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Chapter - 9

Ray optics & optical Instruments

Optics - is the branch of physics which deals with the sources properties and effects of light.

" Light is the form of energy which makes the object visible".

Ray optics

Ray optics describe light propagation in term of rays. the ray in geometric optics is an abstraction useful for approximating, the paths along which light propagates under certain circumstances.

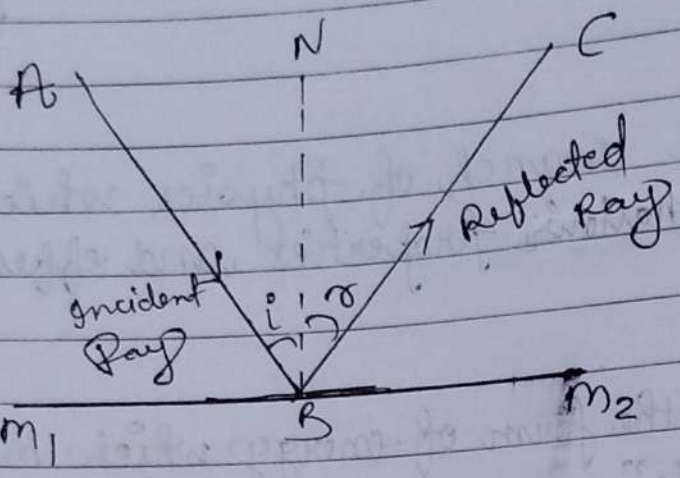
Light

Light is electromagnetic radiation within a certain portion of electromagnetic spectrum. The word usually refers to visible light, which is the responsible for the sense of light.

Speed = 3×10^8 m/sec

Range of wave length of visible light is 4000 Å to 7800 Å

Reflection of Light



i = angle of incident
r = angle of reflection

Reflection of light is a process of sending back the the light rays which falls on the surface of an object.

"when a ray of light falls on a polished and shining surface of an object then it is send back in the same medium".

Laws of Reflection

i The incident ray, the reflected ray and the normal to the surface at the point of incident all lie in the same surface.

ii The angle of reflection (r) is every time equal to angle of incident (i)

Image

The rays emerging from a point of object actually meet at a point after reflection (or refraction) or appears diverse from the point then this point is called image of first point.

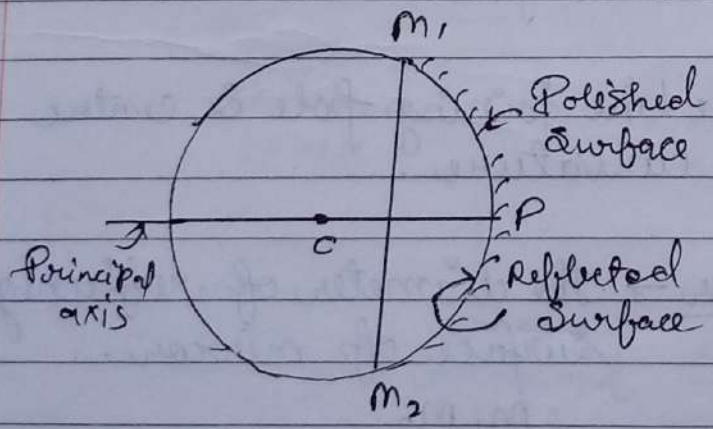
There are two types of image.

① Real Image – Image will be real if ray actually meet at point after reflection.

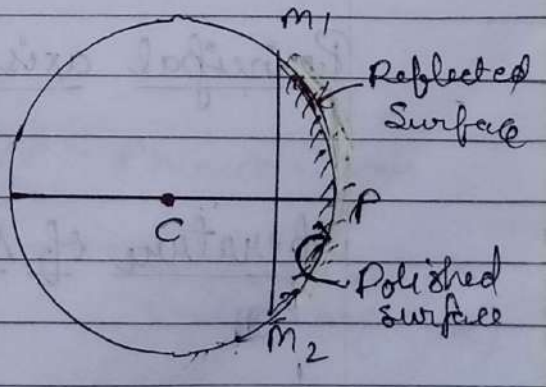
② Virtual Image – If the rays do not actually meet after reflection but appear to diverge from the point when produced backward the image is called Virtual.

"☆ The real image can be taken on screen while Virtual image can not be taken on screen"

Spherical Mirror



(i) Concave mirror



(ii) Convex mirror

Concave mirror → Concave mirror is a spherical mirror whose reflecting surface is curved outwards.

Convex mirror → reflecting surface is curved outwards.

A reflecting surface which is a part of a sphere is called Spherical mirror

Centre of Curvature → The centre of that sphere which mirror is a part is called centre of curvature.

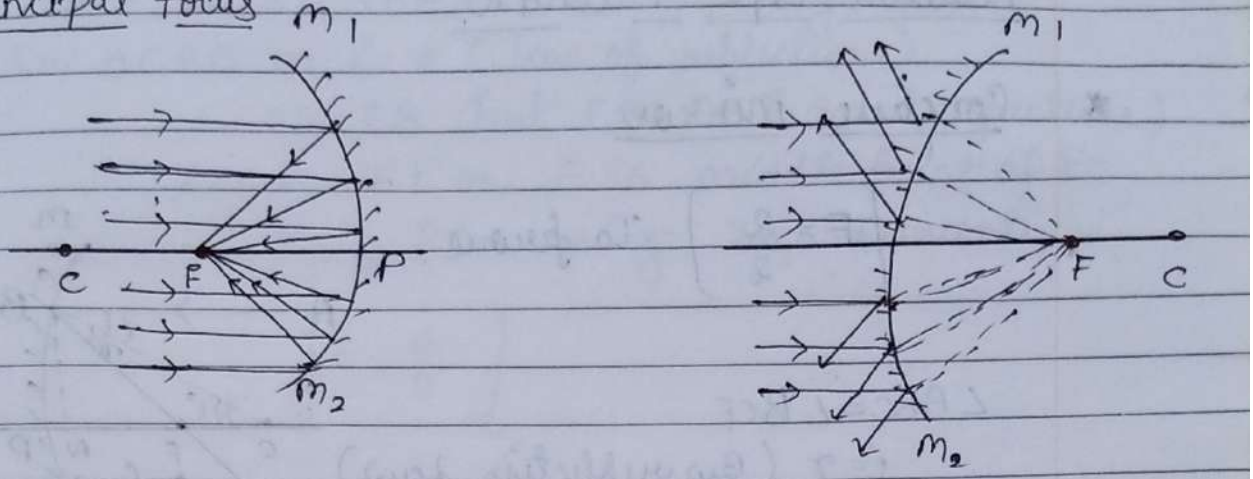
Radius of curvature → The radius of that sphere which mirror is a part is called radius of curvature

Pole → The middle point of reflecting surface of mirror is called pole.

Principal axis → The line joining pole & centre of curvature.

Aperature of Mirror → The diameter of reflecting surface of mirror.
$M_1 M_2$.

Principal Focus

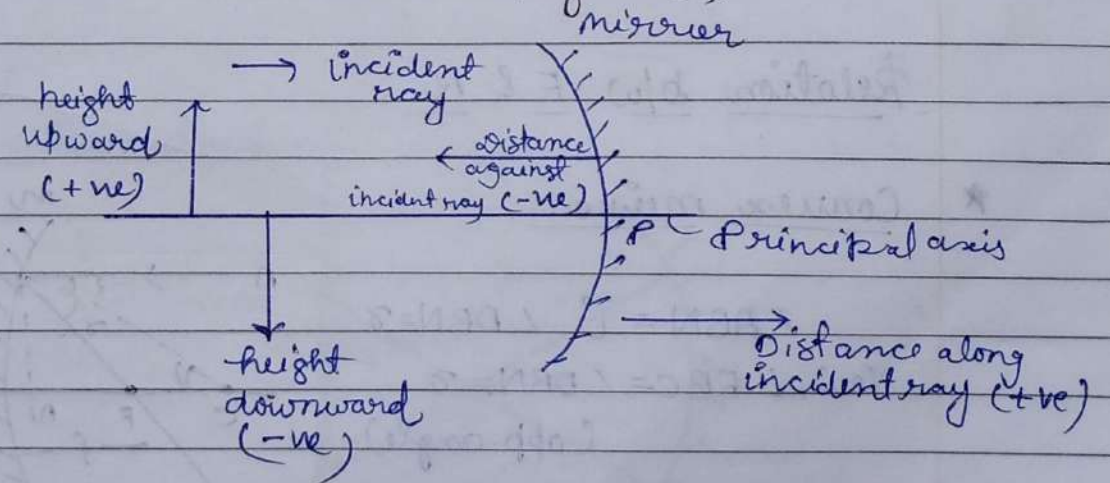


The light rays coming parallel to principal axis after reflection from mirror really meet or appear to meet at a point of principal axis is called principal focus of mirror. (F).

Focal length → the distance b/w Pole and Principal focus.

Sign Convention of measuring Distances

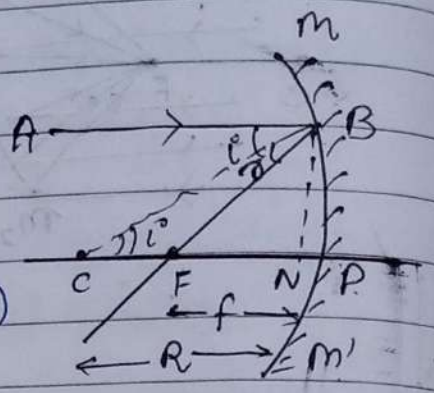
(Co-ordinate system)



Relation b/w F and R

★ Concave mirror

$\left[F = \frac{R}{2}\right]$ To prove



$\angle ABC = \angle BCF$

$i = r$ (By reflection law)

$\angle ABC = \angle BCF$

(alternate angle)

So, $\angle BCF = \angle CBF$

$\Rightarrow CF = BF$

∵ Aperture of mirror mm' is very small to

$BF = PF$

So, $CF = FP$

$CF + PF = PF + PF$

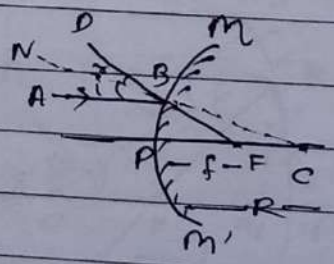
$CP = 2FP$

$R = 2f$

$\left[f = \frac{R}{2}\right]$

Relation b/w F & R

★ Convex mirror



$\angle ABN = i$ $\angle DBN = r$

Now, $\angle FBC = \angle DBN = r$

(opp. angle)

$\angle BCF$, as $= \angle NBA = i^\circ$ (corresponding angle)

In $\triangle CBF$, as $i = r$ (law of reflection)

$\therefore CF = FB$ but $FB = FP$ (small aperture)

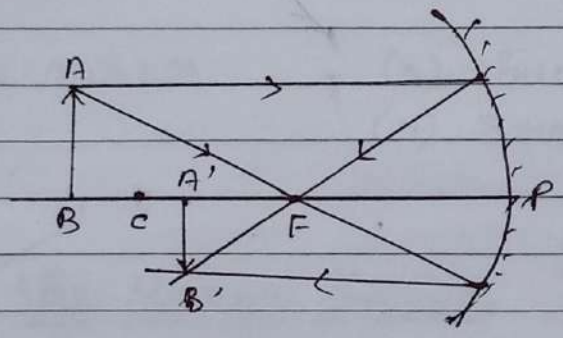
$\therefore CF = FP$ or F is middle point of PC

$\therefore F = \frac{1}{2} PC$, using sign convention

$$\left[F = \frac{R}{2}\right]$$

Formation of image by concave Mirror

(a) Object beyond C



The image is :-

1) B/w C & F
2) Read
3) Inverted
4) Smaller than object.

(b) Object at C.

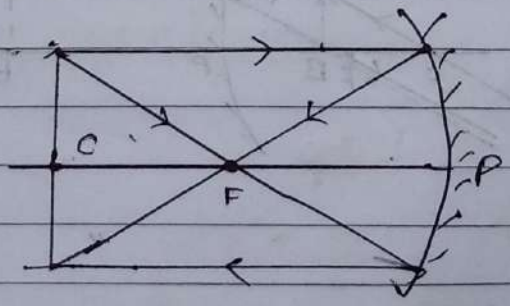


Image is :-

(1) At C
(2) Real
(3) Inverted
(4) Same size as object.

(c) Object between F and C

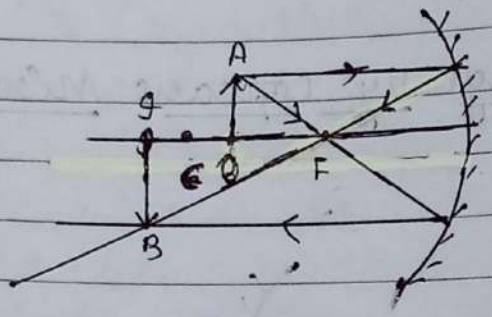


Image is

(1) Beyond C
(2) Real
(3) Inverted
(4) Layer Larger than object.

(d) Object between F and P

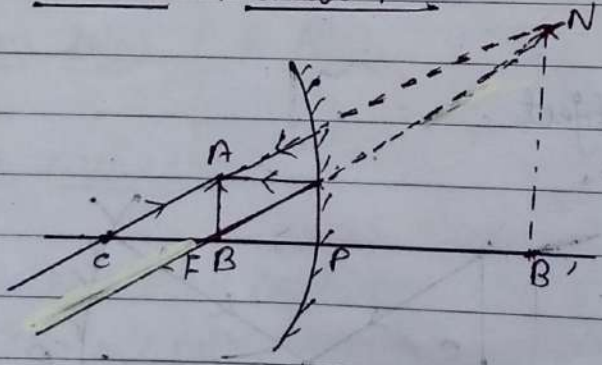
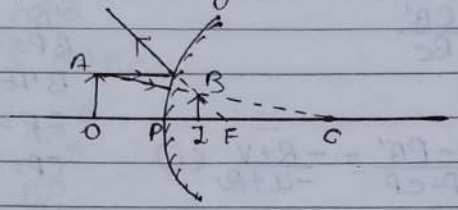


Image is
(1) Behind the mirror
(2) Virtual
(3) Larger than object
(4) Erect.

Image formation by Convex mirror



(1) Behind the mirror
(2) Erect
(3) Virtual
(4) Smaller than object.

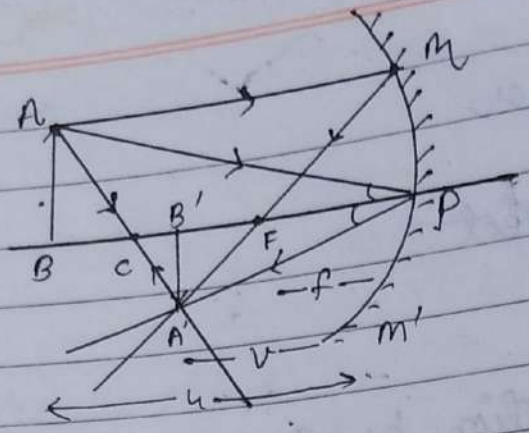
The Mirror formula

It is a mathematical relationship b/w object distance u, image distance v and the focal length f

$$\star\left[\frac{1}{v}+\frac{1}{u}=\frac{1}{f}\right]$$

Derivation for a Concave mirror

i real image



Now $\Delta A'B'C \sim \Delta ABC$

$\therefore \frac{A'B'}{AB} = \frac{CB'}{BC}$

Sign
$BP = -u$
$B'P = -v$
$FP = f$
$CP = -R = -2f$

$$\frac{A'B'}{AB} = \frac{CP - PB'}{BP - CP} = \frac{-R+v}{-u+R} \quad (i)$$

As $\Delta A'B'P \sim \Delta ABP$

$$\therefore \frac{A'B'}{AB} = \frac{PB'}{BP} = \frac{-v}{-u} = \frac{v}{u} \quad (ii)$$

from eq i) & ii)

$$\frac{-R+v}{-u+R} = \frac{v}{u}$$

$$-uR + uv = -uv + vR$$

$$vR + uR = 2uv$$

Divide by uvR both Side

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

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{R} \quad (R = 2f)$$

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{2f}$$

$$\left[\frac{1}{f} = \frac{1}{u} + \frac{1}{v}\right]$$