# Light

## Learning Objectives

1. **Introduction**
2. Rectilinear propagation of light
3. Reflection of light
   - Laws of reflection
4. Image formation
   - Plane mirror
   - Concave mirror
   - Convex mirror
5. Refraction of light
   - Concave lens
   - Convex lens
6. Dispersion of light
   - Rainbow
7. Recombination of the colors of the spectrum
   - Newton's disc

### INTRODUCTION

Light is a form of energy which creates sensation of vision. Sun is the main source of light. The objects that have their own light are known as luminous objects. Eg. Sun, stars, candle, bulb, etc. The objects that do not have their own light are known as non-luminous objects. Eg. Table, chair, etc. Non luminous objects become visible by light falling on them from some luminous objects.

**Do you know?**

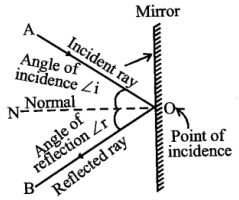
**Scientists study the properties and behaviors of light in a branch of physics known as optics**

### RECTILINEAR PROPAGATION OF LIGHT

Light travels in a straight line as long as it is travelling in the same medium. This property of light is known as rectilinear propagation of light. It explains a lot of phenomena associated with light. Light does not require any material medium to propagate. It travels with a very high speed of about $3\times10^{8}\,m/s$ in air or vacuum.

### REFLECTION OF LIGHT

When light falls on a surface, it bounces off the surface. This is called reflection of light. Reflection always involves two rays - an incoming or "incident" ray and an outgoing or "reflected" ray




Note: we are able to see an object because light from the object can move through space and reach our eyes. Once light reaches our eyes, signals are sent to our brain, and our brain decode the information in order to detect the appearance, location and movement of the objects we are looking at.

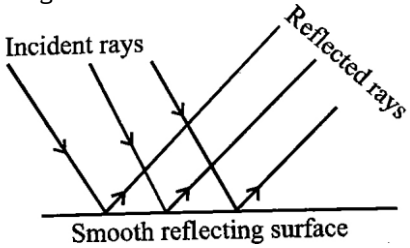
**Incident ray:** This is the ray of light that falls from the source of light on the surface i.e., AO.
**Reflected ray:** This is the ray of light which is reflected from the surface i.e., BO.
**Normal:** An imaginary line perpendicular on reflecting surface is known as normal i.e., NO.
**Angle of incidence (i):** The angle formed between the incident ray and the normal is called the angle of incidence i.e., Z AON.
**Angle of reflection (r):** The angle formed between the reflected ray and the normal is called the angle of reflection i.e., Z BON.

**Do you know?**

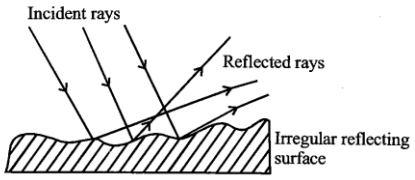
Between 18% and 35% of the human population is estimated to be affected by a so-called "photic sneeze reflex," a heritable condition that results in sneezing when the person is exposed to bright light.

### Regular and Diffused Reflection

**Regular reflection:** When a parallel beam of light falls on a smooth, highly polished surface, the reflected beam is also parallel. Hence the entire light falling on the surface is reflected in a definite direction. Such a reflection is called regular reflection and the reflecting surface is called a regular reflector.



**Diffused reflection:**
When a parallel beam of light falls on a rough or irregular surface, the reflected beam gets scattered in different directions and the light spreads over a wide area. As such the observer can see it from any position near it. Such a reflection is called irregular or diffused reflection and the reflecting surface is called a diffused reflector.




**Lows of Reflection**
**First law:** It states that the incident ray, normal and reflected ray all lie in the same plane.
**Second law :** It states that the angle of reflection Zr is always equal to the angle of incidence Zi. i.e., Zi = Zr

**IMAGE FORMATION**
**Plane Mirror**
A plane mirror is a flat reflecting surface that produces an erect and virtual image of an object.
**Characteristics of image formed by plane mirror**
1. The image formed is always erect.
2. The image is the same size as the object.
3. The image is laterally inverted.
4. Distance of object from mirror = Distance of image from mirror
5. The image formed is always virtual.

**Lateral inversion:** If an object is placed in front of plane mirror the right side of the object appears to become the left side of image and the left side of object becomes right side of image. This change of side of an object and its mirror image is called lateral inversion.

**Uses of Plane Mirror:**
1. Plane mirrors are used at home as looking glass.
1. These mirrors are fixed on the walls to provide false dimensions in show-rooms.
3. These mirrors are used in kaleidoscope, periscope and solar cooker.

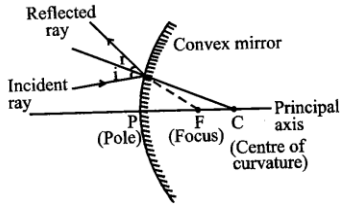
**Note:** When two plane mirrors are arranged along their vertical edge such that they make a certain angle $\theta$ with each other. In this condition image formed in one mirror acts as a object for the second mirror. The actual number of images (n) formed is given as

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

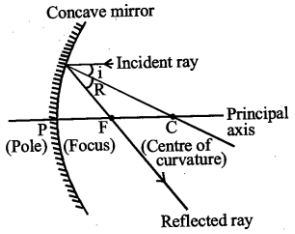
$if \frac{360^\circ}{\theta}$ is even integer and $n = \frac{360^\circ}{\theta} if \frac{360^\circ}{\theta}$ is an odd integer

**Spherical Mirror**
Spherical mirrors form a part of a sphere. If the cut-off part of the glass sphere is silvered on the inside surface is called a **convex mirror** and if the bulged out side is silvered, then is called **concave mirror.**

**Some Basic Terms Related to Spherical Surfaces**
**1. Centre of curvature (C):** It is the centre of sphere of which the mirror is apart.
**2. Radius of curvature (R):** It is the radius of curvature of which the mirror is a part. PC is the radius of curvature.
**3. Pole (P):** It is the geometrical centre of the spherical reflecting surface.




**4. Principal axis:** It is the straight line passing through the pole and centre of curvature.
**5. Focus (F):** When a narrow beam of light, parallel to the principal axis and close to it, is incident on the surface of a mirror, the reflected beam is either found to converge or found to diverge from a point on the principal axis. This point is called focus.




**6. Focal length (F):** The distance between the pole and the focus is called focal length. P F is the focal length.

Focal length $f = \frac{R}{2}$

**Characteristics of image formed by a concave mirror:**

1. When the object is close to the concave mirror, its image is erect and comparatively larger than the size of the object.
2. When the object is moved away from the concave mirror, its image in the mirror becomes inverted and comparatively smaller than the size of the object.

**Uses of concave mirror:**

1. Concave mirrors are used as shaving mirrors. It forms a magnified and erect image of the object placed within its focal length.
2. Dentists use concave mirrors for examining teeth and gum problems.
3. Concave mirrors are used in solar cookers to converge the sun rays at a point which provides sufficient heat for cooking.

**Do you know?**

Sunlight can reach a depth of around 80 meters (262 feet) in the ocean.

**Characteristics of image formed by convex mirror:**

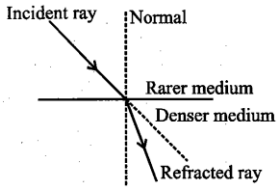
1. The image formed by convex mirror is always erect and comparatively smaller than the size of object. Thus it covers a wide range of area.

**Uses of convex mirror:**

1. Convex mirrors are used as a rear view mirror in vehicles to have a wide view of the traffic coming from behind.
2. Convex mirrors are used in street lamps to spread light over a large area.
3. These mirrors are used in supermarket to look out for thieves and shop lifters.

## REFRACTION OF LIGHT

The bending of the light ray from its path in passing from one medium to the other medium is called refraction of light.




If the refracted ray bends towards the normal relative to the incident ray, then the second medium is said to be denser than the first medium. But if the refracted ray bends away from the normal, then the second medium is said to be rarer than the first medium.

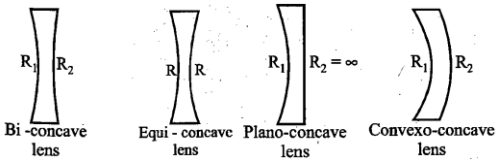
**Do you know?**

Because of atmospheric refraction of light sun is visible to us 2 minutes, before actual sunrise and after actual sunset.

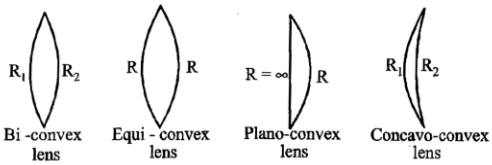
## LENS

A lens is a transparent medium bound by two curved or one curved and one plane refracting surfaces.

**Concave lens:** A concave lens is thicker at the edges than in the middle. Things look smaller through a concave lens. It diverges parallel rays and behaves as divergent lens.




**Convex lens:** A convex lens is thicker at the middle than at the edges. Things look magnified through a convex lens. It converges parallel rays and behaves as a convergent lens.




The nature of the image formed with a convex lens varies as we change the distance of the object from the lens. However, with a concave lens, we always get virtual, upright and diminished image regardless of the object distance.

**Basic Terms Related to Lens**

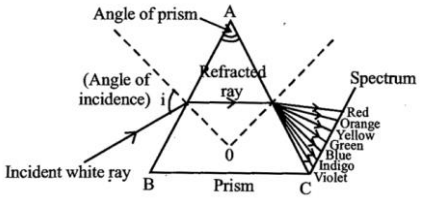
1. Optical centre: A point for given lens through which any ray passes undeviated.
2. Principal axis: A line passing through the optical centre and perpendicular to the lens.
3. Principal focus: A lens has two surfaces and hence two focal points first focal point is an object on the principal axis for which image is at infinite while second focal point is an image point on the principal axis for which object is at infinity.
4. Focal length (f): It is defined as the distance between optical centre of a lens and the point where the parallel beam of light converges or appears to converge.

**Do you know?**

Virtual image cannot be taken on the screen but it can be photographed.

## DISPERSION OF LIGHT

The decomposition of the white light into the component colors while passing through a prism or through a transparent object is called dispersion of light. When a ray of light passes through a prism the light is decomposed into component colors as VIBGYOR.

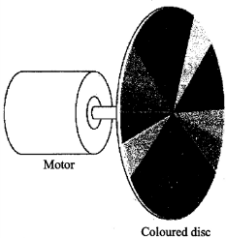



The band of the colored components (seven colors) of a light is called **spectrum.**

### Rainbow

White light coming from the sun splits into seven colors of light when it passes through the tiny droplets of water suspended in the atmosphere before or after the rains. A big arch of a band of seven colors is formed in the sky in the direction opposite to the location of the sun. Rainbow is composed of seven colors. These are: Violet (V), Indigo (I), Blue (B), Green (G), Yellow (Y), Orange (0), Red (R). VIBGYOR. In a rainbow the violet color is towards the inner curve and red color is towards outer curve. Recombination of Colors of the Spectrum-Newton's Disc White light is composed of seven colors. When these colors combine, they look white.

**Newton's Disc:** Newton's disc is a seven colored (VIBGYOR) disc painted in the correct proportions.




When the disc is rotated at a high speed, the colors blur together and the eye unable to respond rapidly enough, thus it sees the colors mixed together to form white.

### Do you know?

An image seen by our eye continues to by seen for about 1/16 or a second.

## CONCEPT MAP