"Optics"

DATE

Newton → light energy is concentrated in tiny Particles (Corpuscles). → theory explained the phenomena of refraction.

Huygen $\xrightarrow{\text{Put}}$ wave theory of light
↓ Modified by
Fresnel's theory $\xrightarrow{\text{could explain}}$
- Refraction of light
- Interference " "
- Diffraction " "

Maxwell $\xrightarrow{\text{theory}}$ explain polarization of light.

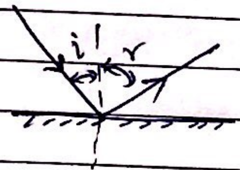
Finally, De-Broglie $\xrightarrow{\text{explains}}$ Dual Nature of light
↓ combined
Newton's + Hugens theory

neutronclasses.com

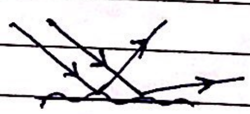
Reflection of light :

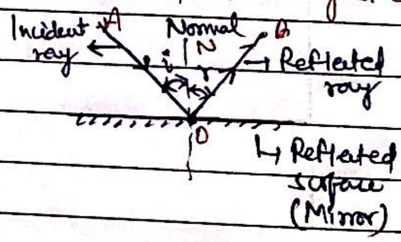
Change in the Path of light without any change in Medium.

- → Regular Reflection or Specular Reflection → light is reflected in one direction
- → Irregular Reflection or Diffuse Reflection. → light is reflected into Many direction.



(Regular)


(Irregular)



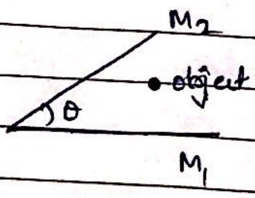
Laws of Reflection :

① Angle of incidence is equal to the angle of reflection.
i.e. $\angle i = \angle r$

② Incident ray (AO), reflected ray (OB) and Normal (ON) to the mirror, all lie in the same plane.

** If an object is placed in between two plane mirrors (M_1) and M_2, inclined at θ, Then total Number of images formed are

$$n = \frac{360^\circ}{\theta} - 1$$



If $\frac{360}{\theta}$ is an odd $\xrightarrow{\text{use}}$ $n = \frac{360^\circ}{\theta}$

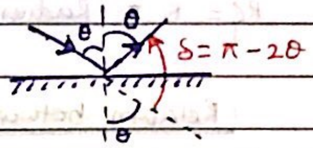
classmate

PAGE

DATE

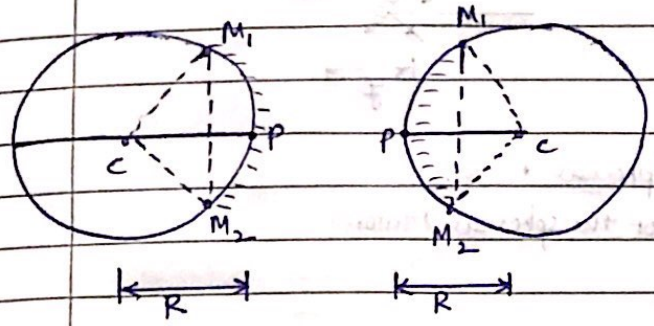
If $\frac{360^\circ}{\theta}$ = even $\xrightarrow{\text{use}}$ $n = \frac{360^\circ}{\theta} - 1$

NOTE: * If a plane mirror is turned clockwise/Anticlockwise through an angle θ, then Reflected ray turns with an angle 2θ.
* If θ is the angle formed by the incident ray then angle of deviation $\delta = \pi - 2\theta$



Spherical Mirrors:

↳ Parts of a Hollow sphere.



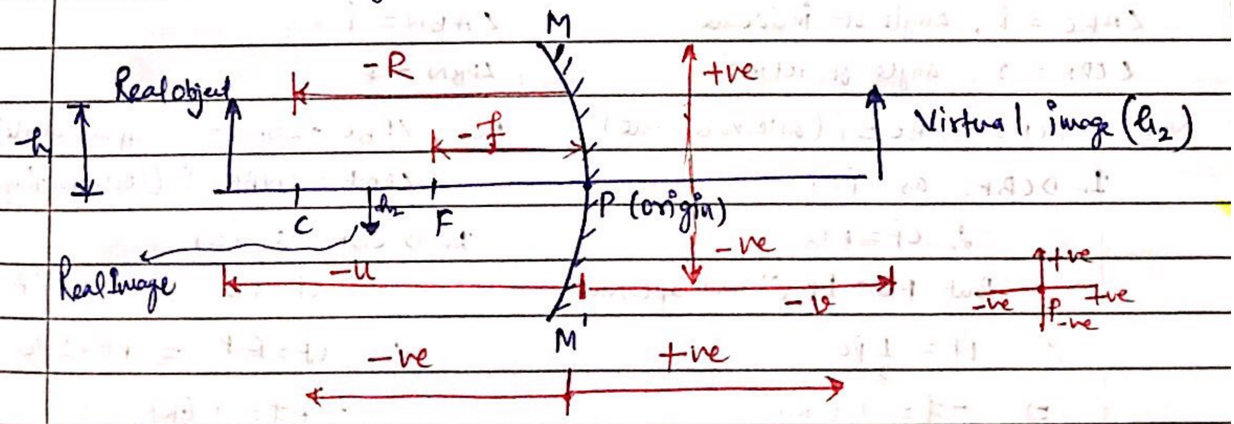
Concave Mirror   Convex Mirror

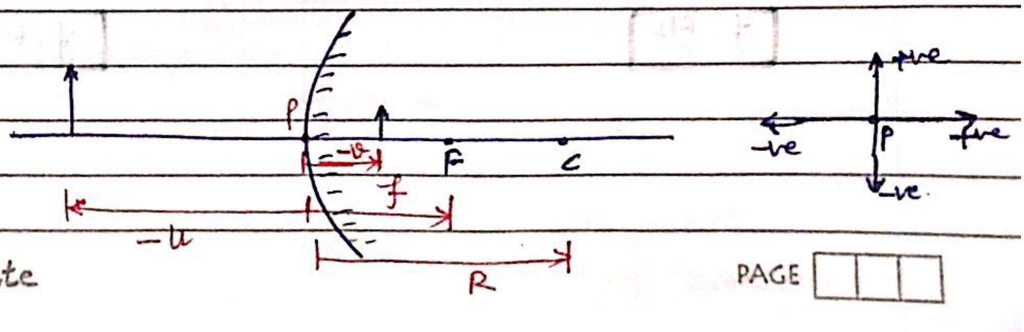
Terminologies:

→ centre of curvature (C) → centre of the sphere
→ vertex or Pole (P), → centre Point of aperture (M_1M_2)
→ Radius of curvature (R) → distance b/w C and P
→ Aperture or linear aperture (M_1M_2)
→ Angular Aperture M_1CM_2, subtended at C by M_1M_2
→ Principal Axis → straight line which joins C and P.

New cartesian Sign conventions:

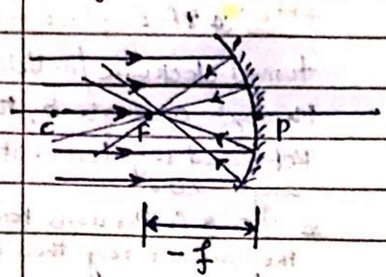
neutronclasses.com

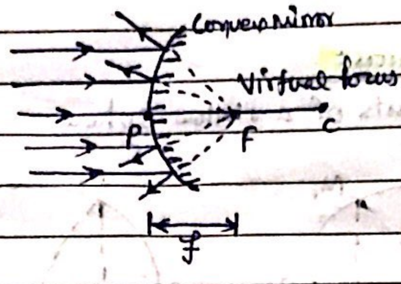




DATE

Principal focus: It is a Point on the Principal axis of the Mirror at which Parallel rays (to Principal axis) after reflection actually meets.



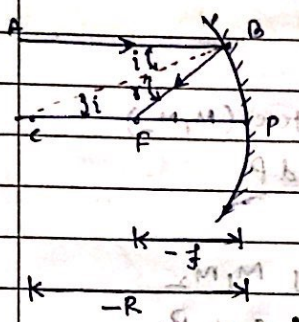


PF = f = focal length of the spherical Mirror.

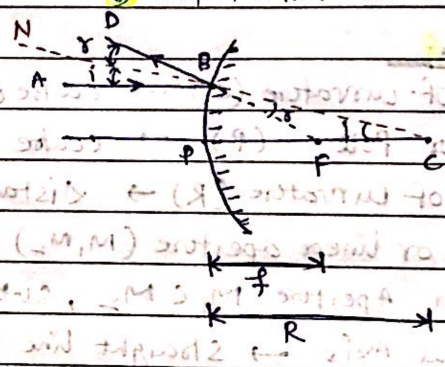
PC = R = Radius of curvature of the spherical Mirror.

Relation between f and R

a) Concave Mirror



b) Convex Mirror



let a ray of light AB be incident on the mirror in a direⁿ Parallel to the P. axis of the Mirror.

a)

$\angle ABC = i$, angle of incidence

$\angle CBF = r$, angle of reflection

Now, $\angle BCF = \angle ABC = i$ (alternate angle)

In ΔCBF, as $i = r$

$\therefore CF = FB$

But $FB = FP$ ($\because$ Small aperture)

$\therefore PF = \frac{1}{2} PC$

$\Rightarrow -f = \frac{1}{2}(-R)$

$$f = R/2$$

b)

$\angle ABN = i$

$\angle DBN = r$

Now, $\angle FBC = \angle DBN = r$ (opposite angle)

$\angle BCF = \angle NBA = i$ (corresponding angle)

In ΔCBF as $i = r$

$\therefore CF = FB$ But, $FB = FP$

$\therefore CF = FP \Rightarrow PF = \frac{1}{2} PC$

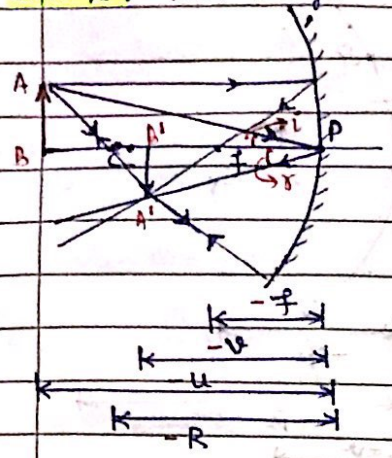
$= +f = \frac{1}{2}(+R)$

$$f = R/2$$

DATE

Mirror formula for concave Mirror: (Relationship in b/w focal length of Mirror, distance of the object and image from the Mirror)

CASE 1: Real Image:



When the object is held in front of a concave Mirror beyond the Principal focus f of the mirror, image formed is real.

AB = Object Held ⊥ to P. axis

A'B' = Image formed (Real in Nature)

u = Distance of object from the Pole (P)

v = Distance of image formed from Pole (P)

In Δ ABC and A'B'C (Similar)

$$\frac{AB}{A'B'} = \frac{CB}{CB'} \quad \text{—(i)}$$

In Δ ABP and A'B'P (Similar)

$$\frac{AB}{A'B'} = \frac{PB}{PB'} \quad \text{—(ii)}$$

from (i) & (ii)

$$\frac{CB}{CB'} = \frac{PB}{PB'} \quad \text{—(iii)}$$

As $CB = PB - PC$ and $CB' = PC - PB'$

∴ equ^n (3) will become as

$$\frac{PB - PC}{PC - PB'} = \frac{PB}{PB'}$$

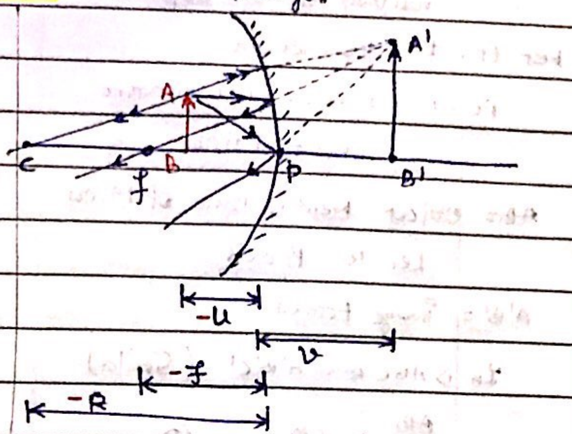
$$\frac{-u-(-R)}{-R-(-v)} = \frac{-u}{-v}$$

$\Rightarrow uv - vR = uR - uv \Rightarrow 2uv = uR + vR$ —(iv)

dividing both the sides by uvR of equ^n (iv)

$$\therefore \frac{2}{R} = \frac{1}{v} + \frac{1}{u} \Rightarrow \boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$$

CASE 2: Virtual Image:



When object is held in b/w Pole and focus then Image formed is virtual, erect and Magnified.

↔ SAME

In Δ ABC and A'B'C (Similar)

$$\frac{AB}{A'B'} = \frac{CB}{CB'} \quad \text{—(i)}$$

In Δ ABP and A'B'P (Similar)

$$\frac{AB}{A'B'} = \frac{PB}{PB'} \quad \text{—(ii)}$$

from (i) & (ii)

$$\frac{CB}{CB'} = \frac{PB}{PB'} \quad \text{—(iii)}$$

As, $CB = PC - PB$ and $CB' = PC + PB'$

∴ equ^n (3) will become as

$$\frac{PC - PB}{PC + PB'} = \frac{PB}{PB'}$$

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

$\Rightarrow uR - uv = -vR + uv \Rightarrow 2uv = uR + vR$ —(iv)

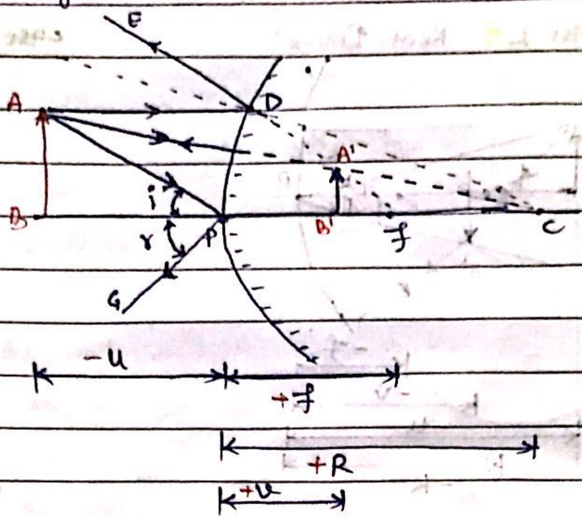
divide equ^n (4) by uvR

$$\therefore \frac{2}{R} = \frac{1}{v} + \frac{1}{u} \Rightarrow \boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$$

DATE

Mirror Formula for convex Mirror:

Image formed in convex Mirror is always virtual and erect, whatever the Position of the object.



Let $PF = f$ = focal length

$PC = R$ = radius of curvature of the Mirror

AB = object Held in front of Mirror Ler to P. axis

$A'B'$ = image formed.

In ΔABC and $A'B'C'$ (Similar)

$$\frac{AB}{A'B'} = \frac{CB}{CB'} \quad \text{—(I)}$$

In ΔABP and $A'B'P$ (Similar)

$$\frac{AB}{A'B'} = \frac{PB}{PB'} \quad \text{—(II)}$$

From equ^n (I) & (II)

$$\frac{CB}{CB'} = \frac{PB}{PB'} \quad \text{—(III)}$$

As $CB = PB + PC$ and $CB' = PC - PB'$

$\therefore$ Equ^n (III) will become as

$$\frac{PB+PC}{PC-PB'} = \frac{PB}{PB'} \quad \text{(or)} \quad \frac{-u+R}{R-v} = \frac{-u}{v}$$

$$\Rightarrow -uv + vR = -uR + uv \quad \text{(or)} \quad vR + uR = 2uv \quad \text{—(IV)}$$

Divide equ^n (IV) by uvR

i.e. $\frac{2}{R} = \frac{1}{v} + \frac{1}{u}$ (or) $\boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$

NOTE:
- If any Part of the Mirror is Painted, even it is very small, then it will form complete image of the object.
- Brightness of image $\propto$ amount of light reflected by mirror.

Linear Magnification of a Spherical Mirror: (m)

$$m = \frac{\text{size of image}}{\text{size of object}}$$

let h_1 = size/ Height of object → Always Positive

& h_2 = size/ Height of image → May be Positive or Negative

NOTE Whether the image is Real or virtual, it is always decided by the ratio of $\left(\frac{h_2}{h_1}\right)$ only.

DATE

In CASE of Concave mirror

When image formed is Real

$h_1 = +ve$ & $h_2 = -ve$

$\therefore \quad m = \frac{-h_2}{h_1}$

But, $\frac{-h_2}{h_1} = \frac{-v}{-u} = \frac{v}{u}$

$\therefore \quad m = \frac{-h_2}{h_1} = \frac{v}{u}$

(or) $m = \frac{h_2}{h_1} = \frac{-v}{u}$

When image formed is virtual

$h_1 = +ve$ and $h_2 = +ve$

$m = \frac{h_2}{h_1}$

But, $m = \frac{h_2}{h_1} = \frac{+v}{-u}$

or $m = \frac{h_2}{h_1} = \frac{-v}{u}$

linear Magnification in terms of u, v, f

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

Multiply Both sides by u

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

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

(or) $\frac{v}{u} = \frac{f}{u-f}$

As $m = -\frac{v}{u} \quad \therefore \quad m = -\frac{v}{u} = \frac{f}{f-u}$

Multiply Both sides by v

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

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

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

As $m = -\frac{v}{u} \quad \therefore \quad m = \frac{f-v}{f}$

Relation b/w speed of object & image.

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

Differentiate above equ^n w.r.t time

$\therefore \quad -\frac{1}{u^2}\frac{du}{dt} - \frac{1}{v^2}\frac{dv}{dt} = 0 \quad$ (or) $\quad \frac{1}{v^2}\frac{dv}{dt} = \frac{-1}{u^2}\frac{du}{dt}$

$\Rightarrow \frac{dv}{dt} = -\left(\frac{v}{u}\right)^2 \frac{du}{dt} \quad$ (or) $\quad V_i = -\left(\frac{v}{u}\right)^2 V_o$

V_i → speed of image, V_o → speed of object

Uses of Spherical Mirrors

Concave Mirror

→ Search light, Head light of vehicles, solar cooker, telescope, shaving mirror, ENT specialists, ophthalmoscope

Convex Mirror

Street lights, Rear Mirror of vehicles,