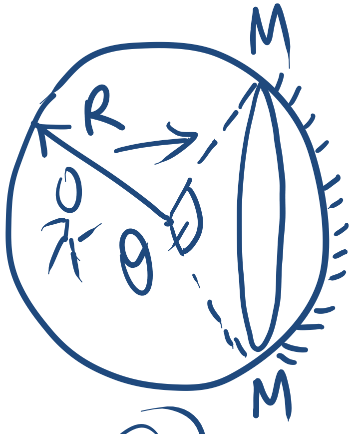
Session 16: Ray Optics –
Reflection & Refraction @ curved surfaces

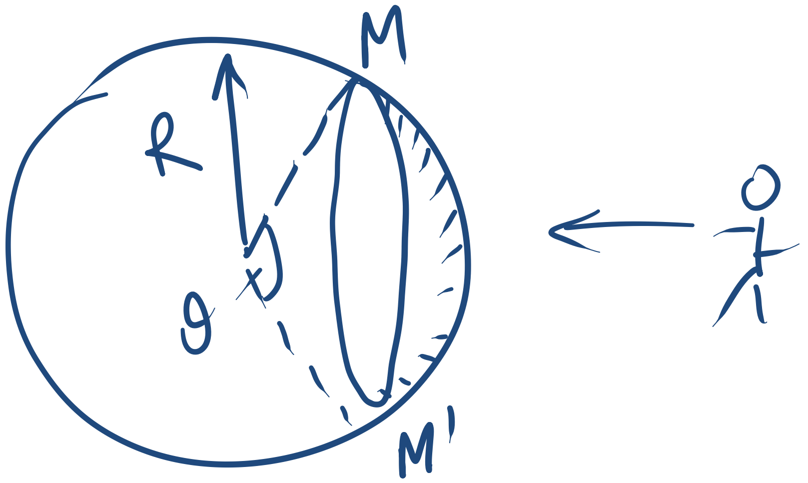
- Reflection at curved surfaces
- Mirror types
- Terminology
    - geometrical &
    - optical
- Mirror Formulae
- Ray diagrams for concave & convex mirror
- Visualizations

Reflection @ curved surfaces (spherical mirrors)

Fermat's Principle
↓
(Least time)
↓
Laws of reflection
→ $(i = r)$
→ N, I, R → lie in same plane



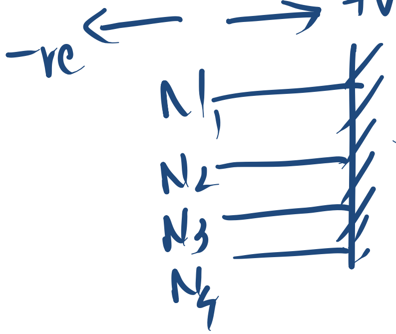
①

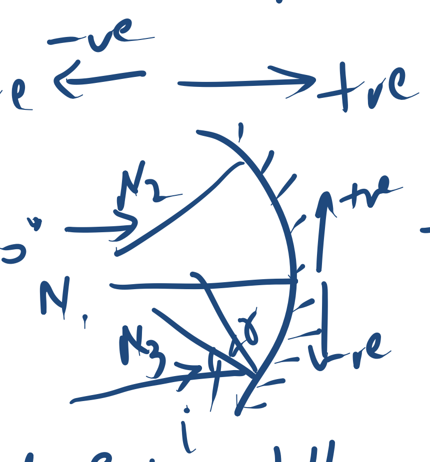


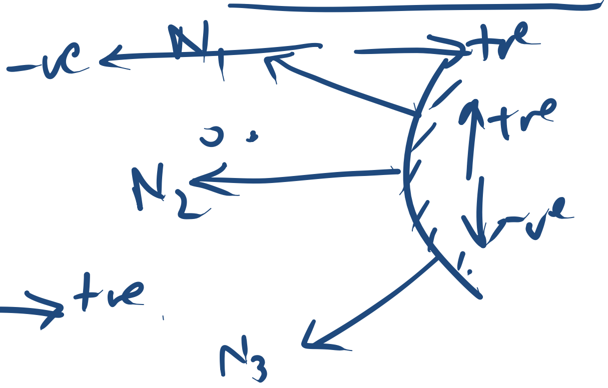
②

Concave Mirror
to shave

Convex Mirror
Back Mirror







Note → Usually, we keep mirror on right & obj on left → +ve

Terminology for spherical mirrors

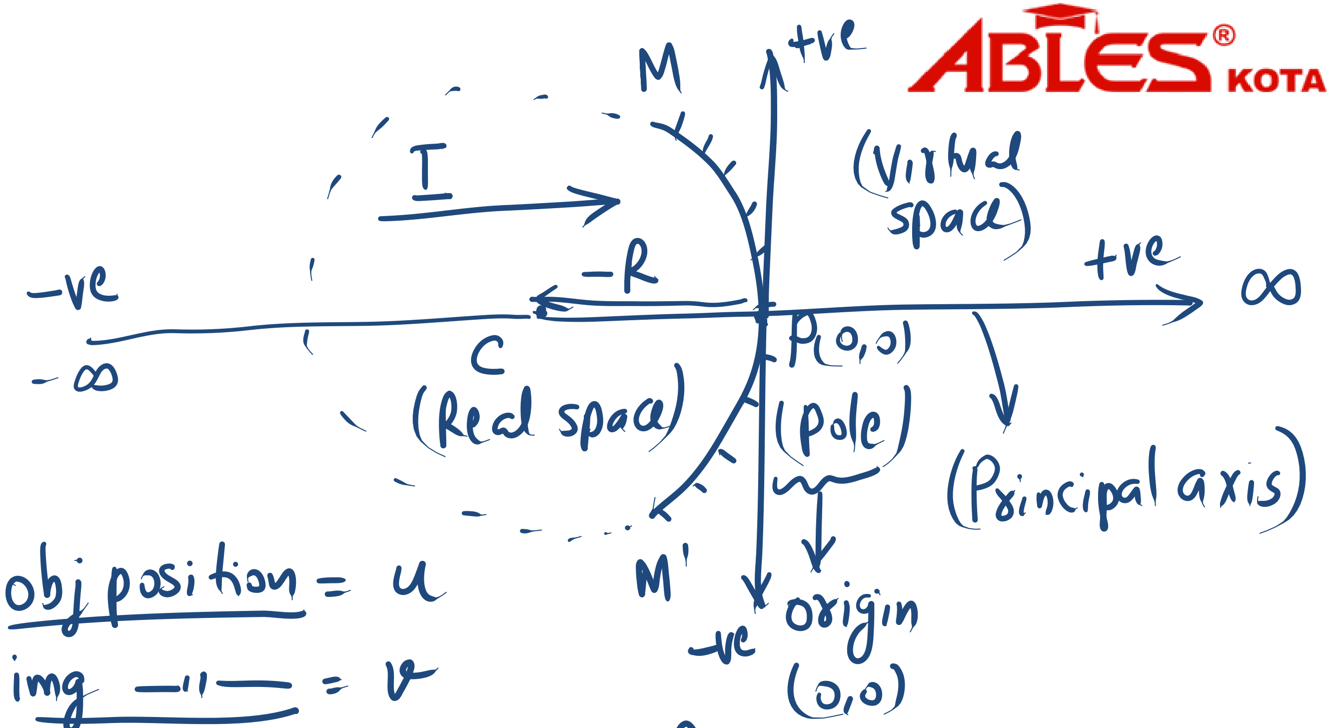
Geometrical termin.

Pole, centre of curvature,
radius " —"—
Principal Axis, Concave - Convex,
Sign Convⁿ.

optical terminology

Principal Focus, paraxial v/s marginal rays,
aperture, u, v, focal length (f),
magnification (m), h_I, h_o,

Geometrical Terminology →



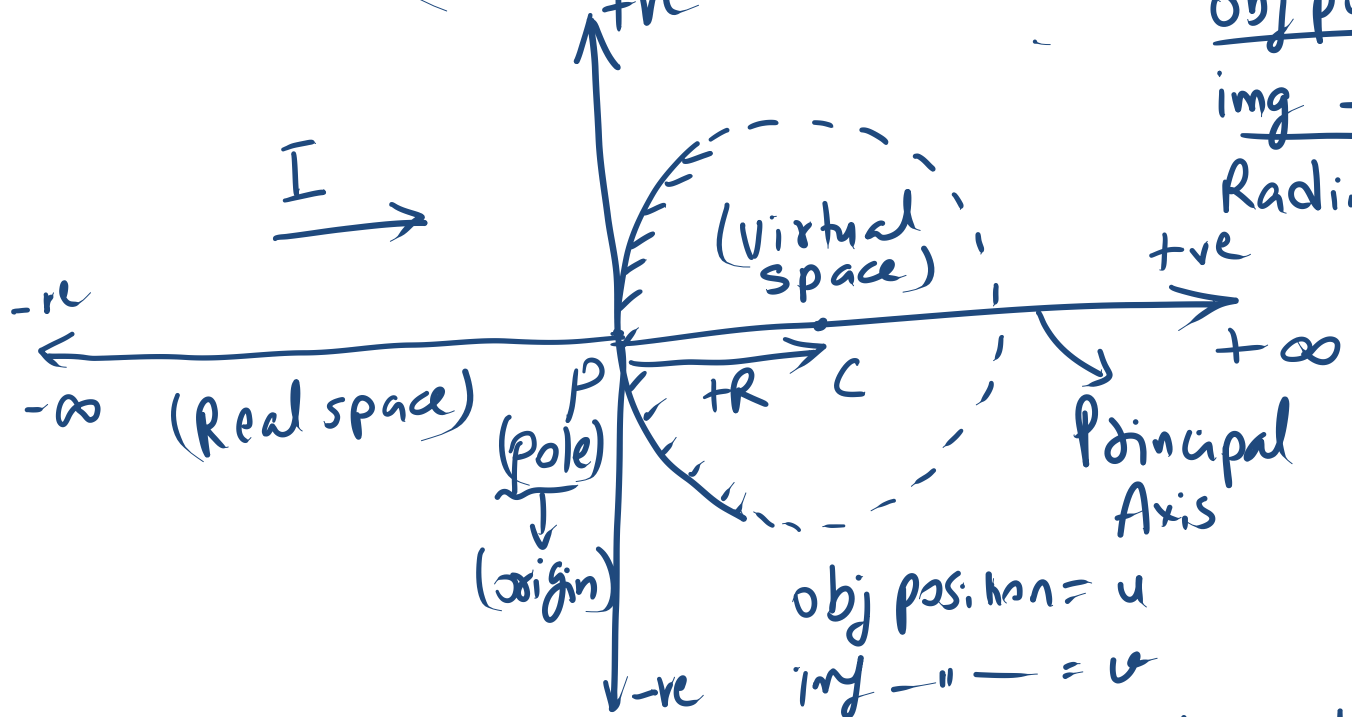
obj position = u

img —''— = v

Radius of curvature = $-R$

(Concave Mirror)
(Shaving Mirror)

(Convex Mirror
Back Mirror)



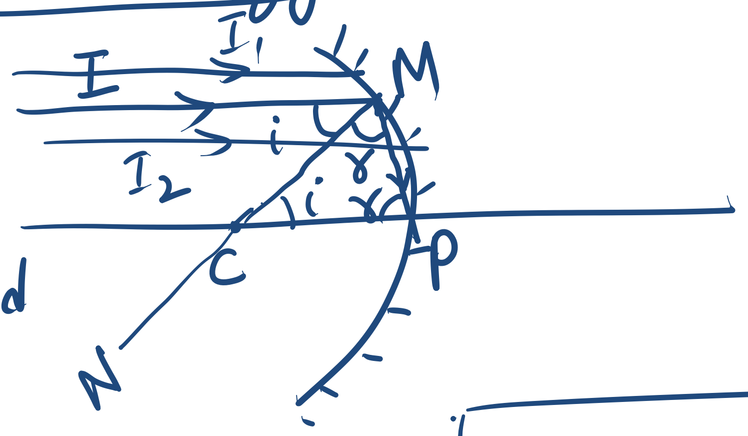
obj position = u

img —''— = v

Radius of curvature = $+R$

Optical Terminology →

Ex.1 Find angle of incidence of I s.t reflected ray passes thru pole of the mirror.



$i = r$

$\Delta CMP \to CM = CP = \text{Radius}$

$\Rightarrow \angle CPM = r$

$i + 2r = 180^\circ$

$3r = 180^\circ$

$\Rightarrow \boxed{i = r = 60^\circ}$

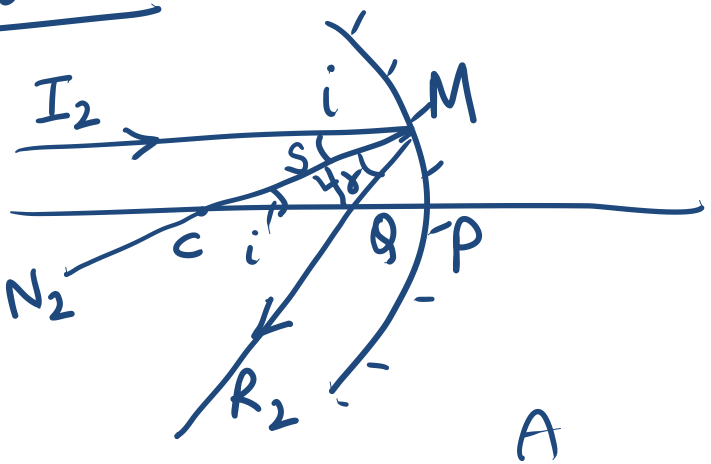
$\Delta CMP \to$ equilateral.

for I_1, $i > 60^\circ$

for I_2, $i < 60^\circ$

Ex.2 Find dist CQ

$i \to$ given



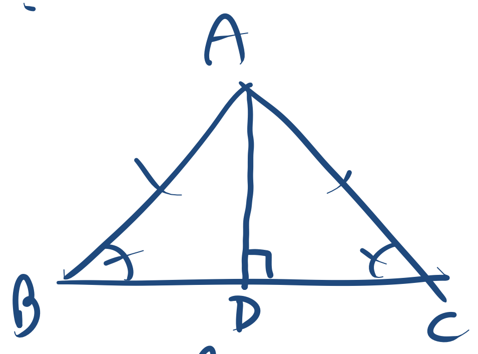
$I_2 \parallel$ principal axis.

$\angle MCQ = i$

$\angle CMQ = r = i$

$\Delta CMQ \to$ isoceles.

$\Rightarrow CQ = MQ$



$BD = DC$?

Draw a $\perp^{ar}$ from Q to CM,

$CS = SM = R/2$

$CQ = \dfrac{(R/2)}{\cos i} \Rightarrow \boxed{CQ = \dfrac{R}{2\cos i}}$

(if i is small) $\to \cos i = 1 \Rightarrow \boxed{CQ = R/2}$

Principal focus & [paraxial incident rays v/s Marginal incident rays]

$CQ = CF = \frac{R}{2\cos i}$

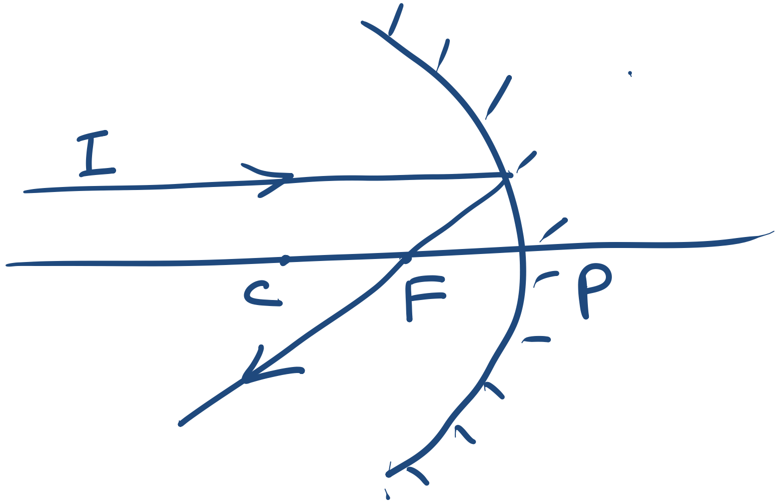
for paraxial rays

→ i → small < 10°.

→ close to principal axis.

⇒ $\cos i \to 1$

$CQ = CF = R/2$



F → Principal focus of the mirror.

↳ All the rays from ∞ get focus or concentrated @ a single pt. F called as focus of the mirror.

Focal length of the mirror (f).

$f = R/2$ → concave, → convex.

for concave mirror →

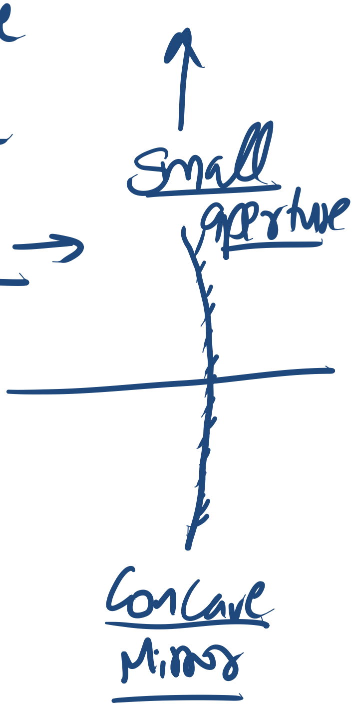
$R \to -ve$

& $f \to -ve$

for convex mirror →

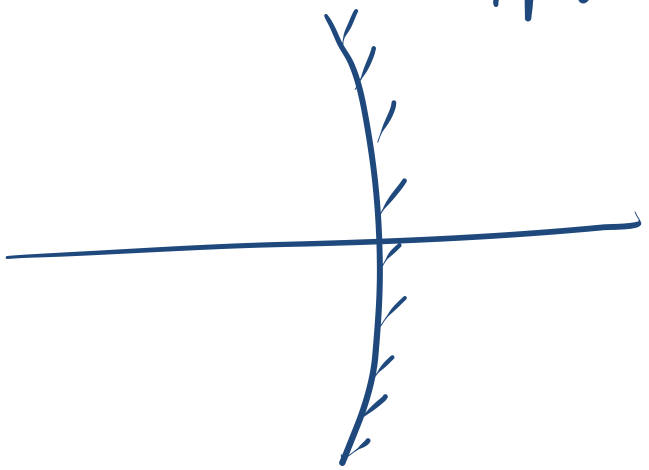
$R \to +ve$

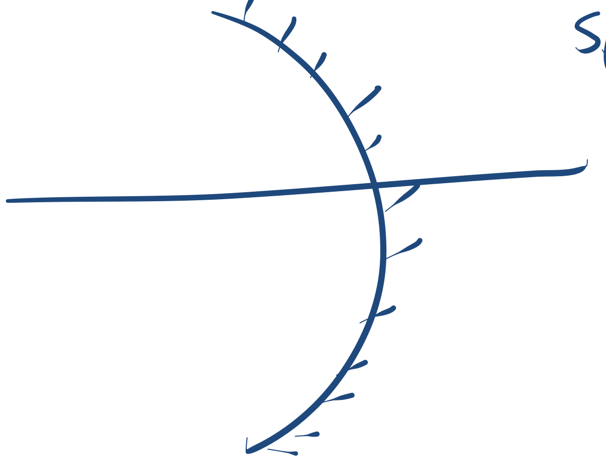
$f \to +ve$



Aperture

→ Aperture refers to the diameter of the circle in the spherical mirror.





①	②
Aperture small	Aperture large
R → large	R → small
f → large	f → small
paraxial approx valid	paraxial approx. not valid
pt obj → pt. img.	pt. obj → img need not be pt. img.
obj @ ∞ → image @ focus.	obj @ ∞ → won't be having any particular focus.

Geometrical Optics

1). Spherical Mirrors & lenses

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

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

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

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

f is more prevalent in lenses!!

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

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

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

$$m = v/u = \frac{f}{f+u} = \frac{f-v}{f}$$

Spherical surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$