CHAPTER 9: LIGHT – REFLECTION AND REFRACTION

Introduction

Light is a form of energy that enables us to see objects. We see objects because they reflect light into our eyes. In the absence of light (for example, in a dark room), objects are not visible.

Light generally travels in straight lines. This is called **rectilinear propagation of light**. However, in certain situations such as diffraction, this assumption does not hold, but for this chapter, we consider straight-line propagation.

Reflection of light

Definition

Reflection of light is the phenomenon in which light rays bounce back after striking a surface.

Laws of Reflection

1. The angle of incidence is equal to the angle of reflection.
2. The incident ray, reflected ray, and the normal at the point of incidence all lie in the same plane.

These laws are valid for all reflecting surfaces, including spherical mirrors.

Image Formation by a Plane Mirror

- Image is **virtual and erect**
- Image size is equal to object size
- Image is formed at the same distance behind the mirror as the object is in front
- Image is laterally inverted (left-right reversed)

Spherical mirrors

Spherical mirrors are mirrors whose reflecting surface is a part of a sphere.

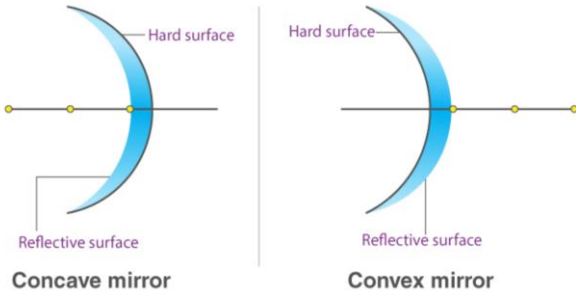
Types

Concave Mirror

- Reflecting surface curves inward
- Converges parallel rays of light

Convex Mirror

- Reflecting surface curves outward
- Diverges light rays



Important Terms

- **Pole (P):** The centre point of the mirror surface
- **Centre of Curvature (C):** The centre of the sphere of which the mirror is a part
- **Radius of Curvature (R):** Distance between pole and centre of curvature
- **Principal Axis:** Straight line joining P and C
- **Principal Focus (F):**
    - Concave mirror: point where parallel rays meet after reflection
    - Convex mirror: point from which rays appear to diverge
- **Focal Length (f):** Distance between pole and focus
- **Aperture:** Diameter of reflecting surface

Relationship between R and f

$$R = 2f$$

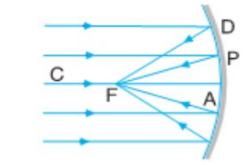
Image formation by spherical mirrors

Concave Mirror

Image characteristics depend on object position:

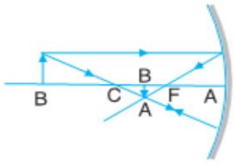
- At infinity → image at focus, highly diminished, real and inverted
- Beyond C → between F and C, diminished, real and inverted

- At C → at C, same size, real and inverted
- Between C and F → beyond C, enlarged, real and inverted



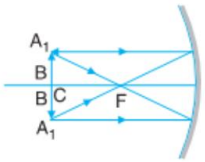
Real, inverted, highly diminished image at focus

(a) When the object is situated at ∞



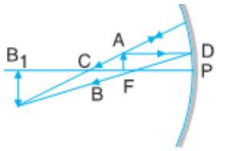
Real, inverted, diminished between C and F

(b) Object beyond C



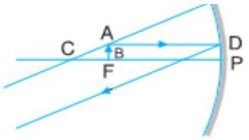
I, inverted image of the same as object at C

(c) Object at C



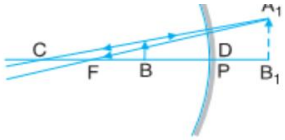
Real, inverted, enlarged image beyond C

(d) Object between C and F



Real, inverted, highly enlarged image at infinity

(e) Object at F



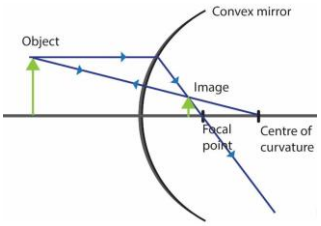
Virtual, erect, enlarged mage behind the mirror

(f) Object between F and P

- At F → image at infinity
- Between F and P → behind mirror, enlarged, virtual and erect

Convex Mirror

- Always forms image between pole and focus
- Image is always:
  - Virtual
  - Erect
  - Diminished



Uses of Mirrors

- Concave mirrors:
  - Headlights, torches (parallel beam)
  - Shaving mirrors (magnified image)
  - Solar furnaces (concentration of heat)
- Convex mirrors:
  - Rear-view mirrors (wide field of view)

Ray diagram rules

To locate image position, use any two rays:

1. Parallel ray → passes through focus (concave) or appears from focus (convex)
2. Ray through focus → becomes parallel
3. Ray through centre of curvature → reflects back
4. Ray through pole → reflects obeying laws of reflection

Sign convention

- All distances measured from pole
- Left side of mirror → negative
- Right side → positive
- Above principal axis → positive
- Below principal axis → negative

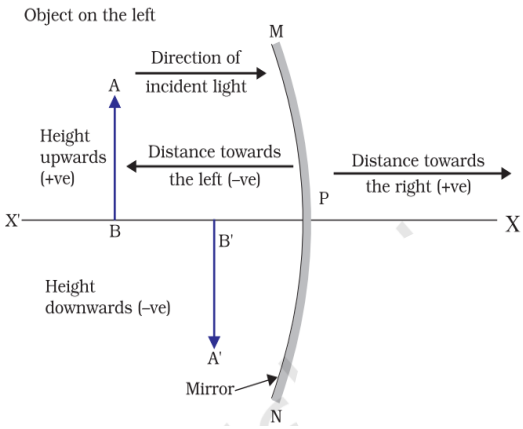
Mirror formula

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

u

ft

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v},\ v\approx 28,\ m\approx -1$$



F = 28 | m = -1

Where:
u = object distance
v = image distance
f = focal length

Magnification (Mirror)

$$m = \frac{h'}{h} = -\frac{v}{u}$$

- m positive → virtual image
- m negative → real image

Refraction of light

Definition

Refraction is the bending of light when it passes from one transparent medium to another.

Cause of Refraction

Refraction occurs due to change in speed of light in different media.

Laws of Refraction

1. Incident ray, refracted ray and normal lie in the same plane
2. Snell's law:

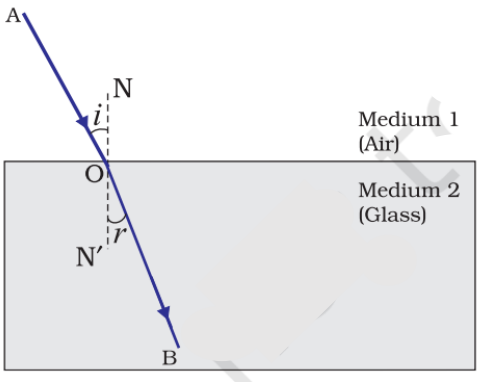
$$\frac{\sin i}{\sin r} = constant$$

Refractive index

Absolute Refractive Index

$$n = \frac{c}{v}$$

- c = speed of light in vacuum
- v = speed in medium



Important Concepts

- Higher refractive index → optically denser medium
- Lower refractive index → optically rarer medium

Bending Rules:

- Rarer → denser: bends towards normal

- Denser → rarer: bends away from normal

REFRACTION THROUGH GLASS SLAB

- Light bends at both surfaces
- Emergent ray is parallel to incident ray
- There is lateral displacement

Spherical lenses

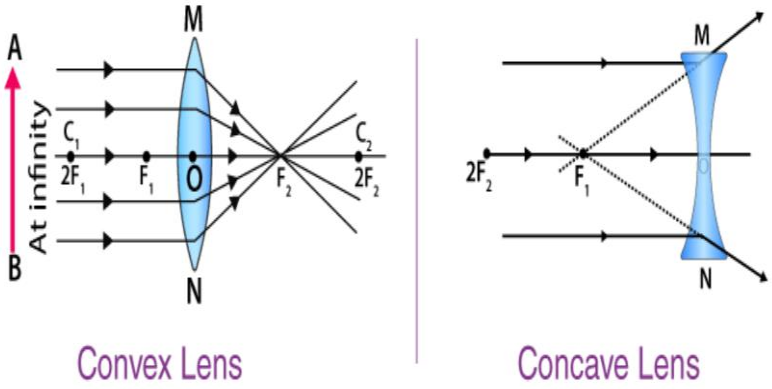
Types

Convex Lens

- Converging lens
- Thicker at centre

Concave Lens

- Diverging lens
- Thinner at centre



Important Terms

- Optical centre (O)
- Principal axis
- Principal foci (F_1 and F_2)
- Focal length

Image formation by lenses

Convex Lens

- Beyond 2F → diminished, real, inverted
- At 2F → same size
- Between F and 2F → enlarged
- Between F and O → virtual, erect

Concave Lens

- Always forms:
  - Virtual
  - Erect
  - Diminished image

RAY DIAGRAM RULES (LENSES)

1. Parallel ray → passes through focus
2. Ray through focus → becomes parallel
3. Ray through optical centre → undeviated

SIGN CONVENTION (LENSES)

- Same as mirrors, but distances measured from optical centre
- Convex lens → focal length positive
- Concave lens → focal length negative

Lens formula

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

Magnification (Lens)

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

Power of lens

$$P = \frac{1}{f}$$

- Unit: Dioptre (D)
- f in metres

Key Points:

- Convex lens → positive power
- Concave lens → negative power

IMPORTANT APPLICATIONS

- Convex lens: magnifying glass, microscope, camera
- Concave lens: spectacles (myopia correction)
- Concave mirror: headlights, solar furnace
- Convex mirror: rear-view mirror