Light

TALENT & OLYMPIAD

Introduction

When ever we hear the word light, many questions arises in our mind. But the most common question that comes in our mind is 'what is light?'. Why we are able to see the object in presence of light and not in the dark? What makes the things visible to us? And many such questions keeps wondering in our mind.

Light is can be defined as the form of energy which produce the sensation of vision. Whenever the light falls on a object it gets reflected by the object and received by our eyes, therefore enable us to see that object. There are many wonderful phenomenon associated with the light, such as **image formation, refraction of light, twinkling of star, rainbow formation** just after rain, etc. In this chapter we will discuss about all these phenomena associated with the light, in detail.

Light exhibits two properties known as **dual property** i.e. **wave nature and particle nature**. Light consists of electromagnetic waves which do not require any medium to travel. According to particle nature of light, light travels in a straight line and cannot pass through the opaque wall or any other barrier.

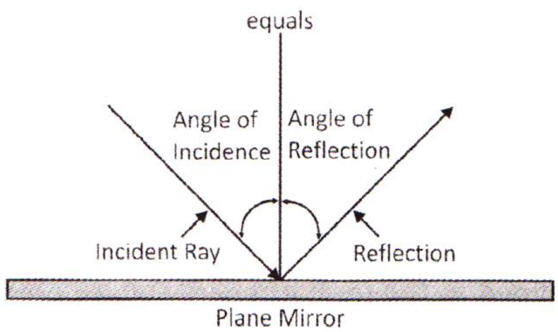
Other phenomena like reflection, refraction, and casting of shadow also shows the particle nature of light. Thus the quantum theory of light explains both the nature of light according to the condition.

Reflection of Light

Whenever light falls on an object some of it is reflected and others are absorbed by the surface. If the light is not reflected by the surface, i.e. all the light is absorbed by the surface, then the object will appear black, like black board or black hole, which is not visible to us. If the light falls on a polished surface, it gets reflected back in the same plane from where it is incidented. This bouncing back of light, after striking a polished surface, is called reflection of light.

Silver metal is considered to be one of the best reflector of light.

Reflection of light shows the particle nature of light. For example, when a rubber cricket ball is strike against a wall it bounces back in the opposite direction, or in other words it is reflected back by the wall. Similarly, if we try to see objects in a dark room it is not visible to us, but if we switch on the light it becomes visible to us. This is because when we switch on the light, the light falls on the object and is reflected back and absorbed by our eyes, and hence we are able to visualize the objects.



Thus on the basis of above observation the laws of reflection has been formulated as below:

There are Two Laws of Reflection. These are

- The incident ray, the reflected ray, and the normal all lies on the same plane,
- The angle of incidence is equal to the angle of reflection.

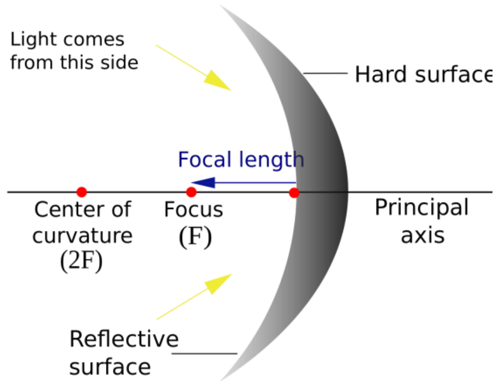
As we know that the silver metal is the best reflector, we can make an ordinary mirror simply by coating a layer of silver metal on the surface of glass. A plane mirror is a good reflector of light. The reflecting surface is divided into two category as plane and spherical surfaces.

The Spherical Mirror is Again of Two Types

- Concave Mirror
- Convex Mirror

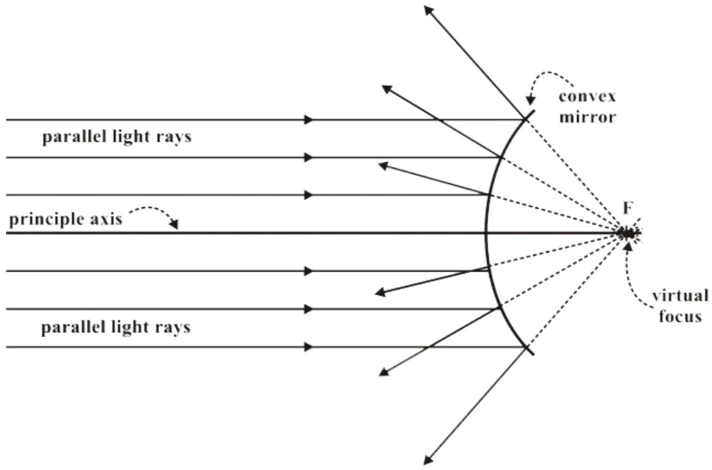
Concave Mirror

The mirror which is curved inwards is called a concave mirror. It is also known as converging mirror. It converges the ray of light falling on its surface at a point on the surface.



Convex Mirror

The mirror which is curved outward is called a convex mirror. It is also known as diverging mirror.

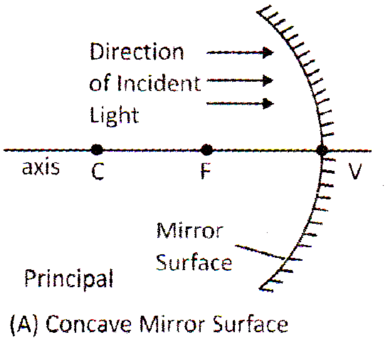


The centre of curvature of a spherical mirror is the centre of the hollow spherical surface of which mirror is consider to be the part. The centre of curvature does not lay on the mirror, it lies in front of the concave mirror and behind the convex mirror. The distance between the pole and centre of curvature of the mirror is called the **radius of curvature**. It is represented by letter **R**.

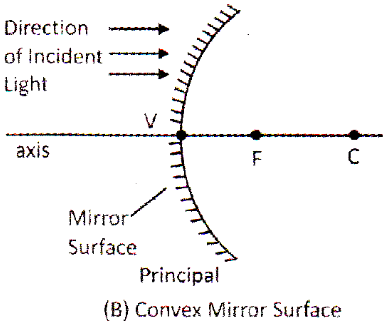
Pole is defined as the centre of the mirror and it lies on the mirror. It is normally denoted by P. The principle axis is the imaginary line which passes through the pole of the mirror. The principle axis is always perpendicular to the surface of the mirror.

The centre of curvature, pole, focus, all lies on the principal axis. The focus is defined as the point on the principal axis at which ray of light converges after reflection. It lies at the midpoint between the centre of curvature and pole of the mirror. It is denoted by **f**. The distance between the pole and focus is called the focal length. It is expressed by $f = \frac{R}{2}$.

The portion of a mirror from which the reflection of light actually takes places is called the **aperture of the mirror**. It is also the diameter of the spherical surface or also the size of the spherical mirror.



(A) Concave Mirror Surface

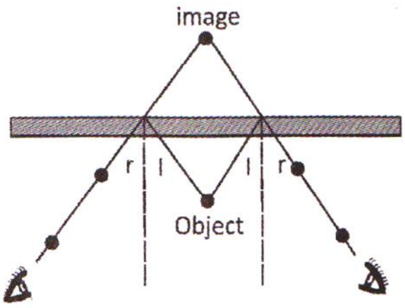


(B) Convex Mirror Surface

Objects and Images

In this chapter we will use the term objects and image more often. Here the objects refers to the sources of light, which falls on the mirror and reflection takes places. It may be of two types, i.e. either very small or very large. The very small objects are called the point objects. The other term is the image which is obtained when the ray of light from an objects is reflected from a reflecting surface and an object like appearance is obtained. Image is of two types: **real image and virtual image**.

The real image are the images which can be obtained on the screen. **For example the image which we see on the screen of the cinema hall is a real image**. The image which cannot be obtained on the screen are called the virtual image. **For example the image obtained from the reflection in the mirror are all virtual image**. It is just an illusion of which we can simply think of and which cannot be obtained in real sense. A plane mirror always forms the virtual image.

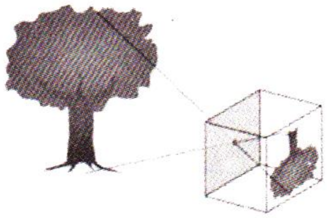


The image in the case of plane mirror is obtained only when we look into the mirror and cannot be obtained on the screen. It we place a screen behind the mirror it will not be possible for us to obtained the image of any object on the screen. The dotted line shown behind the mirror are only imaginary ray of lights.

There is no real ray of light behind the mirror as the surface of mirror is painted with silver paints, which do not allow the ray of light to pass through it. It is only the reflected light coming from the mirror, where the image is actually formed. **Hence the image formed by the plane mirror is virtual and erect and size of the image is equal to the size of the object**. The distance of the image is same as that of the object in front of the mirror.

Lateral Inversion

All of us might have observed that when we stand in front of the mirror our left appears right and right appears left and vice versa. It seems that as if our images have been reversed. This reversal of image is called the lateral inversion. Hence, we can say that the image formed in the plane mirror is



In the above figure, we may observe that a tree which has been placed in front of a plane mirror he left side of the tree appears right and right side of the tree appears left. We can, therefore say that the image formed in the plane mirror is **laterally inverted.** The most common phenomena of lateral inversion which we observe is that the word **AMBULANCE** on the hospital van is written in the form of its mirror image as ƎƆИAJUꓭMA .This is because when we are driving a car and see the hospital van coming from behind in our rearer view mirror, we can read it as **AMBULANCE** and give side to the van as it carries the serious patient to the hospital.

The plane mirror can be used in barbershop, bathroom, jewelry shops, at the blind turns of some of the busy roads and in periscope.

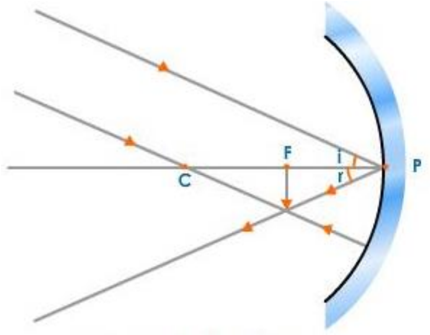
Image Formation by a Concave Mirror

In this part we will discuss about the nature, position, and relative size of the mage formed of the various position of the objects. The image may be re a or real or virtual. We will try to find out, with the help of a mirror, the position of the objects. The nature of image formed depends on the position o the object The position carnage is obtained by intersection of at least two of the reflected rays.

When the Object is at Infinity

When the object is at infinity, in the case of a concave mirror, the image formed has the following properties:

- The image is real.
- The image is inverted.
- The image is highly diminished.
- The image is formed at the principal focus in front of the concave mirror.

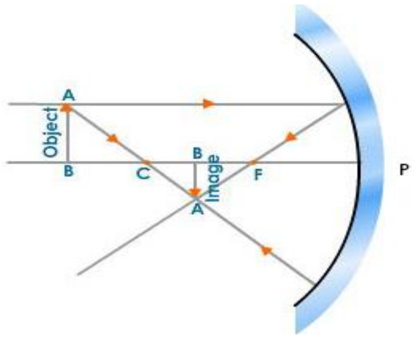


When the Object is Infinity

When the Object is Beyond C

When the object is beyond C, the image formed has following properties:

- The image is real.
- The image is inverted.
- The image is diminished to a point.
- The image is formed between focus and centre of curvature in front of the concave mirror.

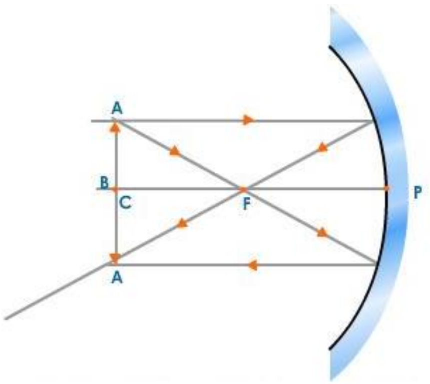


When the Object is placed beyond C

When the Object is at C

When the object is beyond C, the image formed has following properties:

- The image is real.
- The image is inverted.
- The image is equal in size to that of the object.
- The image is formed at centre of curvature in front of the concave mirror.

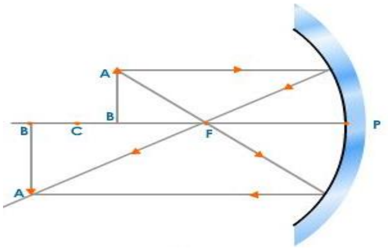


When the Objects is Placed at the Centre of Curvature

When the Object is between Centre of Curvature and Focus

When the object is between C and F, the image formed has following properties:

- The image is real.
- The image is inverted.
- The image is enlarged in size in comparison to that of the object.
- The image is formed beyond centre of curvature in front of the concave mirror.

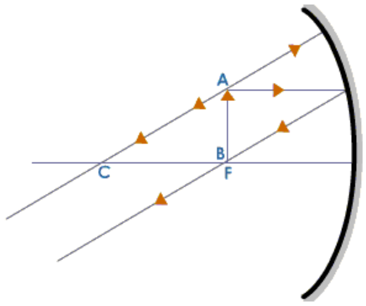


When the Object is Between C and F

When the Object is at Focus

When the object is at F, the image formed has following properties:

- The image is real.
- The image is inverted.
- The image is highly enlarged in size to that of the object.
- The image is formed at infinity in front of the concave mirror.

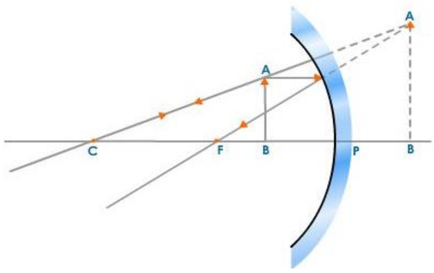


When the Objects is at the Focus

When the Object is between Focus and Pole

When the object is between F and P, the image formed has following properties:

- The image is virtual.
- The image is erect.
- The image is enlarged in size to that of the object.
- The image is formed behind the mirror.

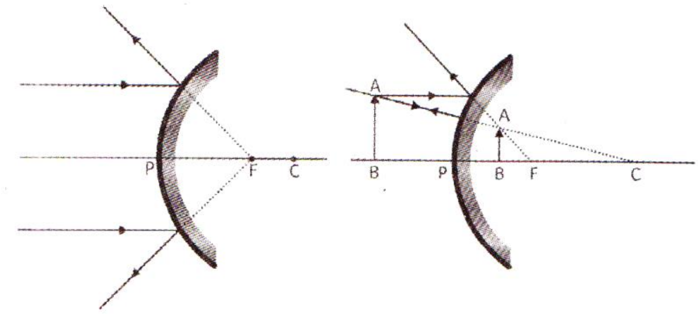


When the objects is between the pole and Focus

The summary of the above observation is given in the Table Below:

SL. No.	Position of the Object	Position of the Image	Nature of Image	Size of Image
1.	At Infinity	At the Focus F	Real and Inverted	Highly Diminished
2.	Beyond C	Between C and F	Real and Inverted	Smaller in Size
3.	At C	At C	Real and Inverted	Equal in Size
4.	Between C and F	Beyond C	Real and Inverted	Larger in size
5.	At F	At Infinity	Real and Inverted	Highly Enlarged
6.	Between F and P	Behind the Mirror	Virtual and Erect	Larger in Size

Image formation by a convex mirror



When the object is placed between P and F

When the object is placed in front of convex mirror, the image formed has following properties:

- The image is virtual.
- The image is erect.
- The image is enlarged in size to that of the object.
- The image is formed behind the mirror.

The Summary of the above Observation is given in the Table below:

S. NO.	Position of Object	Position of Image	Nature of Image	Size of Image
1	In front of Mirror	Behind Mirror and between P and F	Diminished	Virtual and Erect
2.	At infinity	Behind the mirror and at F	Highly diminished	Virtual and Erect

Uses of Concave Mirror

- It is used as a reflector in torches, vehicle head light and search lights. It is used in search light because it produces powerful beam of parallel light, which helps us to see the objects at a considerable distance in the darkness of night.
- It is used as a shaving mirror to see the large image of the face.
- It is used by the dentist to see the large images of the teeth and to find out the problem, the person is suffering from.
- It is also used in solar furnace to focus the solar radiation for the heating purpose.

Uses of Convex Mirror

- It is used as a rear view mirror in vehicles to see other vehicles coming from behind, as it produces an erect image of the object, which is easy to identify. It also gives the driver the wider view of the traffic behind him.

Sign Convention for Spherical Mirrors

Concave Mirror

- For Object in front of the mirror U will be negative.
- For real image formed in front of mirror V will be negative.
- Focus (F) is negative.
- For virtual image formed behind the mirror V is positive.

Convex Mirror

- For object in front of mirror U is negative.
- Image is formed behind the mirror V is positive.
- Focus is behind the mirror F is positive.

Mirror Formula

The formula which gives the relation between the object distance (U), image distance (V) and focal length (F) is called the mirror formula. The distance between the pole and the object is called the object distance and is denoted by U. The distance between the pole and image is called the image distance and is denoted by V and the distance between the pole and focus is called focal length and is denoted by F. Hence the mirror formula is given by

$$\frac{1}{\text{Focal Length}} = \frac{1}{\text{Object Distance}} + \frac{1}{\text{Image Distance}} \quad \frac{1}{F} = \frac{1}{U} + \frac{1}{V}$$

While finding one of the three value in the relation we must take care of sign convention of the mirror. Out of three parameter in the relation we can find any one of them provided two of them is given.

Magnification

It is defined as the extent to which an image can be enlarged or diminished by a mirror. For the spherical mirror the linear magnification is defined as the ratio of height of image to the height of object. If the magnification has positive sign then the image is virtual and erect. On the other hand, if the sign is negative the image is real and inverted. The linear magnification is also defined as the ratio of image distance to the object distance. It is expressed as:

$$M = \frac{h_2}{h_1} = -\frac{V}{U}$$

Where,

h_1 is the height of object,

h_2 is the height of image,

U is the object distance

V is the image distance

Commonly Asked QUESTIONS

What is the position of image when the object is placed at the infinity?

(a) Focus (b) Between F and C

(c) At C (d) Beyond C

(e) None of these

Answer: (a)

When an object is placed in front of the plane mirror the left appears right and the right appears left. This phenomenon is called

(a) Reflection (b) Mirage

(c) Lateral Inversion (d) Looming

(e) None of these

Answer: (C)

The point on the principal axis at which the ray of light converges after reflection is called

(a) Centre of Curvature (b) Focus

(c) Pole (d) Radii

(e) None of these

Answer: (b)

What is the nature of image when it is reflected from convex mirror?

(a) Real (b) Inverted

(c) Highly Enlarged (d) Virtual

(e) None of these

Answer: (d)

An object at 5 cm high forms an image at a distance of 6 cm and focal length of 15 cm. Find the position of image.

(a) 5cm (b) 10cm

(c) 15cm (d) 20cm

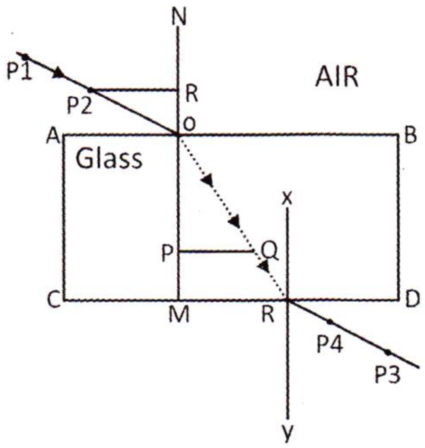
(e) None of these

Answer (B):

Refraction of Light

We know that light always travels in a straight line and never changes its direction. But this fact is true as long as it travels in one medium. As soon as it changes its medium i.e. as it goes from one medium to another, it changes its direction at the border of the two medium. This change in the direction of **light as it goes from one medium to another is called refraction of light**.

For example, when light travels from air to glass, glass to water, water to air, etc it undergoes refraction. Let us consider a rectangular glass slab ABCD as shown in the figure given below. A ray of light PQ is incidented on the glass slab from air at the point Q. The incident light passes through the glass slab. Since the glass slab is optically denser than air, so the ray of light changes its direction as it goes from air into the glass along the line QR, inside the glass slab.



This ray of light when emerges from the glass slab along RS, again it changes its direction, because of the difference in the density of both the medium. Here PQ is **incident ray,** QR is **refracted ray** and RS is **emergent ray**. The incident ray and the refracted ray are not along the same direction. N_1QN_2 and N_3RN_4 **are the normal** at the point **Q** and **R** to the surface of the glass slab. The angle, between the incident ray and the normal is called angle of incidence and the angle, between the refracted ray and the normal at that point is called angle of refraction. The angle of incidence and angle of refraction are not usually same.

The real cause for the refraction of light is the difference in the density of the two medium. Due to difference in the density of the two medium, the speed of light changes as it goes from one medium to the another, and hence refraction takes places. The medium, in which the speed of light is more of the two medium, is called the rarer medium and the medium, in which the speed of light is less is called the denser medium. When the ray of light goes from rarer medium to the denser medium it bends towards the normal; and when it goes from denser medium to the rarer medium, it bends away from the normal. The distance between the emergent ray and the original direction of the ray of the light is called the lateral displacement.

Various Effect of Refraction of Light

A Pencil Appears Bent when Partially Immersed in a Glass of Water

When a pencil is partly immersed in water and held obliquely to the surface of water, it appears bent at the point where it enters into the water. This apparent bending of the pencil is due to the refraction of light as it passes from air into the water is due to the refraction of light.

The Swimming Pool Appears to be Less Deep than Actually it is

The apparent depth of the water in the swimming pool appears less than actually it is, because of refraction of light when it passes from air into the water. When we look into the pool from above, the ray of light converges above the base of the pool; and hence it appears to be less deep, than actually it is.

A Coin Placed under Water appears to be raised

A coin appears to be raised from the base, when placed in a glass of water. It is due to the refraction of light that takes place when it goes from water into air. When the coin is place under water, due to refraction of light a virtual image is formed near the surface of the water. Since the virtual image of coins which we see is near the surface of water, the coin appears to be raised.

Laws of Refraction

When the light travels from one medium to another, it undergoes refraction according to the following law:

- The incident ray, the refracted ray and the normal, all lies in the same plane.
- The ratio of sine of angle of incidence to the sine of angle of refraction, is always a constant for the two given medium, in which refraction takes places.

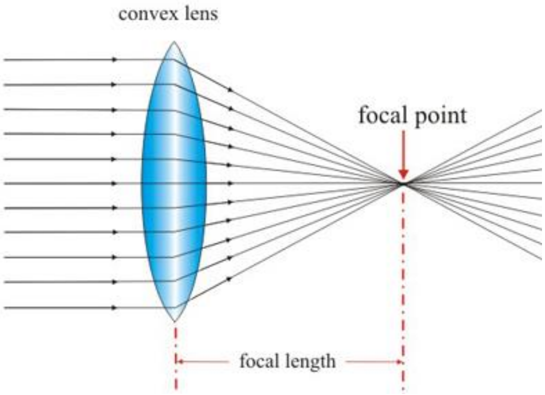
$$\frac{\sin i}{\sin r} = \text{constant} = \mu$$

This constant is called the refractive index of the medium. It is also known as the Snell's law. The refractive index of a medium gives an indication of the light bending ability of that medium. For example, the refractive index of glass is more than that of water, hence light rays bend more on passing from water into glass. When light goes from one medium to another, the value of refractive index is called the relative refractive index. If the light is going from vacuum to another medium, the value of the refractive index is called the absolute refractive index. An object, having higher refractive index is optically denser than another object, having lower refractive index.

Lens

A transparent object having two refracting surface is called **lens**. It is of two types, **concave lens and convex** lens. Working of lens is based on the refraction of light passing through it.

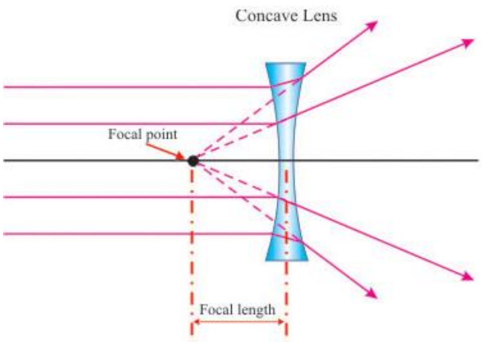
Convex Lens



Convex lens is the lens which is thicker at the centre and thinner at the edge. It has two refracting surfaces. It is also called the converging lens as the ray of light converges at a point after refraction. The point, at which ray of light converges after refraction, is called the focus of the lens.

Concave Lens

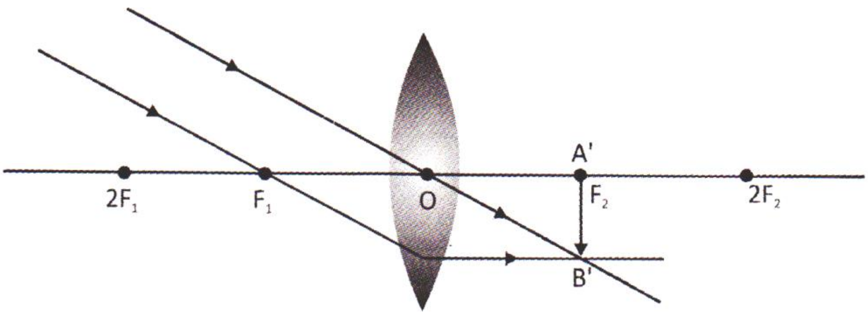
It is the lens which is thinner at the centre and thicker at the edge. It also has two refracting surfaces. It is called **diverging lens** as the ray of light diverges in different direction after refraction.



The centre of the lens is called the optical center. It is normally denoted by C. The ray of light passing through optical center do not undergo any' deviation, and goes in a straight line. Thus, the line passing through the optical centre of the lens and perpendicular to both the face of the lens, is called the principal **axis**. The ray of light that converges at a point on the principal axis is known as the **principal focus**. The distance between focus and optical centre is called the **focal length**.

Image Formation by a Convex Lens

I. When the object is at infinity



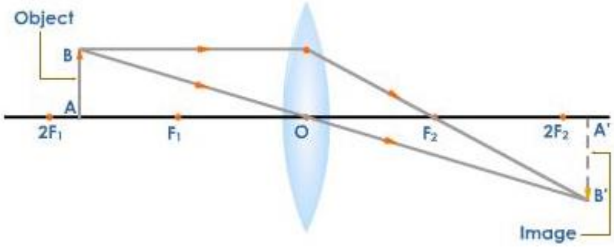
Properties of Image formed is

A. Image is formed at focus.

B. Image is real and inverted.

C. Highly diminished.

II. When the object is beyond $2F_1$



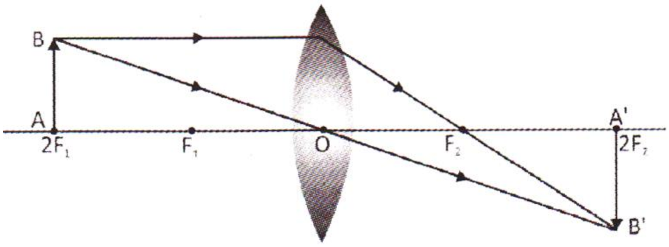
Properties of Image formed is

A. Image is formed between F_2 and $2F_2$.

B. Image is real and inverted.

C. Image is diminished.

III. When the object is at $2F_1$



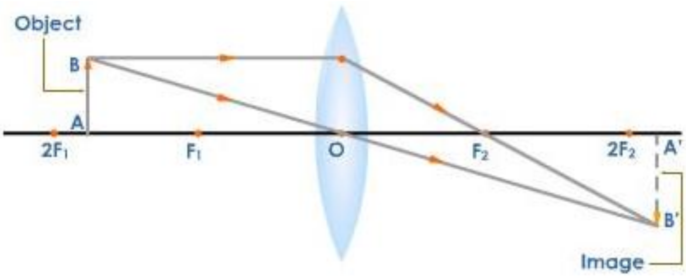
Properties of Image formed is

A. Image is formed at $2F_2$.

B. Image is real and inverted.

C. Image is equal in size to that of the object.

IV. When the object is between $2F_1$ and F_1



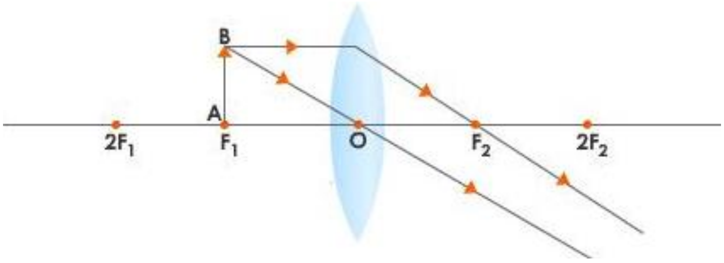
Properties of Image formed is

A. Image is formed beyond $2F_2$.

B. Image is real and inverted.

C. Image is larger in size to that of the object.

V. When the object is at F_1



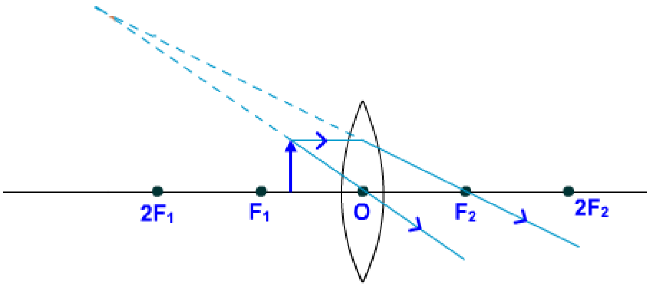
Properties of Image formed is

A. Image is formed infinity

B. Image is real and inverted.

C. Image is highly enlarge.

VI. When the object is F_1 is between optical centre



Properties of Image formed is

A. Image is formed behind object.

B. Image is virtual and erect.

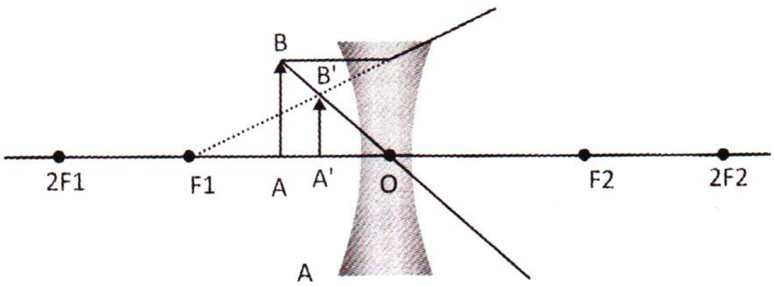
C. Image is enlarged.

The summary of the above observation is given in the table below:

S. No.	Position of Object	Position of Image	Nature of Image	Size of Image
1.	At infinity	At Focus	Real and Inverted	Highly diminish
2.	Beyond $2F_1$	Between F_2 and $2F_2$	Real and Inverted	Smaller in size
3.	At $2F_1$	At $2F_1$	Real and Inverted	Equal in size
4.	Between F_1 and $2F_1$	Beyond $2F_2$	Real and Inverted	Equal in size
5.	At F_1	At Infinity	Real and Inverted	Highly Enlarge
6.	Between F_1 and O	Behind Object	Virtual and Erect	Larger in size

Image Formation by a Concave Lens

When the objects at any point between optical centre and infinity



Properties of Image

A. Image is formed between 0 and P.

B. Image is Virtual and Erect.

C. Smaller is size.

Uses of Concave Lens

- It is used for correcting myopia.
- Along with convex lens it can be used for correction of spherical aberration and chromatic aberration, and chromatic aberration.
- It is used in binoculars.

Uses of Convex Lens

- It is used as a magnifying glass.
- It is used for correcting hypermetropia defects in eyes.
- It is also used in microscope and reflecting telescope.

Sign Convention used in Lens

- For convex lens the object distance is negative, as it is to the left of the lens. The image distance and focal length is positive for all real image, as it is to the right of the lens.
- For virtual image the image distance is negative, as it is formed behind the object and to the left of the lens.
- For concave lens the object distance, image distance and focal length are all negative, as all of them lie to the left of the lens.

Lens Formula

The mathematical relationship between the object distance, image distance, and focal length is called the lens formula. It is expressed as;

$\frac{1}{f}=\frac{1}{v}=\frac{1}{u}$, where, f is the focal length, v is the image distance and u is the object distance.

Magnification of the lens is defined as the ratio of height of image to the height of object or ratio of image distance to the object distance. It is expressed as:

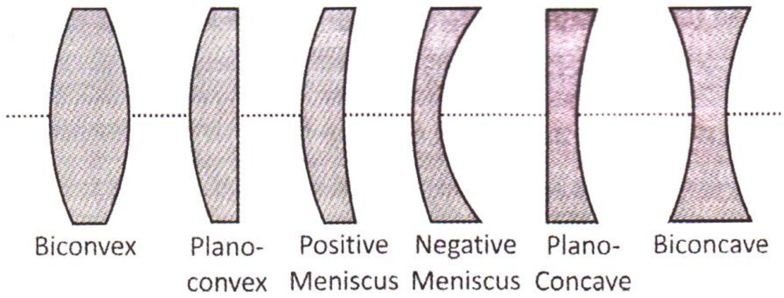
$$m=\frac{v}{u}=\frac{h_2}{h_1}$$

Power of Lens

Power of the lens is defined as the ability of the lens to converge or diverge the ray of light passing through it. The power of the convex lens is said to be more, if the ray of the light converges more strongly towards the optical centre. The power of the lens depends on the focal length of the lens. It is defined as the reciprocal of the focal length in meters. It is expressed as $P=\frac{1}{f}$.

The SI unit of power of the lens is **diopter and is denoted by D**. One diopter is defined as the power of the lens having focal length of one meter. The focal length of the convex lens is positive so the power is positive and that of the concave lens is negative as its focal length is negative.

Types of Simple Lenses



Power of Combination of Lens

When number of lens are placed in contact with each other, the power of combination of the lenses is equal to the algebraic sum of the powers of the individual lenses . If $P_1, P_2, P_3, ---P_n$ are n lenses placed in contact with each other then the combined power of the lens is given by $P = P_1 + P_2 + P_3 + ---- + P_n$

The system of combination of lens is used in designing the optical instrument like cameras, microscope and telescope. It increases the sharpness of the image.

Commonly Asked Questions

The speed of light in water is found to be:

(a) $3\times10^8\ m/s$ (b) $3.2\times10^8\ m/s$

(c) $1.2\times10^8\ m/s$ (d) $2.25\times10^8\ m/s$

(e) None of these

Answer: (d)

A stick partially immersed in water appears to be bent when seen from outside because of:

(a) Reflection (b) Refraction

(c) Dispersion (d) Scattering

(e) None of these

Answer: (b)

On which one of the following does the refractive index of the light depend?

(a) Intensity (b) Frequency

(c) Wavelength (d) Density of medium

(e) None of these

Answer: (c)

Where will the image forms if the object is placed at 2F in case of convex lens?

(a) At F (b) Between F and 2F

(c) At 2F (d) Beyond 2F

(e) None of these

Answer (c)

Find the power of lens whose focal length is +10 cm.

(a) -10 D (b) +10 D

(c) +1D (d) -1 D

(e) None of these

Answer: (b)

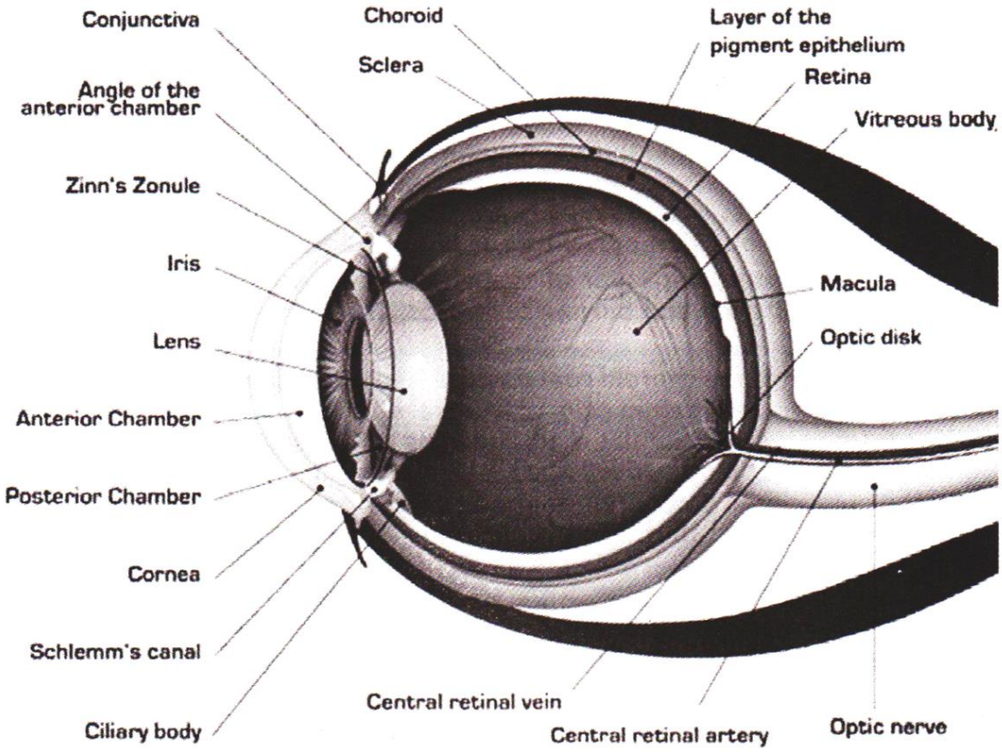
Human Eyes

It is one of the important-organ of human beings. It works on the' refraction of light as the other optical instruments, like camera, telescope, microscope etc. In this part we discuss about the structure and various defects of human eyes. The main parts of human eyes are **Cornea, iris, pupil, ciliary muscles, lens, retina, aqueous humour, vitreous humour, and optic nerves**.

Cornea is the outermost layer of the human eyes which is made up of a transparent substance and bulging outwards. The light enters into our eyes through cornea.

In front of the eye, the choroid coat forms the iris. This may be pigmented and is responsible for the different color of the eye. An opening, the pupil, is present in the center of the iris. The size of this opening is variable and under automatic control. In dim light the pupil enlarges, letting more light into the eye. In bright light, the pupil closes down. This not only protects the interior of the eye from excessive illumination, but improves its image-forming ability and depth of field.

The inner coat of the eye is the **retina**. It contains the visual sensing apparatus such as, **the actual light receptors, the rod cells and cone cells**. The exterior of the cornea is bathed by tears, while the interior is bathed by the aqueous humor. It is an isosmotic fluid containing **salts, albumin, globulin, glucose, and other constituents**. The aqueous humor brings nutrients to the cornea and to the lens and removes end products of metabolism from these tissues. The vitreous humor is a collagenous or gelatinous like mass that not only helps to maintain the shape of the eye, but also allows it to retain some pliability. The lens of the eye is located just behind the iris. It is held in position by ligaments. Ordinarily, these are kept under tension and the lens is correspondingly flattened. However, contraction of muscles attached to these ligaments relaxes them and permits the lens to take on a more nearly spherical shape. These changes in lens shape enable the eye to shift its focus from far objects to near objects and vice versa. The lens of the eye is bathed, on one side by the **aqueous humor,** and supported on the other side by the vitreous humor. The lens has no blood supply, but it is an active metabolizing tissue. The lens is mostly water and protein. The proteins are synthesized within the lens, occurring mostly in an epithelial layer around the edge of the lens. The center area of the lens, the core, consists of the lens cells that are present at birth. The lens grows from the periphery. The human lens increases in weight and thickness with age and becomes less elastic. On an average the lens may increase threefold in size and approximately 1.5-fold in thickness from birth to about the age of 80.



The iris and the lens divide the interior of the eyeball into **two main chambers**. The anterior one is filled with a watery fluid, **the aqueous humor. The porterior** chamber is filled with a jellylike material of marvelous clarity, **the vitreous humor**. Eyes are in continuous movement during watching. Even when they are observing, a resting object they are doing small, involuntary movements. Movement of the eyeball is accomplished by three pairs of muscles, the members of each pair working antagonistically. The coordinated action of these muscles enables the eyeball to be rotated in any direction. Thus, we are able to train both eyes in a single direction. This produces two slightly differing views of the same scene, which our brain is able to fuse into a single, three-dimensional image.

When the ray of light coming from the object enters into our eyes from pupil and falls on the eye lens, it converges and produce the real and inverted image on the retina. The image formed on the retina is transmitted to the brain by the optic nerve and produces the sensation of vision. The retina consists of two types of the cells **rod cell and cone cell**. The rod cell produce the sensation of vision and responds to the intensity of light; and cone cell helps in differentiating the colors. The region on the retina, which is insensitive to the light is called the blind spot.

Our eyes can focus distant object, as well as, nearby object on its retina, by changing it focal length. This ability of the eyes is called the power of accommodation of the eyes. The least distance of distinct vision of the normal human eyes is 25 cm. The farthest point from the eye, at which an object can be seen clearly, is known as the far point of the eye and the nearest point up to which eyes can see the object clearly, is called the near point of the eye.

Defects of Vision and their Corrections

Sometime it happens that we cannot see the object clearly due to one reason or the other and such problems are called the defects of vision. There may be different reasons for different defect of vision.

The different defects of vision are:

- Myopia or Shortsightedness
- Hyper Metropia or Long Sightedness
- Presbyopia
- Astigmatism

Myopia

Nearsightedness, also called myopia is common name for impaired vision. In this a person sees near objects clearly, while distant objects appear blurred. In such a defective eye, the image of a distant object is formed in front of the retina and not at the retina itself. Consequently, a nearsighted person cannot focus clearly on an object farther away than the far point for the defective eye.

- **Causes**

  This defect arises because the power of the eye is too large due to the decrease in focal length of the crystalline lens. This may arise due to either

  (a) Excessive curvature of the cornea, or

  (b) Elongation of the eyeball.

- **Correction**

  This defect can be corrected by using a concave lens. A concave lens of appropriate power or focal length is able to bring the image of the object back on the retina itself.

- **Hypermetropia**

  Farsightedness, also called hypermetropia, is the common name for a defect in vision, in which, a person sees near objects with blurred vision, while distant objects appear in sharp focus. In this case, the image is formed behind the retina.

- **Causes**

  This defect arises because either

  (a) The focal length of the eyelens is too great, or

  (b) The eyeball becomes too short, so that light rays from the nearby object, say at point N, cannot be brought to focus on the retina to give a distinct image.

- **Correction**

  This defect can be corrected by using a convex lens of appropriate focal length. When the object is at N', the eye exerts its maximum power of accommodation Eyeglasses with converging lenses supply the additional focussing power required for forming the image on the retina.

Presbyopia

Presbyopia, progressive form of farsightedness that affects most people by their early 60s. The power of accommodation of the eye decreases with ageing Most people find that the near point gradually decreases.

Cause and Cure

It arises due to the gradual weakening of the ciliary muscles and diminishing flexibility of the crystalline lens. Simple reading eyeglasses with convex lenses correct most cases of presbyopia. Sometimes, a person may suffer from both myopia and hypermetropia. Such people often require bi-focal lenses In the bi-focal lens, the upper portion of the bi-focal lens is a concave lens used for distant vision. The lower part of the bi-focal lens is a convex lens, used for reading purposes.

Astigmatism

Astigmatism, a defect in the outer curvature on the surface of the eye that causes distorted vision. In astigmatism, a person cannot simultaneously focus on both horizontal and vertical lines.

Causes

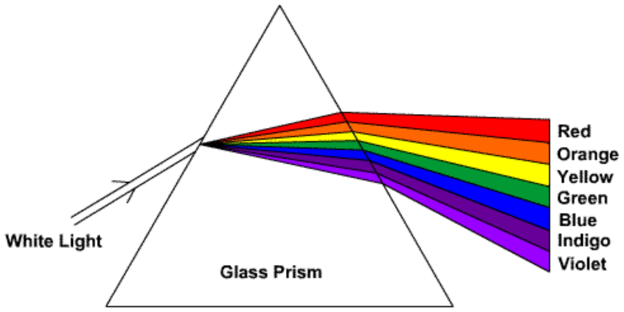
This defect is usually due to the cornea that is not perfectly spherical. Consequently, it has different curvatures in different directions in vertical and horizontal planes. This results in objects in one direction being well-focussed, while those in a perpendicular direction not well focussed.

Correction

This defect can be corrected by using eyeglasses with cylindrical lenses oriented to compensate for the irregularities in the cornea.

Refraction through Glass Prism

When the light passes through the glass prism it bends towards the base of the prism. When the light ray is incidented on a glass prism, it undergoes refraction while passing through the glass prism. The angle between the incident ray and emergent ray is called the **angle of deviation**. When the white light is allowed to pass through the prism, it splits up into its constituent colors, called spectrum. The spectrum is the band of seven colors popularly known as **VIBGYOR**. The VIBGYOR stands for the colour **violet, indigo, blue, green, yellow, orange and red**. This spliting of white light into its constituents colors is called the dispersion of light. Thus, we can say that white light is the mixture of seven colors. When the white light passes through the glass prism it undergoes dispersion because each constituent colors has different angle of refraction. The red color undergoes least deviation and the violet color undergoes maximum deviation.



One of the most beautiful example of dispersion light is the formation rainbow soon after rainfall in the sky. It is also called the natural spectrum. Soon after rainfall when sun comes out, the sunlight falls on the tiny droplets of water hanging in the atmosphere and undergoes dispersion into its constituents colors and appears as a band of seven colors in the sky, in the form of rainbow. The raindrops acts as a prism in the atmosphere.

Atmospheric Refraction

We have different layers in our atmosphere having different optical density. When the light passes through these different layers it undergoes refraction which is called the atmospheric refraction. Some of the optical phenomena in nature which occur due to the atmospheric refractions are as follows:

Twinkling of Stars

We know that stars have the light of their own and their lights passes through the different densities of the atmosphere it undergoes refraction. The continuous change of atmosphere refracts the light from the stars by different amount, from one moments to the another. When atmosphere refracts more light towards us it appears to be bright and when it refracts less light it appears to be dim. Thus the light from stars reaching to us increases and decreases continuously due to atmospheric refraction and hence stars appears to be twinkling during the night.

Advanced Sunrise and Delayed Sunset

During sunrise when the sun is slightly below the horizon, the sunlight which is comming from less dense air to more dense air, is refracted downwards as it passes through the atmosphere. Hence sun appears to be raised above the horizon when actually it is slightly below the horizon. Similarly during the sunset, also due to atmospheric refraction, we can see the sun for about 2 minutes more even after the sun set below the horizon. In other words, sun raise takes places 2 minutes before the actual sunrise and sunset also takes place two minutes after the actual sunset.

Sky Appears Blue

The Sunlight is made up of seven colors and when this mixture of seven colors passes thorough the atmosphere most of the longer wavelength lights do not get scattered much by air particles and passes straight through the atmosphere. However, the shorter wavelength blue color light gets scattered all around the sky by air molecules in the atmosphere and our eyes receives only these blue colors and hence sky appears blue to us. If there would have been no atmosphere, the sky would have appeared black or dark to us, as it appears in the outer space.

We use red color light for the danger signal because it has longer wavelength and are least scattered by the particles in the atmosphere and hence can be seen from the longer distance.

Sun Appears Reddish at the Time of Sunrise and Sunset

At the time of Sunrise and Sunset, the Sun is near the horizon and the Sunlight has to travel the long distance through the atmosphere, before reaching our eyes. During this journey most of the shorter wavelength of the sunlight get scattered away in the atmosphere and only the longer wavelength of light i.e. red light reaches our eyes, hence the Sun appears reddish at the time of sunrise and sunset.

Commonly Asked
QUESTIONS

The part of retina which is insensitive to the light is called:

(a) Rod Cells Spot (b) Cone Cells
(c) Optic Nerves (d) Blind
(e) None of these

Answer: (d)

The least distance of distinct vision is:

(a) 10 cm (b) 15 cm
(c) 25cm (d) 30cm
(e) None of these

Answer: (C)

Which lens can be used to correct the defect of myopia?

(a) Convex Lens (b) Concave Lens
(c) Bifocal Lens (d) Cylindrical Lens .
(e) None of these

Answer (b)

Which one of the following disease is due to the old age of the individual?

(a) Myopia (b) Hypermetropia
(c) Presbyopia (d) Cataract
(e) None of these

Answer (c)

What is the time for delayed sunrise and delayed sunset?

(a) 1 minute (b) 2 minutes
(c) 1 second (d) 2 seconds
(e) None of these

Answer: (b)

You Must KNOW

- It takes 8 minutes 17 seconds for light to travel from the Sun's surface to the Earth.
- Light is a form of energy which our sense of sight can detect.
- Low energy light bulbs last on average up to 12 times longer than traditional fluorescent bulbs.
- A heavy coat of dust can block up to half of the light.

SUMMARY

- The form of energy which produces the sensation of vision is called light.
- The bouncing back of light after striking a polished surface is called reflection of light.
- The spherical surface having only one reflecting surface is called mirror.
- The point at which the ray of light converges after reflection is called focus.
- Bending of light as it passes from one medium is called refraction of light.
- The object having two refracting surface is called lens.
- There are two types of surfaces, convex and concave.
- Spliting of light into its constituent colours is called dispersion of light.
- Human eyes are an important organ which helps to see the objects.
- Human eyes can adjust its focal length according to will.

Self Evaluation TEST

Duration 10 Minutes

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1. The position of object for which the image formed is virtual, erect and larger than object is

(a) At infinity
(b) Beyond C
(c) At F
(d) Between F and pole
(e) None of these

---

2. Find the position of image of a concave mirror which produces three times magnified image when the object is placed at a distance of 10 from the concave mirror.

(a) +30 cm
(b) -30cm
(c) +25 cm
(d) -25cm
(e) None of these

---

3. Which one of the following is the correct lens formula?

(a) $\frac{1}{f}=\frac{1}{u}-\frac{1}{v}$
(b) $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$
(c) $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$
(d) $\frac{1}{v}=\frac{1}{u}-\frac{1}{f}$
(e) None of these

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4. Which color is used for the danger signal?

(a) Violet
(b) Blue
(c) Green
(d) Red
(e) None of these

---

5. The small opening through which light enters into our eyes is:

(a) Cornea
(b) Iris
(c) Pupil
(d) Lens
(e) None of these

---

6. How can we cure the defect of hypermetropia?

(a) Concave lens
(b) Convex lens
(c) Piano Convex lens
(d) Bifocal lens

(e) None of these

---

7. Spliting of white light into its constituent color when it passes through the glass prism is called

(a) Refraction
(b) Reflection
(c) Tyndal Effect
(d) Dispersion
(e) None of these

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8. The extent to which image of an object can be magnified is called:

(a) Refraction
(b) Refractive Index
(c) Magnification
(d) Scattering
(e) None of these

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9. The space between eye lens and retina is filled with liquid called:

(a) Aqueous Humour
(b) Vitreous Humour
(c) Tears
(d) Gell of Protein
(e) None of these

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10. Which cell of the eyes helps us differentiate between the different colors?

(a) Rod cell
(b) Cone cell
(c) Ciliary Muscles
(d) All of these
(e) None of these

Answers – Self Evaluation Test																			
1.	D	**2.**	B	**3.**	C	**4.**	D	**5.**	C	**6.**	B	**7.**	D	**8.**	C	**9.**	B	**10.**	B