

Light and Optical Instruments

Light is a form of energy that enable us to see an object. The objects e.g. sun, lamp, candle, etc., which emit their own light are called **luminous objects**. Those objects which do not emit light energy themselves, while they reflect or scatter the light which falls on them are known as **non-luminous objects** e.g. chair, table etc.

- Speed of light in vacuum or in air is 3×10^8 m/s.
- Light takes 8 min 20 s to reach from sun to earth.

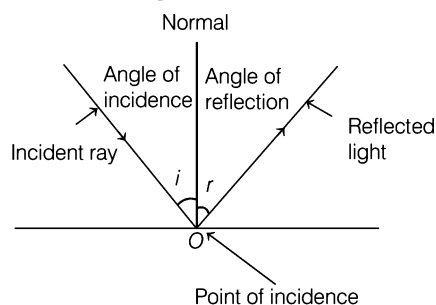
Some Important Terms Related of Light

- **Incident ray** It is the ray of light which falls on the mirror or smooth surface.
- **Reflected ray** It is the ray of light which is sent back by the mirror is known as reflected ray.
- **Point of Incidence** It is 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 lies.
- **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.

Light shows some important phenomenon which are given below.

Reflection of Light

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



Laws of Reflection

There are two laws of reflection.

- (i) Angle of incidence is always equal to the angle of reflection.

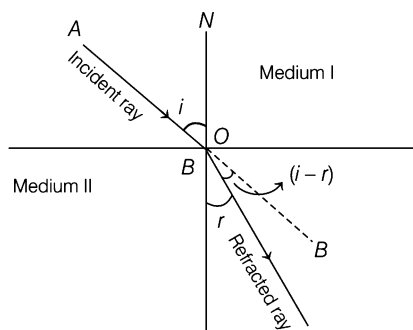
$$\angle i = \angle r$$

- (ii) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

☑ 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. Laws of reflection apply to all kinds of reflecting surface.

Refraction of Light

Change in path of a ray as it passes from one medium to another medium is called refraction of light.



Regular and Diffused 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 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.

Mirror

Mirror is a polished surface like glass, which, reflects almost all the light that is incident on it.

Mirrors are of two types

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 the 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 to be right and vice-versa).

Spherical Mirror

If the reflecting surface of the mirror is spherical, the mirror is called a spherical mirror.

Spherical mirrors are of two types

- (i) **Concave Mirror** The spherical mirror with inward curve reflecting surface is called a concave mirror.

Image formed by concave mirror The image formed by a concave mirror is virtual, erect, and larger than the object (enlarged or magnified).

- (ii) **Convex Mirror** The spherical mirror with outward curve reflecting surface is called a 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 Mirrors

- To see the large image of teeth of a patient, concave mirrors are used by dentists.
- In torches, headlights of vehicles and searchlights 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 vehicles 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.

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. Lenses are of two types

(i) Convex lens (ii) Concave lens

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.

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).
- The image formed by concave lens is always virtual and erect and diminished (or highly diminished).

Uses of Lenses

- Convex lenses are used as a magnifying glass.
- In the manufacturing of spectacles, camera, microscope 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.

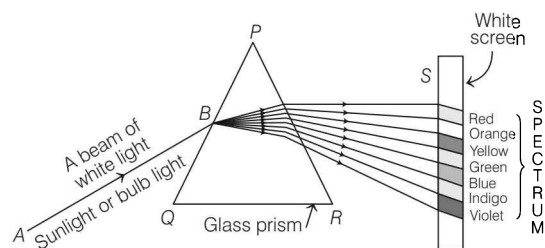
Prism

It is a uniform transparent refracting medium bounded by two plane surfaces inclined at certain angle.

Issac Newton was the first who used a glass prism to obtain the spectrum of light.

Dispersion of Light

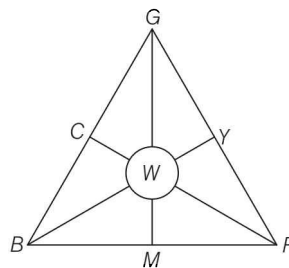
- When a narrow beam of light is incident on a prism, the emergent beam is not only deviated, but at the same time splits up into a coloured band of seven colours. This phenomenon is called dispersion of light.
- The seven colours of band are violet, indigo, blue, green, yellow, orange and red. (VIBGYOR)
- Violet colour deviates through maximum angle and red colour deviates through the minimum angle.
- Red, green and blue are called primary colours or basic colours.



Dispersion of white light by Prism

Colours of Objects

Red (R), Green (G) and Blue (B) are primary colour. All other colours are secondary colours.



$G + R = Y$ (Yellow)

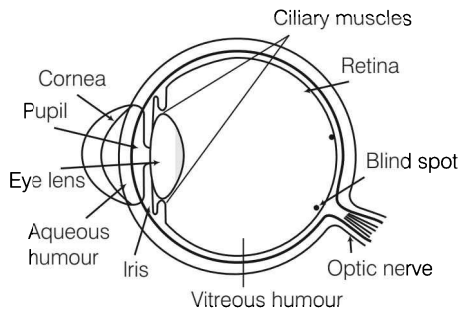
$R + B = M$ (Magenta)

$B + G = C$ (Cyan-peacock blue)

$B + G + R = W$ (White)

Human Eye

Human eye is just like a camera. It is a natural optical instrument given by nature.



Internal Structure of Eye

Main part of eye and their working are given below

- **Eye Ball** Eye ball 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** which respond to the intensity of light and colour of objects respectively by generating electrical signals.
- **Eyelid** It is situated in front of eye which is just like a shutter.
- **Aqueous Humour** It is a viscous liquid filled between cornea and lens which protects the eye with shocks etc.
- **Vitreous Humour** It is a liquid filled between eye lens and retina.

Power of Accommodation of Eye

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

Defects of Eye

(i) Myopia

- 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.
- To removal this defect, we have to use that type of lens which is less convergent. Hence, a concave lens must be used.

(ii) Hypermetropia

- 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.
- To remove this defect, that type of lens must be used which has more converging power.
- The convex lens of suitable focal length is used to remedied this defect.

(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 defect is remedied by using bifocal lens.

(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 (toric lenses).

Optical Instruments

- Optical instrument is a device which is made from proper combination of mirrors, prisms and lenses.
- The principle of working of optical instrument depends on the reflection and reflection and refraction of light.

Various types of optical instruments are given below

Telescope

- Telescope consists of two convex lens system.
- It is used to see the magnified image of the distant objects.

Periscope

- The periscope makes the use of two plane mirrors and enables us to see objects which are not visible directly.
- Periscopes are used in submarines, tanks and also by soldiers in bunkers to see things outside.

Kaleidoscope

- In a kaleidoscope, the number of images formed by mirrors placed at an angle to one another is used to make numerous beautiful patterns.
- It is a interesting feature of a kaleidoscope that the same pattern is never seen again. Designers of wallpapers and fabrics and artists use kaleidoscopes to get ideas for new patterns.

Practice Exercise

1. Light travels in a
(a) random direction (b) straight line
(c) curved line (d) *zig-zag* line
2. In which medium the speed of light is highest?
(a) Solid (b) Liquid
(c) Vacuum (d) Gases
3. The value of speed of light is
(a) 3×10^8 m/s (b) 2×10^5 m/s
(c) 4×10^6 m/s (d) 3×10^9 m/s
4. Shadows give us the information regarding the
(a) size of the object (b) surface
(c) shape of the object (d) shape of the source
5. Two students while sitting across a table looked down onto its top surface. They noticed that they could see their own and each other's image. The table top is likely to be made of
(a) unpolished wood
(b) red stone
(c) glass sheet
(d) wood top covered with cloth
6. Shadow of an object is always seen
(a) blue (b) black
(c) red (d) None of these
7. Angle of incidence is equal to the angle of reflection.
(a) Always
(b) Sometimes
(c) Under special conditions
(d) Never
8. 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
9. An object appears blue when seen in white light. When seen in red light, it will appear
(a) black (b) blue (c) red (d) green
10. The bottom of a beaker filled with liquid appears to be slightly raised due to
(a) reflection
(b) refraction
(c) interference
(d) diffraction

