Light: Reflection and Refraction

Ray of Light

- Light travels in a straight-line path in a uniform medium. This straight path is called a **ray of light**.
- **Example:**
  When sunlight enters a room through a small hole, we can see straight beams of light, showing that light travels in straight lines.

Diffraction of Light

- When light bends around the edges of a very small obstacle or passes through a narrow opening, the phenomenon is called **diffraction of light**.
- **Example:**
  If light passes through a small slit, it spreads out instead of forming a sharp shadow.

Nature of Light (Wave and Particle)

- Light shows both **wave nature** (like diffraction and interference) and **particle nature** (like interaction with matter). Modern theory explains that light has a dual nature.
- **Example:**
  Light behaves like a wave when it spreads, but like particles (photons) when it hits a solar panel.

Reflection of Light

- When a ray of light strikes a surface and bounces back into the same medium, it is called **reflection of light**.
- **Example:**
  Seeing your face in a mirror is due to reflection.

Laws of Reflection

- Reflection of light follows these laws:
  1. The incident ray, reflected ray, and normal lie in the same plane.
  2. Angle of incidence = Angle of reflection ($\angle i = \angle r$).
- **Example:**
  If a light ray strikes a mirror at 30°, it will reflect at 30°.

Plane Mirror

- A flat reflecting surface is called a **plane mirror**. It forms a virtual, erect, and same-size image.
- **Example:**
  Bathroom mirrors are plane mirrors.

Spherical Mirrors

- Mirrors that are parts of a hollow sphere are called **spherical mirrors**.
- **Types:**

(a) Concave Mirror

- A mirror whose reflecting surface curves inward is called a **concave mirror**.
- **Example:**
  Used in shaving mirrors and headlights.

(b) Convex Mirror

- A mirror whose reflecting surface curves outward is called a **convex mirror**.
- **Example:**
  Used as rear-view mirrors in vehicles.

Mirrors Formula

- The relation between object distance (u), image distance (v), and focal length (f):
- $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Parts of mirror

Pole (P)

- The centre point of the mirror's reflecting surface is called the **pole**.
- **Example:**
  All distances in mirror calculations are measured from the pole.

Centre of Curvature (C)

- The centre of the sphere of which the mirror is a part is called the **centre of curvature**.

- **Example:**
  For a concave mirror, it lies in front of the mirror.

Radius of Curvature (R)

- The distance between the pole and centre of curvature is called the **radius of curvature**.
- **Formula:**
  R = 2f

Principal Axis

- The straight line passing through the pole and centre of curvature is called the **principal axis**.

Principal Focus (F)

- The point where parallel rays of light meet (or appear to meet) after reflection is called the **principal focus**.
- **Example:**
  Sunlight converges at a point in a concave mirror.

Focal Length (f)

- The distance between the pole and principal focus is called the **focal length**.

Image position in mirror

Convex mirror				
Position of the object	**Position of the image**	**Size of the image**	**Nature of the image**	**Position of the object**
At infinity	At the focus behind the mirror	Highly diminished	Virtual and erect	At infinity

Between infinity and the pole (P) of the mirror	Between P and F behind the mirror	Diminished	Virtual and erect	Between infinity and the pole (P) of the mirror

Concave mirror

Position of the object	**Position of the image**	**Size of the image**	**Nature of the image**
At infinity	At focus	Highly diminished	Real and inverted
Between infinity and center of curvature	Between focus and center of curvature	Diminished	Real and inverted
At center of curvature	At center of curvature	Equal to the object	Real and inverted
Between center of curvature and focus	Between infinity and center of curvature	Enlarge	Real and inverted
At focus	At infinity	Highly enlarge	Real and inverted
Between focus and pole	Behind the mirror	Enlarge	Virtual and erect

Refraction of Light

- The bending of light when it passes from one medium to another is called **refraction of light**.
- **Example:**
  A pencil appears bent when placed in water.

Laws of Refraction

1. The incident ray, refracted ray, and normal lie in the same plane.

2. $\frac{\sin i}{\sin r} = \text{constant}$ (Snell's Law).

Refractive Index

- The ratio of the speed of light in vacuum to that in a medium is called the **refractive index**.
- **Formula:**
  $n = \frac{c}{v}$
- **Example:**
  Water has refractive index ≈ 1.33.

Lens

- A transparent material bounded by two curved surfaces that refracts light is called a **lens**.
- **Types of Lenses:**

(a) Convex Lens

- A lens that converges light rays is called a **convex lens**.
- **Example:**
  Used in magnifying glass.

(b) Concave Lens

- A lens that diverges light rays is called a **concave lens**.
- **Example:**
  Used in spectacles for myopia.

Parts of lens

Optical Centre

- The central point of a lens through which light passes without deviation is called the **optical centre**.

Lens Formula

- The relation between object distance (u), image distance (v), and focal length (f):

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

Magnification

- Magnification is the ratio of image height to object height.
- **Formula (Mirror):**
  m = -v/u
- **Example:**
  If image is bigger than object, magnification > 1.

Power of Lens

- The ability of a lens to converge or diverge light is called its **power**.
- **Formula:**
  $P = \frac{1}{f}$ (in meters)
- **Unit:**
  Dioptre (D)
- **Example:**
  A lens with focal length 1 m has power = 1D.

Image position in lens

Concave lens

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus f_1	Highly diminished	Virtual and erect
Between infinity and the optical center (O) of the lens	Between optical center (O) and f_1	Diminished	Virtual and erect

Concave mirror

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At focus f_2	Highly diminished	Real and inverted
Between infinity and $2f_1$	Between f_2 and $2f_2$	Diminished	Real and inverted
At $2f_1$	At $2f_2$	Equal to the object	Real and inverted
Between $2f_1$ and f_1	Between infinity and $2f_2$	Enlarge	Real and inverted
At f_1	At infinity	Highly enlarge	Real and inverted
Between f_1 and optical center(O)	On the same side of the lens as the object	Enlarge	Virtual and erect

Sign Convention

- A set of rules used to assign positive or negative signs to distances in mirror and lens formulas.
- **Example:**

- Distance in direction of light → Positive
- Opposite direction → Negative