Unit:-3 OPTICS :- Reflection at curved mirror

classmate
Date
Page

Chapter-14

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

There are 3 types of Optics

(i) Ray optics — Geometric optics
(ii) wave optics] — physical optics
(iii) Quantum optics

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

=> Some properties of light
(i) light is an electromagnetic wave and having wave length of 400 nm - 750nm
(ii) Velocity of light is also constant unless medium is change.
Velocity of light in air (3×10^8 m/s)
(iii) 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.
(i) Reflection
(ii) Refraction
(iii) Dispersion

[under the assumption that light acts as Ray]

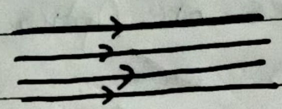
Ray & Beam of light :- The path along which a light travel in a homogenous medium is known as ray of light. It is represented by straight line with the arrow in the middle, in the direction of propagation of light.

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

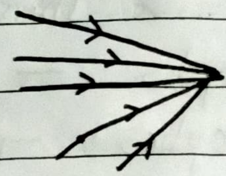
Page

:) Types of beam of light

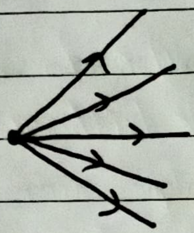
(i) Parallel beam of light.



(ii) Convergent beam of light



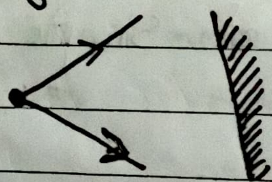
(iii) Divergent beam of light.



object & Image.

(i) 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.

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



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

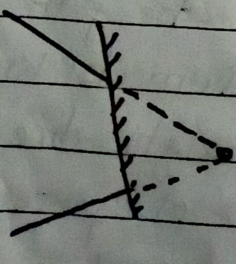
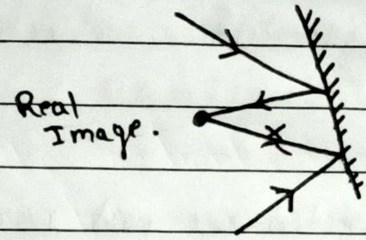
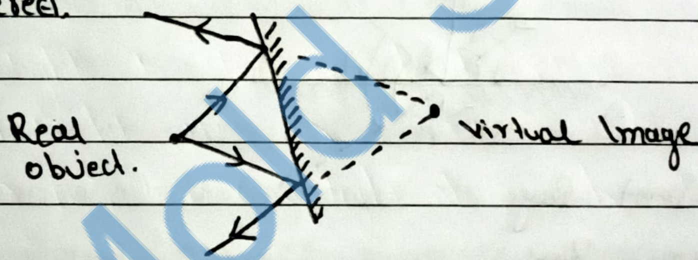


Image :- An ~~object~~ Image is formed due to intersection of reflected ray or refracted ray. There are two types of image :-

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



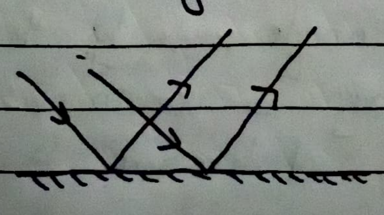
② virtual Image : An Image is said to virtual. If the reflected rays are appeared to diverges from a point. This Image can't be obtained on Screen. the nature of this Image is erect.



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

① Regular Reflection :- The ~~Regul~~ 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.

For eg :- reflection on plane mirror.



Date
Page

(ii) 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.

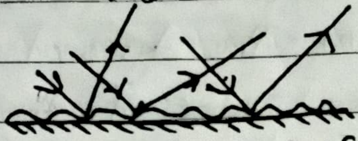
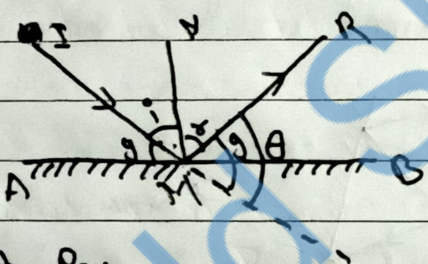


fig :- Diffuse reflection.

laws of reflection :-

(i) The incident ray, reflected ray and normal ray always lie on a same plane
(ii) The angle of incident is equivalent to angle of reflection.



IM = Incident Ray
NM = Normal Ray
RM = Reflected Ray
∠IMN = i = angle of Incident
∠NMR = r = angle of reflection,
g = Glancing angle
θ = Angle of deviation

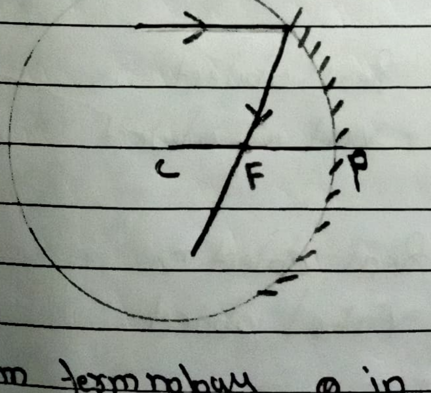
- Glancing angle :- The angle made by a plane mirror either with the incident ray or reflected ray is called glancing angle.

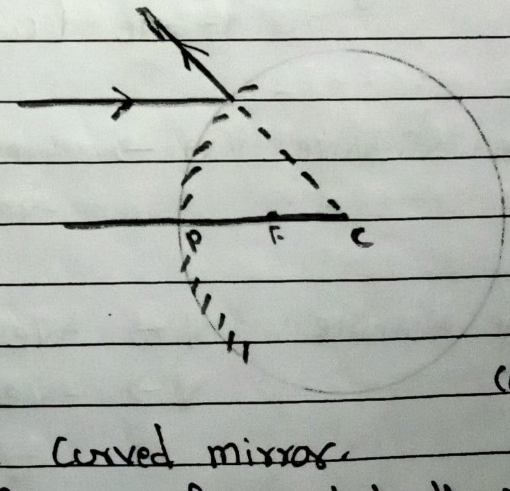
- Angle of deviation :- The angle made by the reflected ray with the direction of incident ray is known as Angle of deviation.
  note :- The angle of deviation is twice of glancing angle.

Note - 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
(i) plane mirror:- if the reflecting surface of a mirror is flat then it is called plane mirror.
(ii) :- 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)
(i) Spherical mirror:- Spherical Mirror is a part of a hollow which one Side is polished. there are two types of Spherical mirror,
(i) Concave mirror:- Concave mirror is the spherical mirror whose reflecting surface is curved inward
(ii) Convex mirror:- Convex mirror is the spherical mirror whose reflecting surface is ~~curved~~ curved outward





convex

Sum termnology in a curved mirror.
(i) Aperature:- That portion of mirror from which the reflection of light actually takes place is called the aperature of the mirror.
Aperature of a mirror represents the size of the mirror

classmate

Date
Page

(ii) Pole :- It is the geometrical centre of the reflecting surface. It is represented by the letter P.

(iii) Centre of curvature :- It is the centre of the sphere of which the mirror forms the parts. It is represented by C.

(iv) Radius of curvature :- It is the radius of the sphere of which the mirror forms the part it is represented by 'PC' = 'R'

(v) 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,

(vi) Focal length :- The distance between the pole and the principle focus of a spherical mirror is called focal length.

Sign convention of mirror.

(i) Radius of curvature : R → +ve (concave mirror)
R → -ve (convex mirror)

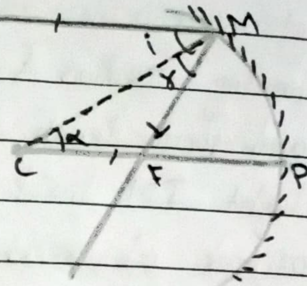
(ii) focal length : f +ve (concave)
f -ve (convex)

(iii) object distance : u → +ve Real object
-ve Virtual object.

(iv) Image distance : v → +ve Real object
v → -ve virtual object.

Relationship between radius of curvature and focal lenth 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 inter-cect the axis at a point (f).

let a normal CM is drawn to a mirror at a point

FP = focal length = f

CP = Radius of curvature = (R)

According law of reflection,

$$\angle i = \angle r \text{ --- (i)}$$

$$\angle i = \angle \alpha \text{ --- (ii) Alternat angle}$$

Then,

ΔCMF is an isosceles triangle [from (i) and (ii)]

Now, CF = FM

for a small Aperature,

$$FM \sim FP \text{ ---- (iv)}$$

Again,

$CP = CF + FP$

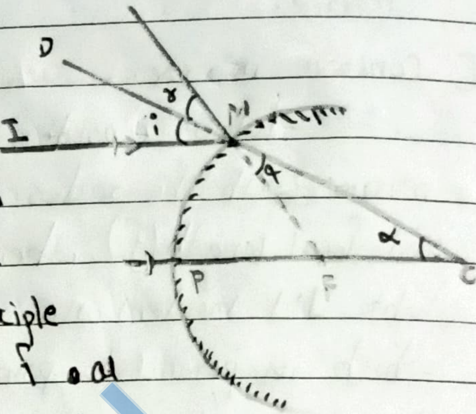
$CP = CF + FM$ --- from iv.

$CP = CF + CF$ from (iii)

$CP = 2CF$

$\therefore R = 2f$

Relation between R and f in Convex mirror.



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

∴ Draw: (i) which is normal for the reflection

∴ FP = f focal lenth

∴ PC = R radius of curvature

According to law of reflection

$\angle i = \angle r$ --- (i)

$\angle r = \angle i = \angle \alpha$ --- (ii) vertical opposit angle + from (i)

$\angle c = \angle \alpha$ --- (iv) Corresponding angle

In Δ MCF.

FC = MF Since base angle are equal (i.e isoceles triangle) -- (v)

Also, when Apparture is very Small

PF ~ MF

∴ PF = MF --- (vi)

Now, PC = PF + FC

or, PC = PF + MF --- from (v)

or PC = PF + PF --- from (vi)

or PC = 2PF

∴ R = 2f proved//

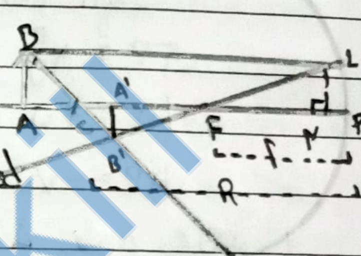
Mirror formula :- (दर्पण सूत्र)

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

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

① Mirror formula for a concave mirror.

① 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

ΔABC and $\Delta A'B'C$ are similar so.

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

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

$\Delta A'B'F$ and ΔFLN are similar,

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

for small aperature of a mirror.

$$FN = FP$$

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

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

Equating ① & (ii)

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

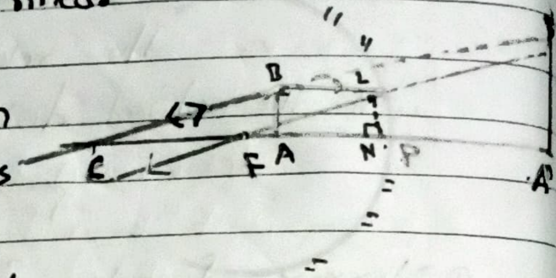
or $2f^2 - vf = uv - uf - 2vf + 2f^2$

or $+vf = uv - uf$ (dividing both side by uvf)

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

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

(1) When virtual image is formed.



Consider an object AB is placed in between F and P an Image A'B' is formed behind the mirror which is virtual, let us Draw a normal LN to the principle axis as shown the figure

Sign convention:

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

$AP = +u$

$A'P = -v$

ΔABC and $\Delta A'B'C$ are similar so,

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

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

ΔFLN and $A'B'F$ are similar,

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

for a small Aperature of a mirror.

$FN \approx FP$

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

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

equating (1) & (1)

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

$$-fv + 2f^2 = -2fv + 2f^2 + uv - uf$$

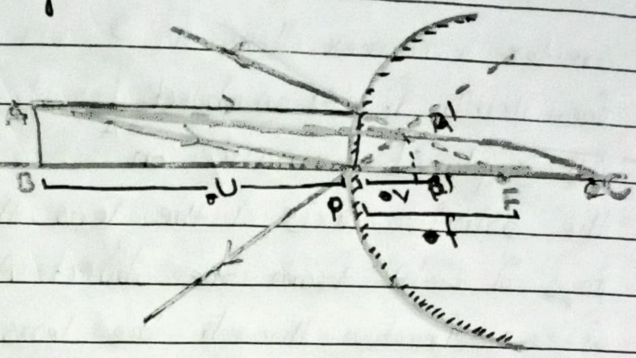
$fv + uf = uv$ Dividing both sid uvf,

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

Q2 Mirror formula for convex mirror.

(a) when ~~Virtual~~ image is formed.

Consider an object AB is placed in ~~between~~ beyond & an Image is formed A'B' which is virtual.



ΔABP and $\Delta A'B'P$ are similar

sign convention
$BP = -u$
$PB' = +v$

$$\frac{AB}{A'B'} = \frac{BP}{B'P'} \quad \text{--- (i)}$$

ΔABC and $\Delta A'B'C$ are similar

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

from (i) & (ii)

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

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

or $\dfrac{-u}{v} = \dfrac{-u+(+R)}{+R-(+v)}$

~~$-u = v(u+R)$~~ $\quad -u(R-v) = v(-u+R)$

or $\quad -uR + uv = -uv + vR$

or $\quad 2uv = vR + uR$

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

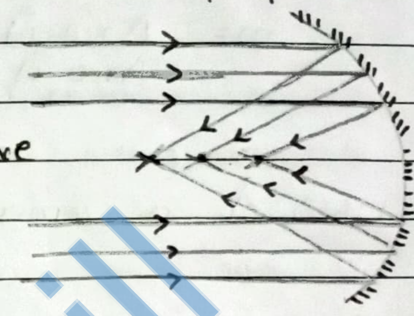
$$\frac{2uv}{uv2f} = \frac{vR}{uvR} + \frac{uR}{uvR}$$

or $\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$

Spherical Aberration.

The inability of an optical device to converse a ~~ray~~ reflected or refracted ray of light at point is known as spherical Aberration.

parbolic mirror is free from sphepical Abberation



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

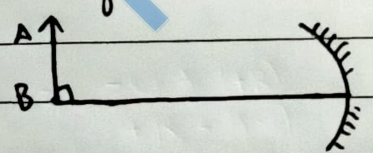
Magnification :- Magnification gives the idea bout the dimension of an image compared to the dimension of an object.

there are three types of magnification

(i) 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 heigh of an object.

Note: $\frac{v-f}{f} = \frac{\cancel{v}f}{u-f}$



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

(ii) Lateral magnification :- I Lateral magnification an object is placed along the principle axis

The Lateral magnification is defined as the ratio of ~~an~~ lenth of an Image to the lenth of an object.

$m = \frac{\text{length of Image}}{\text{length of object}}$ $\quad m = \frac{v_2 - v_1}{u_2 - u_1}$