

CHAPTER 04

LIGHT

Light is a form of energy that enables us to see. An object reflects the light rays that fall on it.

These reflected light rays, when received by our eyes, make the object visible to us. We are able to see through a transparent medium as light is transmitted through it. The speed of light in vacuum or in air is $3 \times 10^8 \text{ ms}^{-1}$.

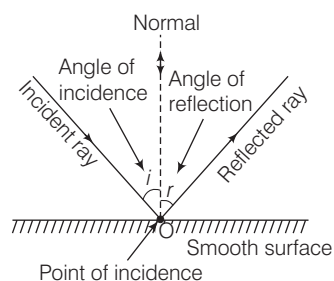
Some Important Terms Related to Light

- **Incident ray** The ray of light which falls on the mirror or smooth surface.
- **Reflected ray** The ray of light which is sent back by the mirror is known as reflected ray.
- **Point of Incidence** The point at which the incident ray falls on the mirror is called the point of incidence.
- **Normal** The normal is a line at right angle to the mirror surface at the point of incidence.
- **Angle of Incidence** This is the angle made by the incident ray with the normal at the point of incidence.
- **Angle of Reflection** This is the angle made by the reflected ray with normal at the point of incidence.

In this chapter, we concentrate on the phenomena of light like as reflection, refraction, dispersion and also describe types of mirror and lens and how lenses and mirror can be used to view of object and human eye.

Reflection of Light

The phenomenon of bouncing back of light rays in the same medium on striking a smooth surface is called reflection of light.



Reflection from Plane Surface

Laws of Reflection

There are two laws of reflection

- (i) Angle of incidence is always equal to the angle of reflection. $\angle i = \angle r$
- (ii) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

Note

- Silver metal is one of the best reflector of light.
- A ray of light which is incident normally on a mirror is reflected back along its own path. Law of reflection can be applied to all kinds of reflecting surface.

Regular and Diffused or Irregular Reflection of Light

- When a beam of incident light is reflected as a parallel beam in one direction, the regular reflection of light takes place from a smooth surface.
- A highly polished metal surface polished wooden table, and still water surface produce regular reflection of light.
- Diffused reflection takes place through the rough surfaces.
- Reflection through cardboard, paper table, walls, unpolished metal objects, etc. are the examples of diffused reflection.
- A book lying on a table can be observed by us due to diffuse reflection of light falling on the book.

Multiple Reflection

The reflection of light back and forth several time between reflecting surfaces is called multiple reflection.

Multiple Images

When two plane mirrors are placed at an angle (θ), then multiple images of an object are formed when the object is placed between the plane mirrors.

The number of image formed (n) = $\frac{360}{\theta} - 1$

where, $\theta = 180^\circ, 120^\circ, 90^\circ, 60^\circ, 45^\circ$ and 0° .

Mirror

Mirror is a polished surface like glass, which, reflects almost all the light that is incident on it. Mirrors are of two types

(i) Plane Mirror

If the reflecting surface of a mirror is plane, then the mirror is called a plane mirror. Image formed by a plane mirror can be seen only by looking into the mirror. Image formed by a plane mirror has the following properties

- It is always virtual and erect.
- The size of image is equal to the size of the object.
- The image formed is as far behind the mirror as the object is in front of it.
- The image is laterally inverted (i.e. left seems be right and *vice-versa*).

Uses of Plane Mirrors

- Plane mirrors are commonly used as looking glass because the reflection that forms the image is always erect and laterally inverted but they are always virtual.
- Used in making periscopes which is used in submarines.
- Used as blind turns of some busy roads, to see the vehicles coming from other side.
- They are used to make kaleidoscope, a toy which produces beautiful patterns from coloured paper, pieces of glass or small coloured beads.

(ii) Spherical Mirror

If the reflecting surface of the mirror is spherical, then the mirror is called a spherical mirror. Spherical mirrors are of two types

(a) Concave Mirror

- The spherical mirror with inward curve reflecting surface is called **concave mirror**.
- **Image Formed by Concave Mirror** The image formed by concave mirror depends on the distance of the object from the pole of concave mirror.

(b) Convex Mirror

- The spherical mirror with outward curve reflecting surface is called convex mirror.
- **Image Formed by Convex Mirror** The image formed by a convex mirror is always virtual, erect and smaller than the object (diminished).

Uses of Concave and Convex Mirror

- To see the large image of teeth of patient, concave mirrors are used by dentist.
- In torches, headlights of vehicles and search lights to get a strong, straight beam of light, etc. concave mirrors are used as reflectors.
- To see a large image of face, then concave mirrors are used as shaving mirrors.
- To see the traffic at the rear side or backside on the road, convex mirrors are used as rear view mirrors or side view mirrors in vehicle such as cars, scooters, buses, etc.
- Big convex mirrors are used as shop security mirrors. By installing a convex mirror in the shop, the shop owner can keep an eye on the customers.

Refraction of Light

- Change in path of a light ray as it passes from one medium to another medium is called refraction of light.
- A medium in which the speed of light is more, is known as optically rarer medium and in which speed of light is lesser is known as optically denser medium.

Everyday Examples of Refraction of Light

- The bottom of a pool containing water appears to be raised due to refraction of light which takes place when light rays pass from the pool of water into the air.
- The letters appear to be raised when viewed through a glass slab placed over the document because of refraction of light.
- A pencil partially immersed in water appears to be bent because of the refraction of light coming from the part of pencil that is under water.

- A lemon kept in water in a glass tumbler appears to be bigger than its actual size, when viewed from the sides.

Lens

A lens is a piece of transparent glass bound by the two spherical surfaces. Lenses are transparent so that light can pass through. Lenses are mainly of two types

(i) Convex Lens (Converging Lens)

- Convex lens is the lens which is thicker in the middle than at the edges. A beam of parallel rays of light falls on a convex lens from the left side.
- **Image formed by a Convex Lens** The nature and size of the image formed by a convex lens depends on the distance of the object from the convex lens.

(ii) Concave Lens (Diverging Lens)

- Concave lens is the lens which is thinner in the middle than at the edge. A parallel beam of light falls on a concave lens. After passing through the concave lens, the rays of light are diverging (or spreading out).
- **Image formed by a Concave Lens** The image formed by concave lens is always virtual, erect and diminished (or highly diminished).

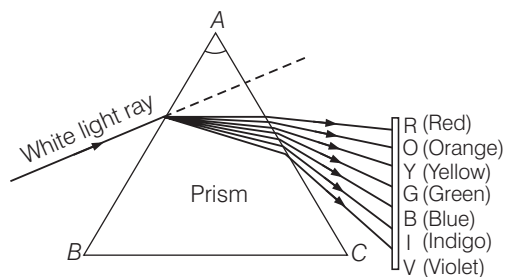
Uses of Lenses

- Convex lenses are used as a magnifying glass. In the manufacturing of spectacles, camera, microscope, telescope and binoculars, convex lenses are used.
- In order to see the image of the person standing outside, concave lenses are used in the peep holes in the door of hotel rooms. Concave lenses are used in making spectacles.

Dispersion of Light

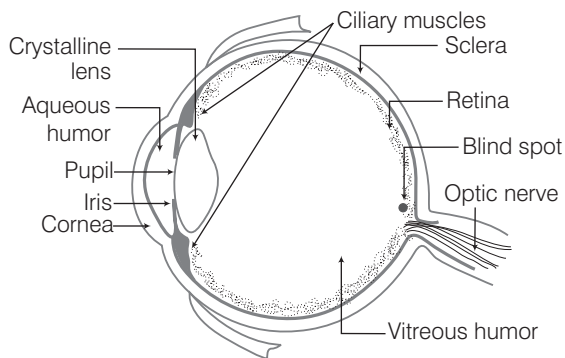
- When a white light ray passes through a transparent prism, then it splits into seven colours. This phenomenon of light is called dispersion of light.

- The seven colours are Violet, Indigo, Blue, Green, Yellow, Orange and Red.
- The deviation in red colour of light is minimum and in Violet colour of light is maximum.
- Red, Green and Blue are primary colours.



Human Eye

- The human eye is one of the most valuable and sensitive sense organ in the human body.
- It enables us to see the wonderful world and colour around us.
- It consists of a lens, which is made up of living tissues.



Internal Structure of Eye

Main parts of eye and their working are given below

- **Eyeball** Eyeball is approximately spherical. Its diameter is 2.3 cm.
- **Cornea** It is made of transparent substance and it is bulging outwards. The light coming from object enters through it.

- **Iris** It is the opaque screen behind the cornea. It has a small aperture at its centre. Generally, the iris is black in colour. It partially covers the front part of the lens.
- **Eye Lens** It is made of transparent and flexible material like jelly made by proteins. It is fixed by ciliary muscles.
- **Ciliary Muscles** The eye lens is held in position by ciliary muscles. Focal length is changed by the action of ciliary muscles.
- **Retina** The screen on which the image is formed in the eye is called **retina**. It is situated behind the lens at the back part of eye. The retina is delicate membrane having large number of light sensitive cells called **rods** and **cones**.
- **Eyelid** It is situated in front of eye which is just like a shutter.
- **Aqueous Humor** It is a viscous liquid filled between cornea and lens which protects the eye with shocks etc.
- **Vitreous Humor** It is a liquid filled between eye lens and retina.

Formation of an Image

An image is formed on the retina by successive refractions at the cornea, the aqueous humor, lens and vitreous humour. A *real, diminished and inverted image* of the object is formed on the retina.

The retina is a delicate membrane having enormous number of light-sensitive cells. These light-sensitive cells get activated upon illumination and generate electrical signals. These signals are sent to the brain *via* the optic nerve. The brain interprets these signals and finally, processes the information, so that we perceive objects as they are.

Power of Accommodation of Eye

The power of adjustment of focal length of eye lens with the help of ciliary muscles to see the near and far objects clearly is called the **accommodation of eye**.

Defects and Care of Eyes

(i) Myopia (Short Sightedness)

- It is a defect of eye because of which we cannot see farther objects clearly though we can see near objects clearly.
- Due to this, the length of the eye ball increases, i.e. the distance between eye lens and retina increases and the focal length of eye lens decreases or the curvature of eye lens increases.
- To remove this defect, we have to use that type of lens which is less convergent. Hence, a concave lens must be used.

Causes A person with this defect has the far point nearer than infinity. This defect arises due to the decrease in focal length of the lens because of

- excessive curvature of eye lens,
- elongation of the eyeball.

As a result, the image is formed before retina.

Remedy This defect can be corrected by using concave lens of appropriate power.

(ii) Hypermetropia (Long Sightedness)

- This is the defect of eye because of which we can not see the near objects clearly while we can see distant objects clearly.
- Due to this, the length of eye ball decreases, i.e., distance between eye lens and retina decreases and the focal length of eye lens increases, i.e. the curvature of eye lens decreases.
- To remove this defect, that type of lens must be used which has more converging power. Hence, convex lens of suitable focal length is used.

Causes This defect arises due to following reasons

- Focal length of eye lens becomes large.
- Eyeball becomes too short, so that the image is formed behind retina.

Remedy This defect can be corrected by using convex lens of appropriate power.

(iii) Presbyopia

- This defect is a combination of myopia and hypermetropia.
- This always happens in old age because of loss of accommodation of eye.
- This is remedied by using bi-focal lenses.

Causes This defect arises due to following reasons:

- Weakness of ciliary muscles.
- Hardening of eye lens or loss of elasticity.

Remedy This defect can be corrected by using bifocal or varifocal lenses which consist of both convex and concave lenses. The upper portion consists of a concave lens (for myopia) and lower portion consists of convex lens (for hypermetropia).

(iv) Astigmatism

- In this defect, the horizontal and vertical lines are not seen clearly simultaneously. Either horizontal and vertical lines are seen clearly.
- This is because the cornea is not perfectly spherical.
- This defect is remedied by using cylindrical lens.

Causes This defect arises due to imperfect shape (not perfectly spherical) of cornea or the lens or of both.

Remedy This defect can be corrected by using cylindrical lenses or refractive surgery.

Visually Challenged Person and Braille System

- Some persons may lose their eye sight due to a disease. Some persons cannot see at all from birth.
- Those persons who are unable to see are known as visually challenged persons.
- Such persons develop their other senses more sharply. They try to identify things by touching and by listening to voices more carefully.
- The most popular resources for visually challenged person which can make them read and write is Braille. It is a written language for the visually challenged person.
- Many Indian languages can be read and written by using the Braille system.

PRACTICE EXERCISE

1. We are able to see through a medium as light is transmitted through it
 (a) Opaque (b) Transparent
 (c) Translucent (d) Rough
2. Due to which property of light sharp shadows of opaque objects are obtained?
 (a) Light travels in straight line
 (b) Light travels in zig-zag
 (c) Light travels in vacuum
 (d) None of the above
3. Which metal is the best reflector of light?
 (a) Magnesium (b) Zinc
 (c) Copper (d) Silver
4. When all the colours of white light are reflected back from an object, then object will appear
 (a) blue (b) green (c) black (d) white
5. The black board seems black because
 (a) it reflects every colour
 (b) it does not reflect any colour
 (c) it absorbs black colour
 (d) it reflects black colour
6. In which of the following media, the velocity of light is maximum?
 (a) Water (b) Glass
 (c) Diamond (d) Vacuum
7. The stars are visible because
 (a) they are emitting their own light
 (b) they are reflecting the light of sun
 (c) they are away from earth
 (d) they are absorbing the light of sun
8. Number of image formed of an object placed between the two inclined plane mirror at an angle of 90° , is
 (a) 2 (b) 3 (c) 4 (d) 5
9. A virtual image, larger than the object can be produced by
 (a) Plane mirror (b) concave lens
 (c) convex mirror (d) concave mirror
10. When an object moves towards a convex lens, the size of the image
 (a) decreases
 (b) first decreases then increases
 (c) increases (d) remain the same
11. When light passes through a prism which colour shows maximum deviation?
 (a) Red colour (b) Violet colour
 (c) Blue colour (d) Green colour
12. When light travels from hot air to cold air, then
 (a) bends towards the normal
 (b) bends away from the normal
 (c) bends towards the normal and scatter
 (d) bends away from the normal and scatter
13. The focal length of convex lens used as a magnifying glass is
 (a) more (b) much more
 (c) less (d) All of these
14. Which one of the following materials cannot be used to make a lens?
 (a) Water (b) Glass (c) Plastic (d) Clay
15. In which of the following conditions the ray will not be deviated on passing through the lens?
 (a) The ray passes through optical centre
 (b) The ray passes through $2F$
 (c) The ray passes through first focus
 (d) The ray passes parallel to principal axis
16. The human eye forms the image of an object at its
 (a) retina (b) pupil (c) cornea (d) iris
17. The image of an object in case of hypermetropia is formed
 (a) behind the retina (b) at retina
 (c) before retina (d) None of these
18. After looking at the sun the colour of other things appears
 (a) black (b) white (c) yellow (d) red

19. Human eyes are always paired. What will happen if humans would have only one eye?
 - (a) the world would become two-dimensional for humans
 - (b) Humans will not be able to see objects beyond 90°
 - (c) All the objects will appear faint
 - (d) All of the above
20. The human eye has a converging lens system that produces an image just like a camera. If the eye views a distant object, which type of image is produced?
 - (a) Real, erect, same size
 - (b) Real, inverted, diminished
 - (c) Virtual, erect, diminished
 - (d) Virtual, inverted, magnified
21. A student is asked to sit at the last bench because he cannot read the letters written on blackboard clearly from front seat but still is unable to read the letters written in his textbook. Which of the following statements is correct?
 - (a) The near point has come closer to him
 - (b) The far point has come closer to him
 - (c) The near point has receded away
 - (d) The far point has receded away
22. What is the function of Iris in human eye?
 - (a) To control or regulate the amount of coming light to the eye
 - (b) To return the coming light to the eye
 - (c) To send the photo to the image lens
 - (d) None of the above

Answers

[illegible]