect.



Reflection :- The Returning of light into the same medium after striking a surface is known as reflection of light. there are two types reflection

① Regular Reflection :- The Regular Reflection that takes place on plane surface is known as regular reflection. In regular reflection, the reflected rays follow the same manner to that of Incident rays.

Ex :- reflection on plane mirror.



⑩ Diffuse reflection:- The reflection that take place on rough is known as diffuse reflection. It is also known as irregular reflection. In this reflection the reflected rays doesn't follow similar manner to that of incident ray.

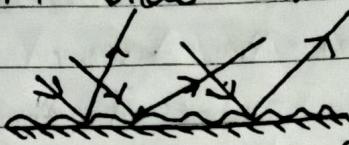
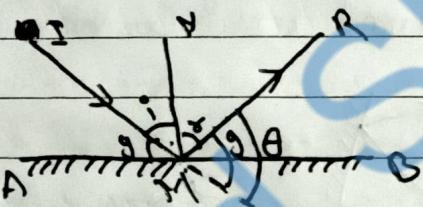


Fig:- Diffuse reflection.

laws of reflection:-

- ① The incident ray, reflected ray and normal ray always lie on a same plane
- ② The angle of incident is equivalent to angle of reflection.



IM = Incident Ray

NM = Normal Ray

RM = Reflected Ray

$\angle IMN = i$ = angle of incident

$\angle NMR = r$ = angle of reflection,

γ = Glancing angle

θ = Angle of deviation

- Glancing angle:- The angle made by a plane mirror either with the incident ray or reflected ray is called glancing angle.

- Angle of deviation:- The angle made by the reflected ray with the direction of incident ray is known as Angle of deviation.
note:- The angle of deviation is twice of glancing angle.

Rule - when an observer is moving towards the plane mirror with the Velocity v then the image is moving towards the observer with a velocity of $2v$

Mirror:- Mirror is a smooth reflector of light which one surface is polished there are two types of mirror

① Plane mirror:- if the reflecting surface of a mirror is flat then it is called plane mirror.

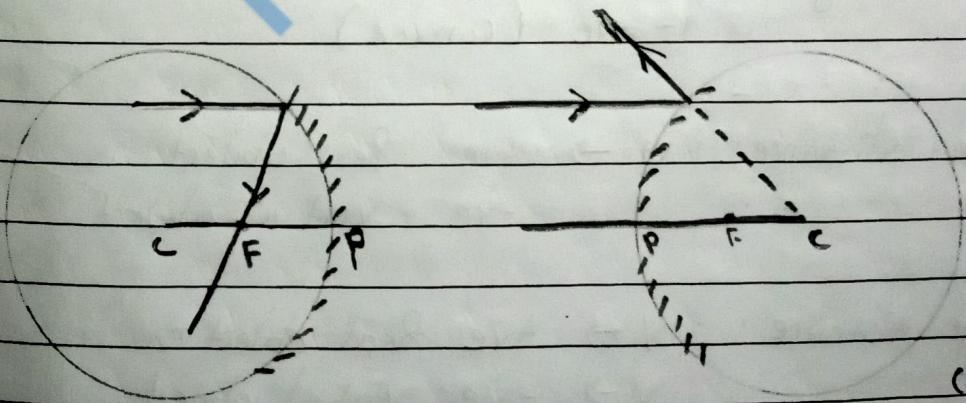
② :- if the reflecting surface of a mirror is curved then it is called curved mirror

- there are two types of curve mirror. (i.e Spherical & cylindrical)

① Spherical mirror:- Spherical Mirror is a part of a hollow which one side is polished. there are two types of spherical mirror,

① Concave mirror:- Concave mirror is the spherical mirror whose reflecting surface is curved inward

② Convex mirror:- Convex mirror is the spherical mirror whose reflecting surface is curved outward



Sum termology in a curved mirror.

① Aperture:- That portion of mirror from which the reflection of light actually takes place is called the aperture of the mirror.

Aperture of a mirror represents the size of the mirror.

- ⑩ Pole :- It is the geometrical centre of the reflecting surface. It is represented by the letter P.
- ⑪ Centre of curvature :- It is the centre of the sphere of which the mirror forms the part. It is represented by C.
- ⑫ Radius of curvature :- It is the radius of the sphere of which the mirror forms the part. It is represented by $PC = R$
- ⑬ Focus :- It is the point of the principle axis at which the rays parallel to the principle axis meet (concave mirror) or appear to meet (convex mirror) after reflection.
- ⑭ Focal length :- The distance between the pole and the principle focus of a spherical mirror is called focal length.

Sign convention of mirror.

① Radius of curvature : $R \rightarrow +ve$ (concave mirror)
 $R \rightarrow -ve$ (convex mirror)

② Focal length : $f \rightarrow +ve$ (concave)
 $f \rightarrow -ve$ (convex)

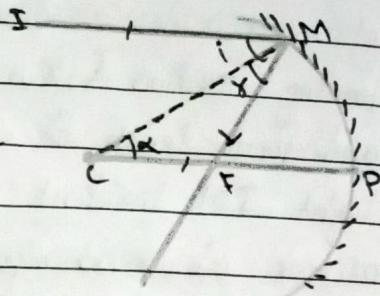
③ Object distance : $u \rightarrow +ve$ Real object
 $-ve$ Virtual object.

④ Image distance : $v \rightarrow +ve$ Real object
 $-ve$ Virtual object.

Relationship between radius of curvature and focal length of mirror.

① Concave mirror.

let us consider, a concave mirror with the radius of curvature (R) and focal length (f). when a ray of light IM incident on a concave mirror which is parallel to principle axis intersect the axis at a point (f).



Let a normal CM is drawn to a mirror at a point P.

$$\text{FP} = \text{Focal length} = f$$

$$CP = \text{Radius of curvature} = (R)$$

According law of reflection,

$$\angle i = \angle r \quad \dots \text{(i)}$$

$$\angle i = \angle x \quad \dots \text{(ii)} \quad \text{Alternate angle}$$

Then,

$\triangle CMF$ is an isosceles triangle [from (i) and (ii)]

$$\text{Now, } CF = FM$$

for a small Aperature,

$$FM \sim FP \quad \dots \text{(iv)}$$

Again,

$$CP = CF + FP$$

$$CP = CF + FM \quad \dots \text{from iv.}$$

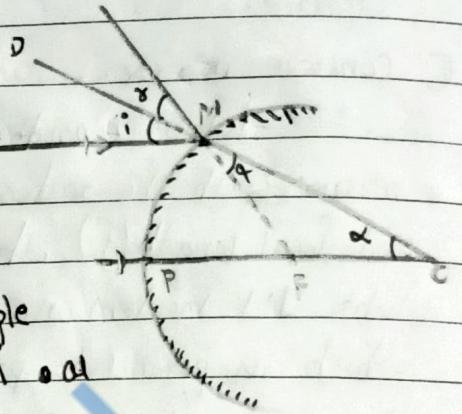
$$CP = CF + CF \quad \text{from (ii)}$$

$$CP = 2CF$$

$$\therefore R = 2f$$

Relation between R and f in Convex mirror.

let us consider a convex mirror having radius of curvature R and focal length f . when a ray of light IM incident on a convex mirror which is parallel to principle axis also appears to intercept in f on axis.



\therefore draw: CO which is normal for the reflection

$$\therefore FP = f \text{ focal length}$$

$$\therefore PC = R \text{ radius of curvature}$$

According to law of reflection

$$\angle i = \angle \beta \dots (i)$$

$$\angle \gamma = \angle i = \angle \alpha \dots (ii) \text{ vertical opposite angle + from } (i)$$

$$\angle C = \angle \alpha \dots (iii) \text{ Corresponding angle}$$

In $\triangle MCF$.

$$FC = MF \text{ Since base angle are equal (i.e isosceles triangle)} \dots (iv)$$

Also, when Apperture is very Small

$$PF \sim MF$$

$$\therefore PF = MF \dots (v)$$

$$\text{Now, } PC = PF + FC$$

$$\text{or, } PC = PF + MF \dots \text{from (v)}$$

$$\text{or } PC = PF + PF \dots \text{from (iv)}$$

$$\text{or } PC = 2PF$$

$$\therefore R = 2f \text{ proved//}$$

Mirror formula :- ($\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$)

The relationship between focal length of a mirror with the object distance and Image distance is given by

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

① Mirror formula for a concave mirror.

② Real Image is formed.

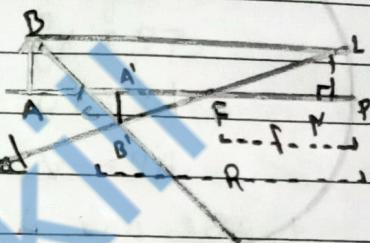
Consider an object AB which is placed

beyond the centre of curvature of a

Concave mirror an Image A'B' is formed

in between C and f. Let us draw

a normal LN to the principle axis as shown in the figure



$\triangle ABC$ and $\triangle A'B'C$ are similar so,

$$\frac{A'B'}{AB} = \frac{A'C}{AC} = \frac{CP - AP}{AP - CP}$$

$\triangle A'B'F$ and $\triangle FLN$ are similar,

$$\frac{A'B'}{AB} = \frac{A'F}{FN} = \frac{AP - FP}{FN} \quad \text{--- (i)}$$

$$\frac{A'B'}{LN} = \frac{A'F}{FN} = \frac{AP - FP}{FN}$$

For small aperture of a mirror.

$$FN = FP$$

$$\frac{A'B'}{AB} = \frac{v-f}{f-p}$$

$$\frac{A'B'}{AB} = \frac{v-f}{f} \quad \text{--- (ii)}$$

Equating (i) & (ii)

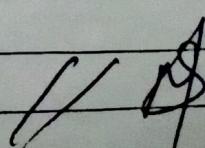
$$\frac{v-f}{f-p} = \frac{v-f}{f}$$

$$v-f^2 - vf = vf - vf - 2vf \Rightarrow f^2 = 2vf$$

$$v-f = vf - vf \quad (\text{dividing both sides by } vf)$$

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

$$\therefore \frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \text{proved}$$



④ when virtual image is formed.

Consider an object AB is placed in between F and P on Image A'B' is formed behind the mirror which

is virtual. Let us draw a normal LN to the principle axis as shown in the figure

Sign Convention:

$$FP = +f, CP = -2f$$

$$AP = +v$$

$$A'P = -v$$

$\triangle ABC$ and $\triangle A'B'C$ are similar so,

$$\frac{A'B'}{AB} = \frac{A'C}{AC} = \frac{A'P + CP}{CP - AP}$$

$$\text{or } \frac{A'B'}{AB} = \frac{-v + 2f}{2f - v} \quad \text{--- ①}$$

$\triangle FIN$ and $\triangle A'B'F$ are similar.

$$\frac{A'B'}{LN} = \frac{A'F}{FN} = \frac{A'P + FP}{FN}$$

for a small aperture of a mirror.

$$FN \approx FP$$

$$\frac{A'B'}{LN} = \frac{-v + f}{FP}$$

$$= \frac{-v + f}{f}$$

equating ① & ②

$$\frac{-v + 2f}{2f - v} = \frac{-v + f}{f}$$

$$-fv + 2f^2 = -2fv + 2f^2 + fv - vf$$

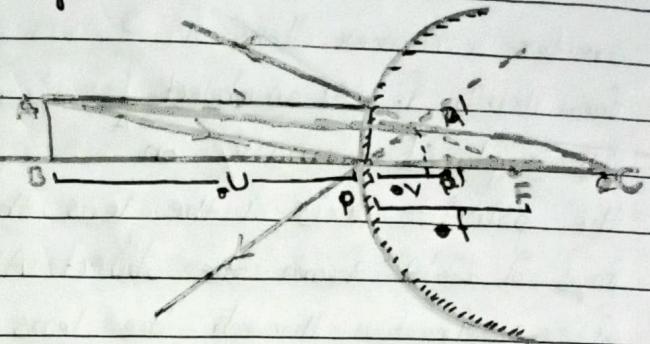
$$9vf - vf = vf \quad \text{Dividing both sides by } vf,$$

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

A.9 Mirror's formula for convex mirror.

① When ~~real~~ image is formed.

Consider an object AB is placed in ~~beyond~~ beyond F so an image is formed A'B' which is virtual.



$\triangle ABP$ and $\triangle A'B'P$ are similar

$$\frac{AB}{A'B'} = \frac{BP}{B'P'} \quad \text{⑩}$$

Sign convention

$$BP = -u$$

$$PB' = +v$$

$\triangle ABC$ and $\triangle A'B'C'$ are similar

$$\frac{AB}{A'B'} = \frac{BC}{B'C} \quad \text{⑪}$$

From ⑩ & ⑪

$$\frac{BP}{B'P'} = \frac{BC}{B'C}$$

$$\frac{BP}{B'P'} = \frac{BP+PC}{BC-PB'}$$

$$\therefore \frac{-u}{v} = \frac{-u+(+R)}{+R-(-v)}$$

$$\therefore u = v(u+R) - u(R-v) = v(-u+R)$$

$$\text{or} \quad -uR + uv = -uv + vR$$

$$\text{or} \quad 2uv = vR + uR$$

Dividing both side by uvR also $R=2f$,

$$\frac{2uv}{uvR} = \frac{vR}{uvR} + \frac{uR}{uvR}$$

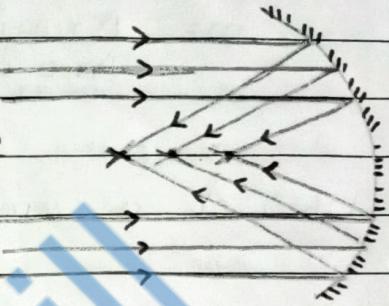
$$\text{or } \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Spherical Aberration.

The inability of an optical device to converge a ~~any~~
selected or refracted ray of light at point is known as
Spherical Aberration.

parabolic mirror is free from Spherical Aberration.

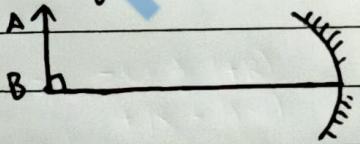
- **Caustic curve :-** When a parallel beam of light incident on a ~~curv~~ concave mirror having large Apperture then reflected rays don't pass through the same point but lies at the different point of curve known as Caustic curve



Magnification :- Magnification gives the idea bout the dimension of an image compared to the dimension of an object.
there are three types of magnification

- ① **Linear Magnification :-** In Linear magnification an object is placed perpendicular to the principle axis.

The linear magnification is defined as the ratio of height of an image to the height of an object.



$$m = \frac{I}{O} = \frac{y}{x}$$

Note: $\frac{x-f}{f} = \frac{y}{x}$

- ② **Lateral magnification :-** Lateral magnification an object is placed along the principle axis

The lateral magnification is defined as the ratio of length of an image to the length of an object.

$$m = \frac{\text{length of Image}}{\text{length of object}}$$

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

