5 LIGHT

5.1 INTRODUCTION

Visibility of things or objects takes place only when light from that object enters to our eyes that we see the object. The light may have been emitted by the object or may have been reflected by it.
As we know that a polished or a shiny surface can act as a mirror. A mirror changes the direction of light that falls on it.
If we enter a dark room, the objects present in the room are not visible. However, if we switch on a bulb, everything in the room becomes visible. Why?
The bulb gives out an invisible energy called light. When this energy falls on the objects in the room, it bounces off from the surface of objects. When this energy enters our eyes, the eyes sense It and send a message to the brain. It is finally the brain which really sees the objects. Eyes are only an aid in seeing the objects around us.
Why do we say that light is invisible? Well, when light energy falls on the objects, we really do not see it. When energy bounces off from the surface of objects and enters our eyes, the sensation produced by this energy, helps our brain to see. Thus, to sum up, we can say:
Light is an invisible energy, which causes the sensation of vision. When the light falls on any object, it bounces off from the surface of the object in all directions. This is called diffusion of light.
We see the colorful and the beautiful world around us when there is light. Nothing is visible in the dark. Even if there is light we cannot see with our eyes closed. Thus both light and the eyes are necessary to see the things. It is light which produces the sensation of sight in our eyes.

"Light is an invisible energy which makes things visible."

5.2 SHADOW

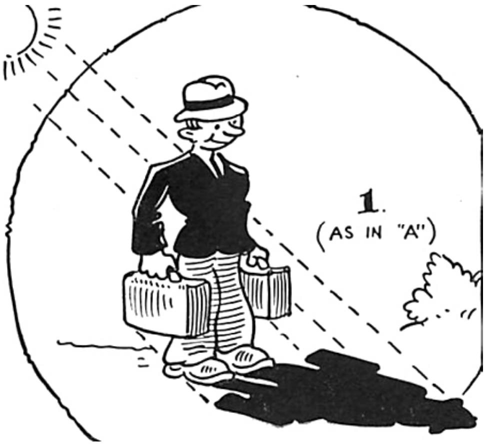
A shadow is a dark outline or image cast by an opaque object that blocks light coming from a source of light.

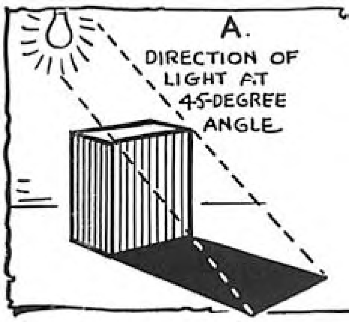
(a) The cause of formation of shadows is
Rectilinear propogation of light (light travels on straight lines)

(b) Essentials of a shadow:
(i) Source of light
(ii) Presence of opaque object in the path of light
(iii) Screen on which shadow is formed

(c) Location of a shadow:

Shadow fills the space between the opaque object and the screen. It is the volume and not area on the screen.



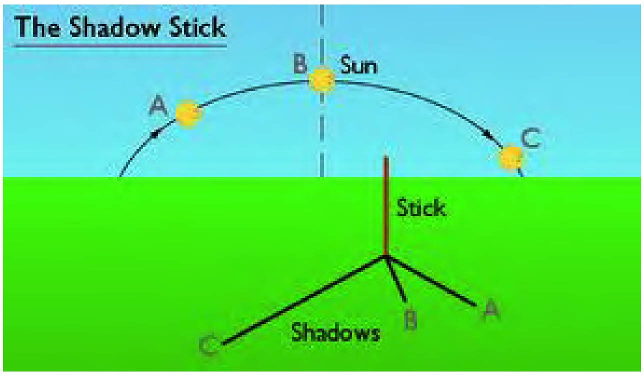


(d) Formation of shadow :

It is formed when light hits the opaque object which does not let the light pass through. Everywhere else around the opaque object, the light continues in a straight path until it bounces off the ground or wall behind the object. The wall or ground behind the opaque object is the screen. On this screen is a dark patch, or shadow, with the same outline as the object surrounded by light. The colour of the opaque object does not affect the colour of the shadow that is formed.

5.2.1 Shadow sticks

A shadow stick is a vertical pole placed in the ground. Sunlight casts its shadow on to a level surface below.(e.g. a sheet of card or just level ground)



As the Sun moves from A to C, the shadow shortens and then lengthen accordingly

The length and position of the shadow then depends on both the time of year and the time of day. Local noon can be found from the time when the shadow is shortest. At this time the Sun is highest in the sky and crossing the meridian.

However, shadow sticks are not good clocks - the azimuth of the Sun's shadow at a given time changes throughout the year with the Sun's declination.

The shape, size and other characteristics of a shadow depend upon :

(i) Position and distance of the source of light with respect to the object.

(ii) The distance between the object and the surface on which the shadow falls.

(iii) The size of the source of light.

5.2.2 A Shadow has two Regions :

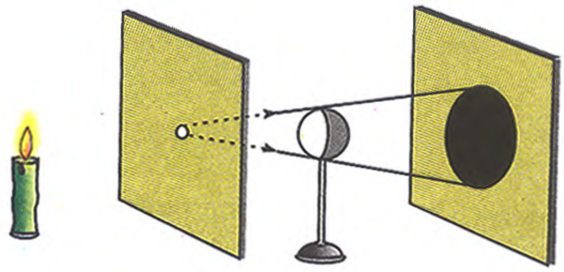
For a non-point source of light (i.e., an extended source of light), the shadow of an object has two parts, namely, the umbra and the penumbra. The umbra is the darkest inner part of the shadow where no light falls at all. The penumbra is the part which surrounds the umbra. Some rays of light fall on this region and partially illuminate it. Thus, the penumbra is called the region of partial darkness.

(i) **Umbra :** The inner region of total darkness is called umbra.It is the evenly dark part of a shadow. Umbra means 'shade' in latin.

(ii) **Penumbra :** The outer region of partial darkness is called penumbra. It is the fuzzy part between the dark and the light . Pene means 'almost' in Latin.

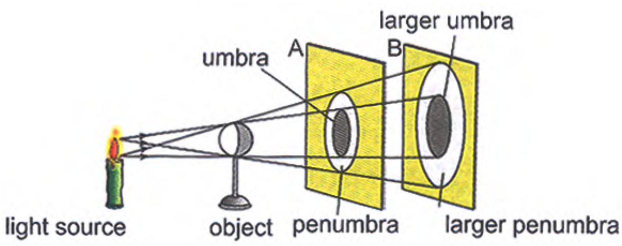
Umbra and penumbra are clearly formed only when the source of light is big and opaque body is small.

If one is in the umbra of an object, the light source is completely obscured. If one is in the penumbra, the source is only partially obscured, to a greater or lesser degree as one moves through the penumbra.

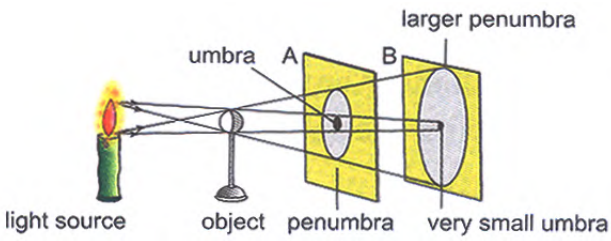


Shadow formed by a point source of light

The wider the light source, the fuzzier is the shadow.



Shadow formed by an extended source
(When size of source is smaller than object)

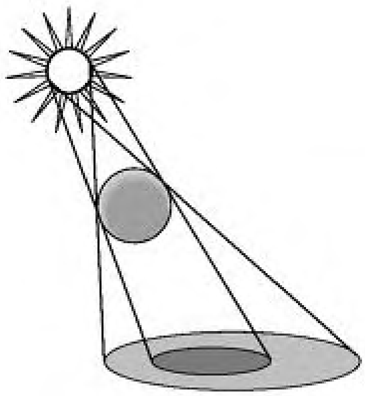


Shadow formed by an extended source
(When size of source is bigger than object)

With a wider light source,the shadow becomes fuzzier.

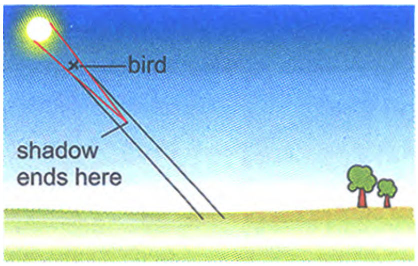
Also, closer the object to the light, the larger and fuzzier is the shadow. In other words, the closer the object to the screen, the smaller and well defined is the shadow. Thus, the size of the umbra becomes smaller and smaller if the screen is moved farther and farther from the light source and the object.

Shadows are often fuzzy, particularly when the surface on which the shadow lies is far from the object casting the shadow. This fuzziness is because of only point light source in space. All sources have some geometrical size.Thus, light from one edge of the source is not quite parallel to light from the other edge



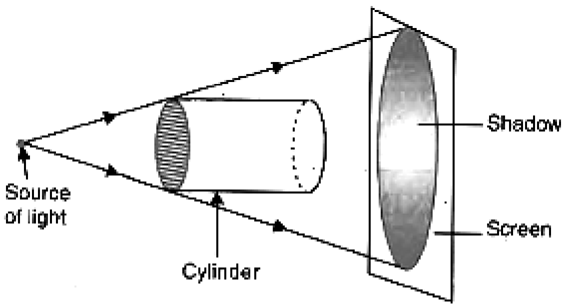
When object is very near to the earth's surface

The result is a larger and fainter penumbra that is hardly visible. This is the reason why we cannot see the shadow of a bird flying high up in the air .

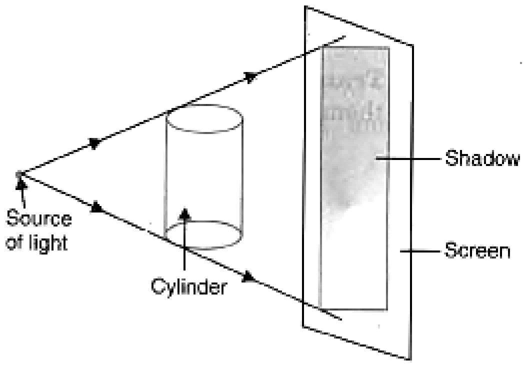


Shadow of a flying bird is not visible

Shadow of same object is different for same source, because of the change in the postion of an object and light falling on different surface of an object for same source.



Getting circular shadow with a cylinder

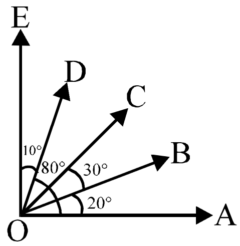


Getting a rectangular shadow with a cylinder

5.3 SOURCES OF LIGHT AND VISIBILITY

All luminous bodies are the source of light. Sun is a luminous body. Sun emits light. Sun makes the day. Flame from fire and the lamps (including electrical lamps) are a source of light for us. The objects which do not emit light are the non-luminous objects. Non-luminous objects are seen only when light falls upon them. We see everything around us from the reflected light from the surface of an object reaching our eyes.

- **Knowledge Based Questions**



Q.1 Value of $\angle AOC$ is
(A) 20º (B) 30º (C) 50º (D) 80º

Q.2 Value of $\angle AOD$ is
(A) 20º (B) 30º (C) 50º (D) 80º

Q.3 Angle bisector of $\angle BOD$ is
(A) BA (B) OB (C) OC (D) OD

Q.4 Normal to ray OE is
(A) OA (B) OB (C) OC (D) OD

5.4 PROPERTIES OF LIGHT

Light can be considered to travel from one point to another along a straight line joining them. The path is called a ray of light and the bundle of such rays constitutes a beam of light.
The light has the following properties:
(i) Light travels in a straight line.
(ii) Velocity of light is maximum in vacuum and is equal to 3×10^8 m/sec.

5.4.1 Nature of light

(a) **Particle Nature of Light (Newton's corpuscular theory) :** According to Newton light travels in space with a great speed as a stream of very small particles called corpuscles.
According to this theory reflection and refraction of light are explained while this theory was failed to explain interference of light and diffraction of light. So wave theory of light was discovered.

(b) **Wave Nature of Light :** Huygen consider the light remains in the form of mechanical rays and he consider a hypothetical medium like ether for propagation of light waves.
So, light waves are decleared electromagnetic waves so there is no need of medium for the propagation of these waves. They can travel in vacuum also. The speed of these waves in air or in vacuum is maximum i.e., 3×10^8 m/s.
Photoelectric effect was not explained with the help of wave theory, so Plank gave a new theory which was known as quantum theory of light.
This theory is failed to explain photo electric effect.

(c) **Quantum Theory of Light :** According to 'Planck' light travels in the form of energy packets or quantas of energy called photons.

The rest mass of photon is zero. Each quanta carries energy $E = h\nu$.

$h \rightarrow$ Planck's constant $= 6.6 \times 10^{-34}$ J-s.

$\nu \rightarrow$ frequency of light

Some phenomenons like interference of light, diffraction of light are explained with the help of wave theory but wave theory was failed to explain the photo electric effect of light. It was explained with the help of quantum theory. So, light has dual nature.

(d) **Dual Nature of Light :** De Broglie explained the dual nature of light, i,e,wave nature and particle nature.

(i) **Wave Nature :** Light is a electromagnetic waves it is transverse in nature and propagate in vacuum.

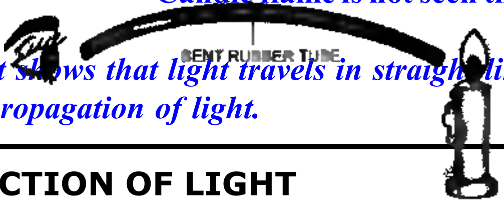
(ii) **Particle or Photon Nature :** With the help of this theory Einstein explained the photo electric effect.

PRACTICAL LEARNING

ACTIVITY -

Light Travels in a Straight Line : *Place a lighted candle on a table. Take a rubber tube and look through it at the flame (Fig.). Bend the tube slightly and try to see the flame again. Can you see it now? Move it to another position and try to see the flame through the bent tube. The candle is not visible through the bent tube. What do you learnt from this activity?*

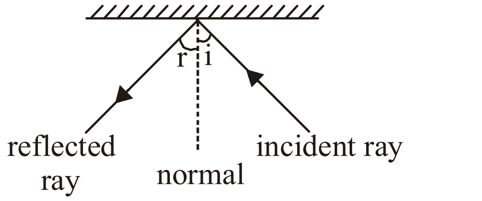
Candle flame is not seen through a bent tube



It shows that light travels in straight line. This phenomenon is called the rectilinear propagation of light.

5.5 REFLECTION OF LIGHT

The phenomena of bouncing back of light in same medium after striking at the interface of two media is called **reflection of light**.



When a ray of light falls upon a smooth surface like a mirror, the ray of light is reflected in another direction. This phenomenon is called reflection of light. The light ray which strikes any surface, is called the incident ray. The ray that comes back from the surface after reflection is known as the reflected ray.

The line making an angle of 90º to the line representing the mirror at the point where the incident ray strikes the mirror is known as the normal to the reflecting surface at that point. The angle between the normal and incident ray is called the angle of incidence ($\angle i$). The angle between the normal and the reflected ray is known as the angle of reflection ($\angle r$).

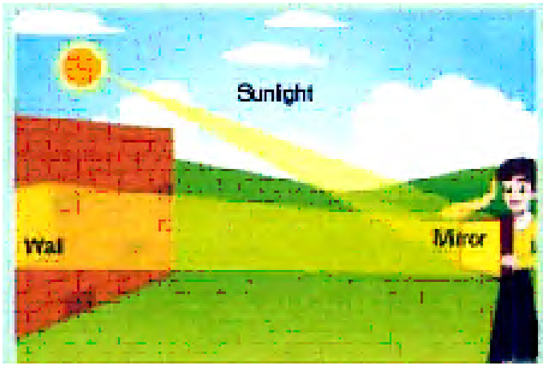
PRACTICAL LEARNING

ACTIVITY - 2

To show that smooth surfaces cause reflection of light.

Materials required : *A small plane mirror (looking glass), a highly polished brass plate, a book, sunlight.*

Method : *Allow the sun rays to fall on mirror. Turn the mirror through various angles, such that the light of sun on striking it, falls on a wall. You will notice that as the angle of the mirror is changed, the position of light on the wall changes. Thus, we can say that a plane mirror reflects light.*



Repeat the activity with a highly polished brass plate. You will notice the same observations as in the case of a mirror.

Repeat the activity by holding a book in sunlight. You will notice that no light patch is formed on the wall. Why?

It is because the surface of the book is rough. Thus, light rays bouncing from it move in various directions. Thus, no light patch is formed.

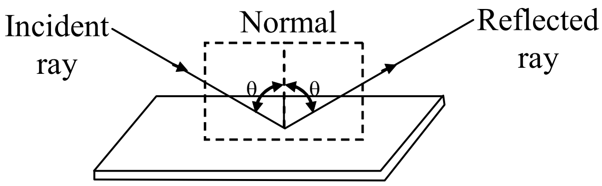
Conclusions : *(i) Smooth surfaces can cause reflection of light. Such a reflection is called regular reflection.*

(ii) Rough surfaces do not cause regular reflection. Such reflection is called irregular reflection or diffused reflection.

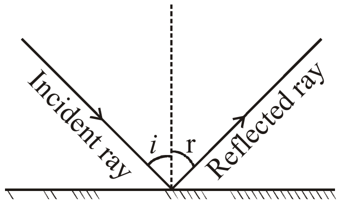
5.5.1 General Terms

- **Mirror :** Any smooth polished surface which can bounce back the parallel rays of light into the original medium as parallel rays is called a mirror:
  A looking glass is the best example of a mirror. Any highly polished metal surface acts like a mirror. Still water or oil has a smooth surface and, hence, acts like a mirror. Even highly polished furniture acts like a mirror.
- **Incident Ray :** A ray of light which travels through an optical medium towards mirror is called incident ray. In Fig. AB is incident ray.
- **Reflected Ray :** A ray of light which bounces off the mirror surface, into the same optical medium in which incident ray was travelling is called reflected ray. In Fig., BC is the reflected ray.
- **Point of Incidence :** The point on the mirror surface where the incident ray strikes or the reflected ray bounces off is called point of incidence. In Fig. point B is the point of incidence.
- **Normal :** The perpendicular drawn at the point of incidence to the surface of mirror is called normal In Fig. BD is the normal to the mirror surface.

- **Angle of Incidence :** The angle which the incident ray makes with the normal is called angle of incidence. In Fig., $\angle ABD = \angle i$, is the angle of incidence.



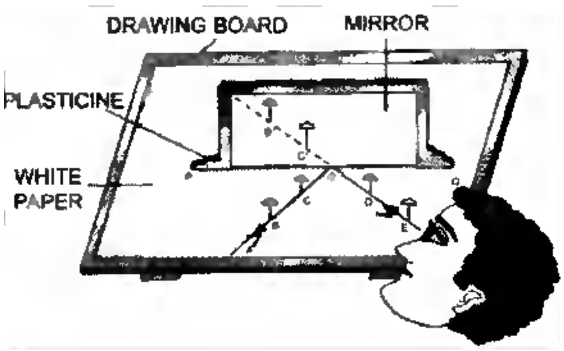
- **Angle of Reflection :** The angle which the reflected ray makes with the normal is called angle of reflection. In Fig. $\angle DBC = \angle r$ is the angle of reflection.
- **Laws of reflection**
  (i) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.
  (ii) The angle of incidence is equal to the angle of reflection.
  $\therefore \quad \angle i = \angle r$



PRACTICAL LEARNING

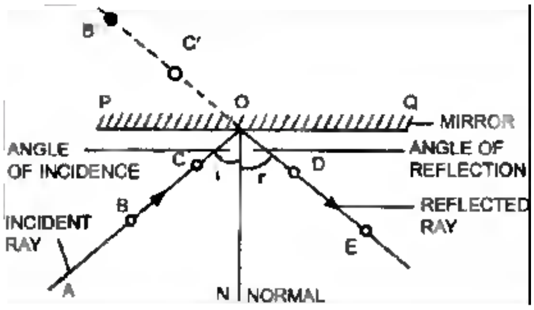
ACTIVITY - 3

Laws of Reflection : Fix a sheet of white paper firmly on a drawing board. Draw a straight line PQ on the paper [Fig. (a)]. Place the long edge of the mirror along the line, and use plasticine to fix the mirror on the paper so that it stands upright. Fix two pins Band C vertically in front of the mirror as shown in Fig.(a). Try to locate the images B' and C' of the two pins, and fix two more pins D and E on the paper in front of the mirror so that they are both in line with B' and C'.



(a) Studying the laws of reflection

Mark the position of the pins with a pencil and remove the pins and the mirror. Draw a line AO joining the points Band C. It meets the mirror at a point O on the line PQ. Now. draw a line EO joining the points D and E. Point O. where the two rays AO and EO meet the mirror is known as the point of incidence. AO is the incident ray. At O draw a perpendicular ON. ON is called the Normal. EO is the reflected ray. The angle between the incident ray and the normal is called the angle of incidence, ∠i. therefore ∠AON is the angle of incidence. The angle between the reflected ray and the normal is called the angle of reflection, ∠r. Therefore ∠EON is the angle of reflection [Fig.(b)]. Now. measure ∠AON and ∠EON with the help of a protractor. They will be equal. If you change ∠i and measure the corresponding angle of reflection ∠r. **You will find that ∠i = ∠r for every value of ∠i. This is the first law of reflection.**



(b) Verifying the laws of reflection

You can also notice from Fig. (b) that **"the incident ray. the reflected ray and the normal, all lie in the same plane, which is the plane of the paper. This is the second law of reflection".**

5.5.2 Lateral inversion

The phenomenon due to which the left hand side of an object appears as the right hand side and vice versa in a mirror is called lateral inversion. All images formed in plane mirror are laterally inverted.

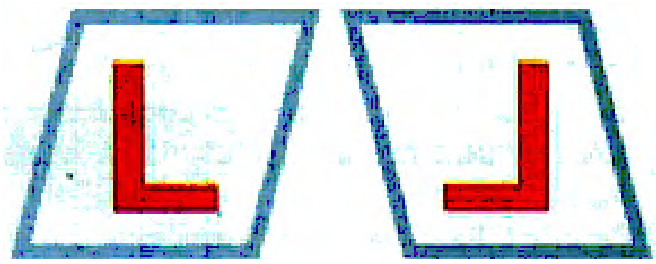
PRACTICAL LEARNING

ACTIVITY - 5

To show that plane mirror produces lateral inversion.

Materials required : A plane mirror, a white carboard.

Method : *Sit in front of a looking glass. Hold your nose with your left hand. What do you see in the mirror ? Your image is the same as you are but it appears as, if you are holding your nose with your right hand.*



White carboard **Plane mirror**

Now take a white cardboard and over it paint a letter L. Place it in front of the mirror. What do you see ? The letter L will appear as shown in figure.

"This property of plane mirror is known as lateral inversion".

5.5.3 Characteristics of the image formed by a Plane Mirror

1. Image formed is virtual. It means the image cannot be taken on a screen.
2. Image is of the same size as is the size of the object.
3. Image is formed as far behind the mirror as the object is in front of it.
4. Image is laterally inverted. It means left hand side of the object appears as right hand side of the image and vice versa.
5. Image is erect.

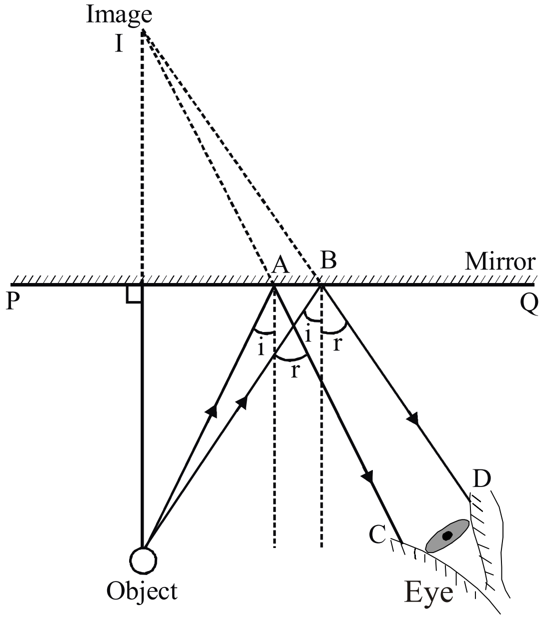
5.5.4 Formation of images in a Plane Mirror

(a) When Object is a Point Source of Light

Consider an object O, situated in front of the plane mirror PQ. The rays of light starting from point O, travel in all directions. Two rays of light OA and OB, starting from point O, on striking the plane mirror PQ, obey the laws of reflection and get reflected along AC and BD.

When this divergent beam formed by AC and BD reaches the eye, then to the eye it appears to come from point I, as illustrated in Fig. Thus, I is the image of point object O.

If we join OI and measure OL and LI it is found that they are equal. This proves that images are formed as far behind the mirror as the object is in front of it.



(b) When Object is an Extended Source of Light

Consider AB (a small pencil) as an extended object placed in front of a plane mirror. We shall consider the formation of images of points A and B, which are the ends of the extended object.

A divergent beam, starting from point A. After reflection from a plane mirror, appears to diverge from point A_1. Similarly, a divergent beam, starting from point B, after reflection from a plane mirror, appears to diverge from point B_1. Thus, A_1B_1 is the virtual image of extended object AB, which is laterally inverted and is formed as far behind the plane mirror as the object is in front it.

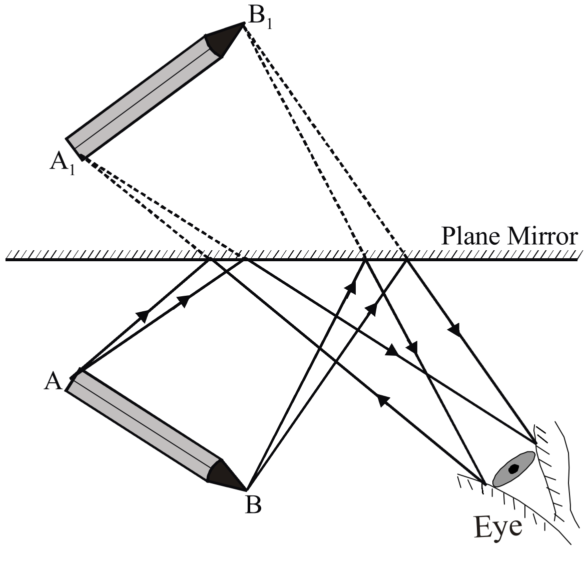
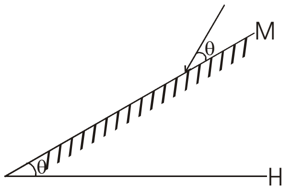


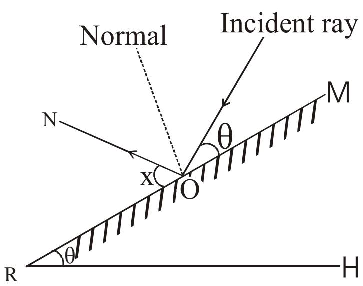
Illustration 1

A mirror is inclined at an angle θº with the horizontal. If a ray of light is incident on mirror making an angle θº with the mirror. Then the reflected ray makes the following angle with the horizontal.



(A) θº **(B) 2θº** **(C) θº/2** **(D) none of these**

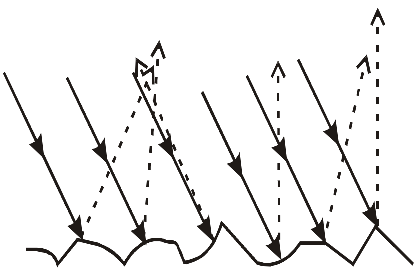
Solution



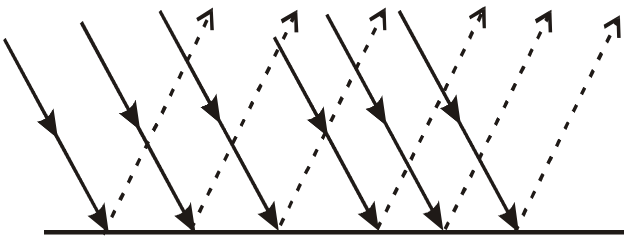
Angle of incidence = (90 – θ)
Angle of reflection = Angle of incidence
= (90–θ)
But angle of reflection + x = 90º
or (90– θ) + x = 90º
or x = θ
or ∠NOR = ∠ORH (but these are alternate angles)
or NO || RH
or Reflected ray is parallel to horizontal.
or Angle between reflected ray and horizontal = θº ∴ **(D)**

5.5.5 Regular (Specular) and Diffused (Irregular) Reflection

When all the parallel rays reflected from a plane surface are not parallel, the reflection is known as diffused or irregular reflection. Remember that the diffused reflection is not due to the failure of the laws of reflection. It is caused by the irregularities in the reflecting surface.
On the other hand reflection from a smooth surface like that of a mirror is called regular reflection. Image are formed by regular reflection and we see most of the objects as an example of diffused reflection.



Irregular or diffused reflection

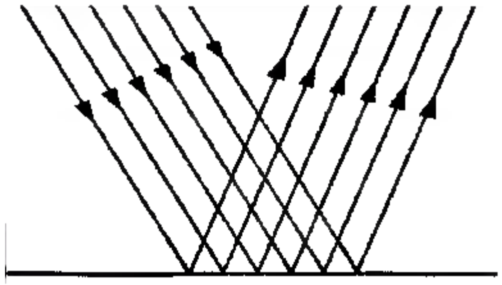


Regular reflection or specular reflection

PRACTICAL LEARNING

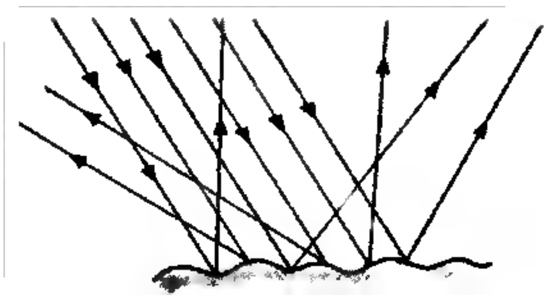
ACTIVITY - 5

Types of Reflection : Hold a mirror in sunlight, facing the Sun and allow the reflected light to fall on a wall. It will form a bright area on the wall. As you change the position of the mirror, the position of the bright area on the wall receiving sunlight also changes. In this case, all the sunlight falling on the mirror is reflected in one direction only. **"This type of reflection from a smooth polished surface is called regular reflection" [Fig. (a)].**



(a) Regular reflection from a smooth polished surface

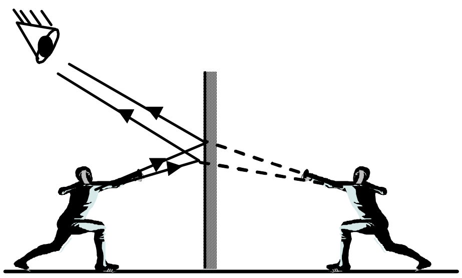
Now, try to do the same with a flat piece of wood or a piece of paper. You will find that no bright area can be obtained on the wall. **"In the case of a rough surface. light is not reflected in one direction only. It is scattered in all directions. This is known as diffused or irregular reflection"** [Fig. (b)]. This is why a mirror that has lost its smoothness does not give a clear image.



(b) Irregular reflection from a rough uneven surface

Irregular reflection of sunlight by objects enable us to see them from every direction.

5.5.6 Reflection from plane surface



The bundle of rays from the top of the object appears to originate from the image behind the mirror

- **Some facts:**
  (i) The focal length and radius of curvature of a plane mirror are infinite. This means that the power of a plane mirror is zero.
  (ii) The magnification of a plane mirror is 1.
  (iii) If the object moves with speed 'u' towards a fixed mirror, the image also moves towards the mirror with speed 'u'. The speed of the image relative to the object in this case is '2u'.
  (iv) If the mirror moves with speed 'u' towards or away from a fixed object, then image appears to move towards or away from the observer with speed '2u'
  (v) If the mirror moves away or towards an object by a distance 'd', then the image moves away or towards the object by a distance '2d'.
  (vi) If a mirror is rotated in the plane of incidence by an angle θ, then the reflected ray is turned through an angle '2θ'.
  (vii) On reflection from a plane mirror, a ray is deviated through an angle $\delta = (180 - 2i)$, where 'i' is the angle of incidence. (δ is called as angle of deviation)
  (viii) The minimum size of the mirror required to see full size image of one self is equal to half the height of the observer.

Illustrations

Illustration 2

A car is moving towards a plane mirror at a speed of 30 m/s. Then the relative speed of its image with respect to the car will be :

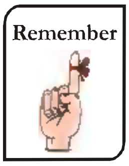
(A) 30 m/s *(B*) 60 m/s* *(C) 15 m/s* *(D) 45 m/s*

Solution

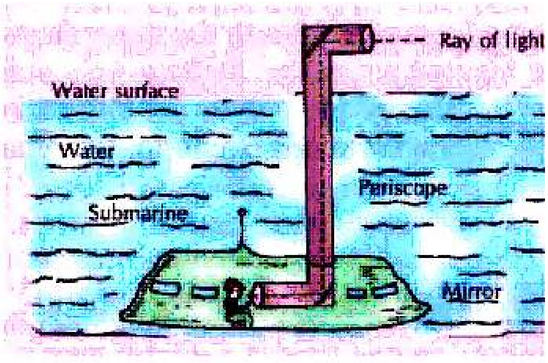
Speed of the car towards the mirror = 30 m/s. And the speed of image of car with respect to car = $2 \times 30 = 60$ m/s. $\therefore$ **(B)**

5.5.7 Reflection light can be reflected again

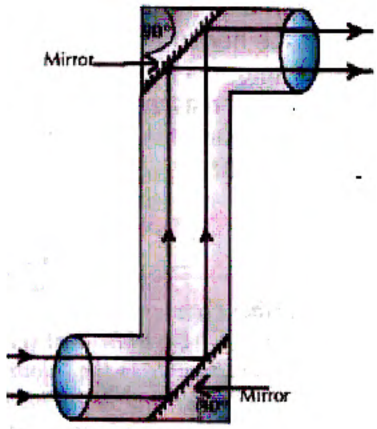
In a hair dresser's shop after hair cut is complete, hair dresser places a mirror at the back of head to show that how the hair has been cut. This shows that reflected light can be reflected again, with the help of this principle we can construct periscope which are used in submarines, tanks and also by soldiers in bunkers to see things outside.



Periscope: Periscope is the use of two plane mirrors placed parallel and facing each other in an inclined position (not vertical) at an angle of 45°.



Use of plane mirror in periscope.



A periscope.

Periscope is used for observing objects, the view of which is being obstructed. For example: from behind a wall we may observe the view on its other side. Periscopes are commonly used in submarines to view the happening on the surface of water in the sea, while sitting in the submarine under water.

5.5.8 Multiple Images

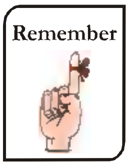
As we know that a plane mirror forms only a single image of an object. If we take two plane mirrors inclined at some angle with each other then we can see that there are more than 2 images of the object placed in between the mirrors.

5.5.9 Differences between Real and Virtual Image

Real Image	Virtual Image
1. It can be obtained on the screen	1. It cannot be obtained on the screen
2. The rays of light after reflection meet at a point.	2. The rays of light after reflection appear to meet at a point behind the mirror.
3. It is always inverted with respect to object.	3. It is always erect, but laterally inverted with respect to object.

Earlier we have learnt that on placing a magnifying glass (a convex lens) between the light coming from brightly lit tree outside your window and a screen or your shirt (white), an upside down picture of the tree is seen on the screen. This is a **real image.**

Now, stand before a mirror. You see your image in the mirror. It appears as if you are standing inside the mirror. Now look at the wall behind the mirror. Do you find your image on the wall ? The image is not received on the screen (wall). This image. Which cannot be received on a screen is the **virtual image**.



Inclined mirror

If the plane mirrors are inclined at an angle θ , then multiple images formed due to multiple reflection of object placed in between the two mirror :

The number of image (n)

(i) When $\frac{360}{\theta}$ is an even integer $n = \frac{360}{\theta} - 1$

(ii) When $\frac{360}{\theta}$ is an odd integer $n = \frac{360}{\theta} - 1$ (for symmetrical placement)

$n = \frac{360}{\theta}$ (for unsymmetrical placement)

(iii) When $\frac{360}{\theta} \neq$ integer $n =$ integer value of $\frac{360}{\theta}$

PRACTICAL LEARNING

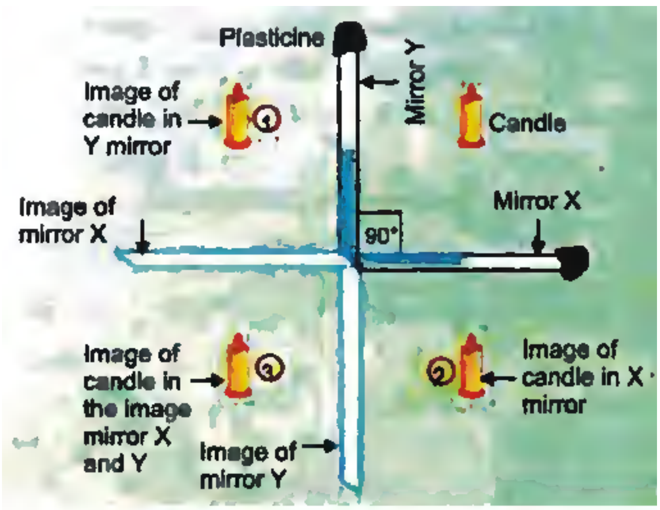
ACTIVITY - 6

When two plane mirrors make an angle of 90° with each other.

Method: Arrange two plane mirror strips at 90° to each other and hold them in a position with the help of plasticine. Now, take a small candle and light it. Place the candle in between the mirrors and look for their images. You will notice there are three images formed in total. Amongst these images the image (3) is the brightest.

How are the images formed?

The mirror X forms its image in the mirror Y, and the mirror Y forms its image in mirror X. These image mirrors also act like original mirrors. The candle placed between the mirrors X and Y forms the image [1] and image [2] respectively. The image (1) in mirror Y falls in front of image mirror X and hence forms image [3]. Similarly, image [2] in the mirror X, falls in front of image mirror Y and forms image (3). Now as the two images from image mirrors X and Y are superimposed on one another; therefore, image [3] is the brightest.



Formation of multiple images when plane mirrors are inclined at 90°

PRACTICAL LEARNING

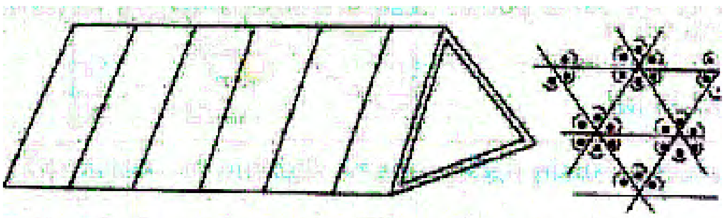
ACTIVITY - 7

When two plane mirrors make an angle of 60° with each other.

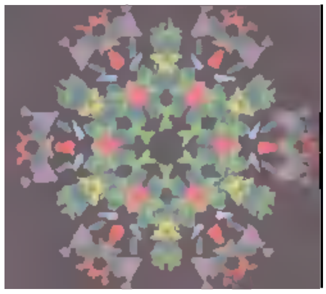
Method : Take a white sheet of paper and draw over it two lines making an angle of 60° with one another, On each of the lines place a strip of plane mirror and hold it in position with the help of plasticine.

Now take any object [say, a small lighted candle] and place it in between the two plane mirrors. Look for the images formed in the plane mirror. You will notice that five images are formed, amongst which the image I_3, I_6 is the brightest. Furthermore, you will notice that all the images and the object taken together form a hexagonal pattern. If you place two or more small objects, such as flower petals, small colored beads, etc., you will find they form a beautiful colored hexagonal pattern. This principle is used in making a toy called **kaleidoscope.**

KALEIDOSCOPE : In a kaleidoscope three rectangular strips of plane mirror are used. All the three strips are of equal size. These strips are placed with their edges touching as shown in the picture.



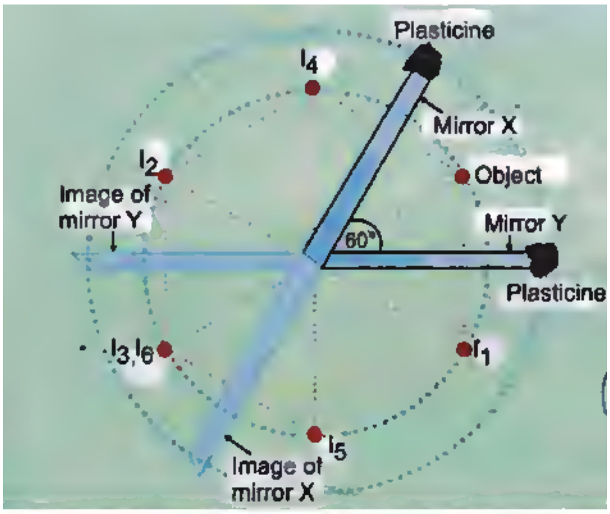
A kaleidoscope and a pattern formed when viewed in it



To keep the mirrors together, they are wrapped with paper and tied with a piece of thread. A few bits of coloured glass are placed in the space between the mirrors. Each angle between the three mirrors is of 60°. Hence, a pattern with multiple images at each angle between the mirrors are formed.

How are the images formed?

Considering reflection in a plane mirror Y only, image I_1 is formed as far behind as the object is in front of it. The image I_1 falls in front of mirror X and hence forms image I_2, as far behind as the object is in front of it. The image I_2 falls in front of image mirror Y and hence forms another image I_3 as far behind as the object is in front of it. Thus, on the whole three images I_1, I_2 and I_3 are formed . Similarly, considering reflection in a plane mirror X only, images I_4, I_5 and I_6 are formed. However. Images I_3 and I_6 are superimposed upon one another. This gives rise to only five images amongst which I_3, I_6 is the brightest on account a superimposition.



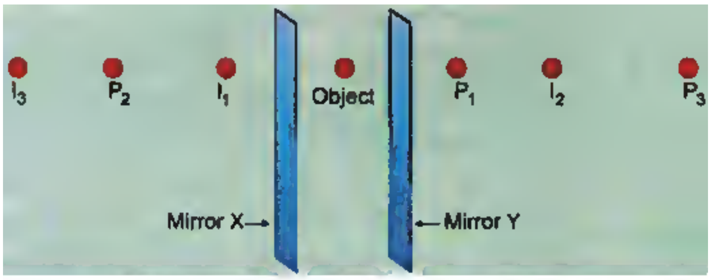
Formation of images in two plane mirrors inclined at an angle of 60°

It has been proved experimentally that the number(s) of image by two mirrors is given by the formulae

—— 1 (where θ is the angle between the two mirrors and n is the number of images).

ACTIVITY - 8

When two plane mirrors are facing one another:

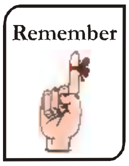


Formation of images in two plane mirrors facing one another

Method : Fix two plane mirrors on the walls such that the mirrors are facing one another. Now try to look in the mirror X. You will observe a large number of images of your face one behind the other. Now look in the mirror Y. You will observe a large number of images of your face one behind the other. However. You will notice that far-off images are faint as compared to nearer images. Theoretically, infinite number of images are formed. However. We can see only a few images because the light get absorbed after every successive reflection.

How are images formed?

The mirror X forms its image in mirror Y. The image formed in mirror Y falls in front of mirror X and again forms its image in the mirror X. This continues and infinite number of images of mirror X are formed in both mirror Y and mirror X. Similarly, infinite number of images of mirror Y are formed in mirror X and mirror Y. Let us consider the reflection taking place In mirror X from an object placed between mirrors X and Y. An image is formed in the mirror X, which is as far behind as the object is in front of it. The image I, falls in front of mirror Y and hence forms an image I_2 which is as far behind as the image I_1 is in front of it. The image I_2 again falls in front of mirror X and hence forms an image I_3, which is as far behind as the image I_2 in front of this. This continues and infinite number of images are formed. Similarly, when we consider reflection taking place in mirror Y from the object, infinite number of images P_1, P_2, P_3, ... are formed.



Uses of plane mirror

1. A plane mirror is usually used as a looking glass in daily life.
2. They are used by barbers to show the customer the back of his head.
3. They are used for signalling by the scouts and the army personnel.
4. They are used by the opticians to provide false dimension when their place of work is very small.
5. They are used for providing false dimensions in showcases, displaying jewellery, wrist watches etc. Two plane mirrors are fixed to the opposite sides of the showcase, such that their reflecting surfaces face each other. This leads to the formation of multiple images.
6. They are used for reflecting the rays of the sun inside the solar cooker.
7. They are used for making toys like kaleidoscope.
8. They are used for making reflecting periscopes. Reflecting periscopes are used by soldiers for seeing enemy while sitting in trenches without putting their lives in danger.

Illustration 3

Two mirror are kept at 60º to each other and a body is placed at the middle. The total number of images formed is :

(A) 3 ***(B) 4*** ***(C*) 5*** ***(D) 6***

Solution

Here $\theta = 60^\circ$

$$n = \frac{360}{\theta} = \frac{360}{60} = 6$$

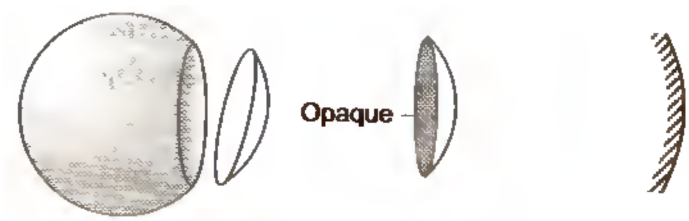
Since n is an even integer :

So number of images : $\frac{360}{\theta} - 1 = 6 - 1 = 5$ $\therefore$ **(C)**

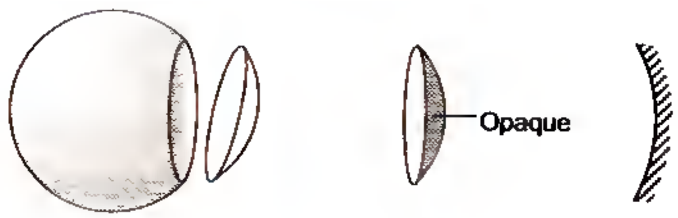
5.6 REFLECTION BY SPHERICAL MIRRORS

A mirror whose reflecting surface is a part of a hollow sphere of glass is known as spherical mirror. For example, a dentist uses a curved mirror to examine the teeth closely, large curved mirrors are used in telescopes .These are of two types convex and concave.

In concave mirror, reflecting surface is concave but in convex mirror, reflecting surface is convex.



Convex Mirror



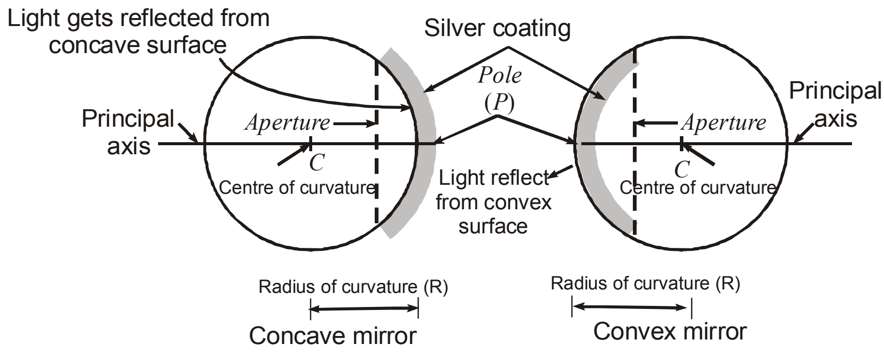
Concave Mirror

Spherical mirrors are of two kinds.

(i) **Concave mirror :** The reflecting surface is towards the centre of the sphere.

(ii) **Convex mirror :** The reflecting surface is away from the centre of the sphere.

Some terms related to spherical mirror :



Important Terms

(i) **Pole (P) :** The centre of the spherical mirror.

(ii) **Centre of Curvature (C) :** The centre of the sphere of which the mirror forms a part.

(iii) **Radius of curvature (R) :** The radius of the spherical surface of which the mirror is a part.

(iv) **Principal axis :** The line joining the pole and the centre of curvature.

(v) **Aperture :** The size of the mirror is called its aperture.

(vi) **Principal focus :**

Focus of concave mirror	Focus of convex mirror
A parallel beam of light after reflection from a concave mirror converges at a point in front of the mirror. This point (F) is the focus of a concave mirror and it is real, as shown in figure (i)	A parallel beam of light after reflection from a convex surface diverges and the rays do not meet. However on producing backward, the rays appear to meet at a point behind the mirror. This point is focus of the convex mirror and it is virtual, as shown Figure (ii)

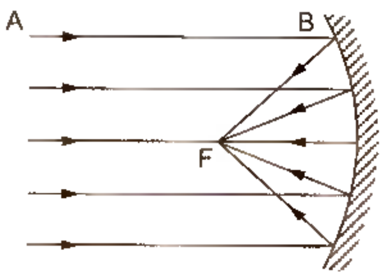


figure (i)

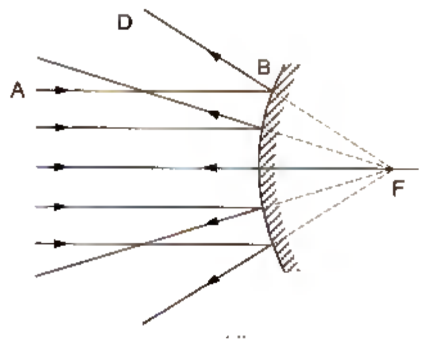


figure (ii)

(vii) **Focal length :** The distance between the pole and principal focus. It is denoted by f.

(viii) **Focal Plane :** Plane passing through the principal focus and at right angles to the principal axis is called focal plane.

5.6.1 Relation between focal length and radius of curvature

$$f = R/2$$

5.6.2 Sign convention for reflection by spherical mirror

In this convention, the pole (P) of the mirror is taken as the origin. The pricipal axis of the mirror is taken as the x-axis (X′X) of the coordinate system. The conventions are as follows

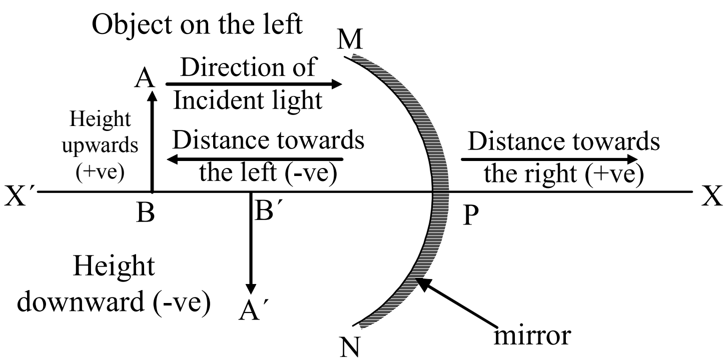
(i) The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left-hand side.

(ii) All distances parallel to the principal axis are measured from the pole of the mirror.

(iii) All the distances measured to the right of the origin (along + x-axis) are taken as positive while those measured to the left of the origin (along -x-axis) are taken as negative.

(iv) Distances measured perpendicular to and above the principal axis (along +y-axis) are taken as positive.

(v) Distances measured perpendicular to and below the principal axis (along -y-axis) are taken as negative.

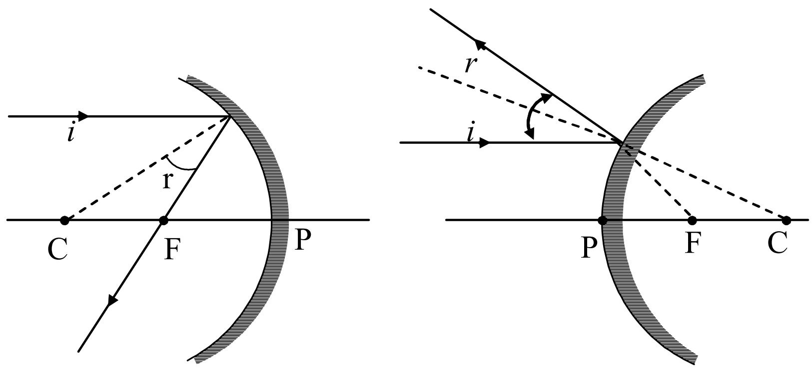


5.6.3 Rules for constructing the images formed by spherical mirrors

To construct the ray diagram, in order to locate the image of an object, it is convenient to consider only two rays.

The intersection of at least two reflected rays give the position of image of the point object. Any two of the following rays can be considered for locating the image.

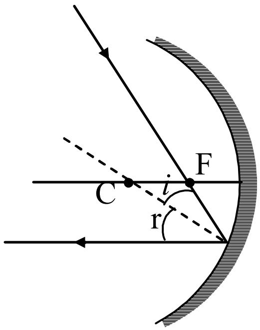
(i) A ray parallel to the principal axis after reflection passes through (concave) or appear to come from the principal focus (convex).



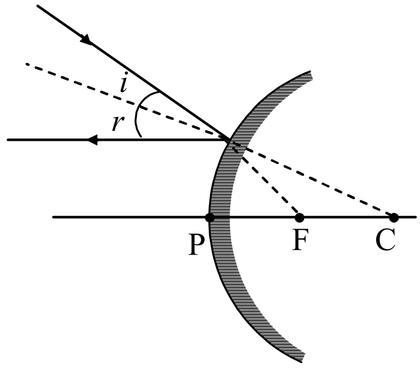
Concave mirror
(a)

Convex mirror
(b)

(ii) A ray which passes through (concave) or directed towards (convex) the principal focus after reflection becomes parallel to the principal axis.

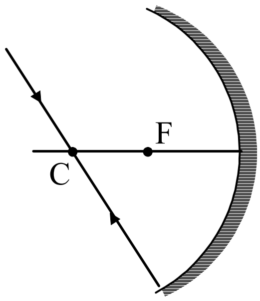


Concave mirror
(a)

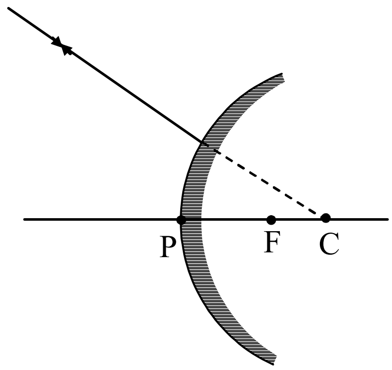


Convex mirror
(b)

(iii) A ray which passes through the centre of curvature after reflection retraces its path back.

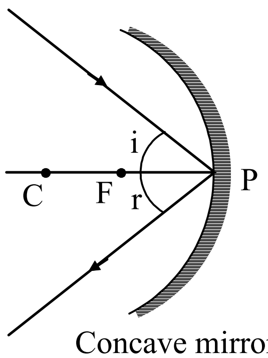


Concave mirror
(a)

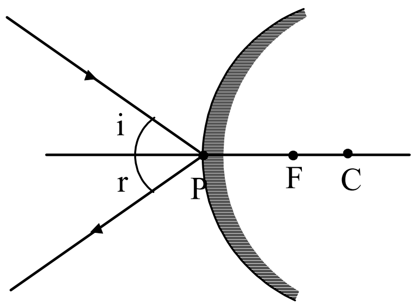


Convex mirror
(b)

(iv) A ray of light incident at the pole and making an angle with the principal axis, after reflection goes on the other side of the principal axis making the same angle with it.



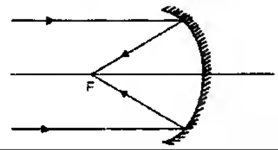
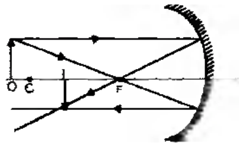
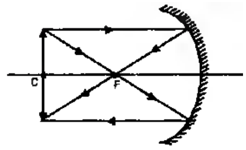
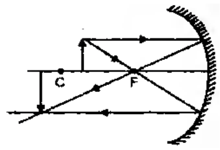
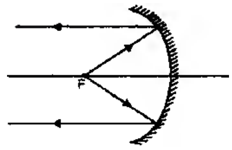
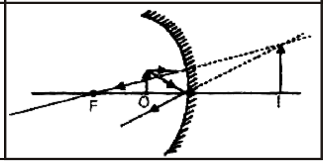
Concave mirror
(a)



Convex mirror
(b)

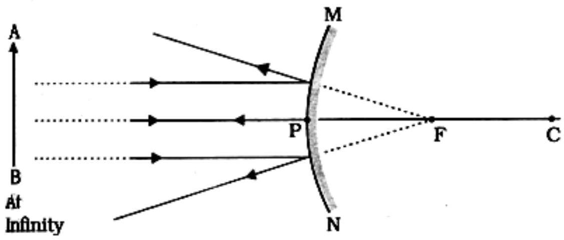
5.7 IMAGE FORMATION IN CASE OF SPHERICAL MIRRORS

(A) Image formation by concave mirror

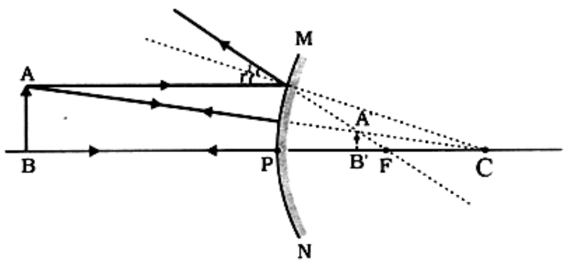
Position of object	Position of image	Nature	Figure
At infinity	At the focus	Real, inverted & diminished	
Between infinity & centre of curvature	Between focus & centre of curvature	Real, inverted & small in size	
At centre of curvature	At centre of curvature	Real, inverted and of the same size	
Between Focus & centre of curvature	Between centre of curvature and infinity	Real, inverted and enlarged	
At Focus	At infinity	Real, inverted and very large	
Between Focus & Pole	Behind the mirror	Erect, virtual & enlarged	

(B) Image formation by convex mirror

	Position of the object	Position of the image	Size of the image	Nature of the image
(a)	At infinity	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect
(b)	Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect



(a)



(b)

5.7.1 Uses of spherical mirrors

(A) Uses of convex mirror : Convex mirror is used as rear view mirror in automobiles like cars, trucks and buses to see the traffic at the back side. It is also used in street lamps.

(B) Uses of concave mirror :

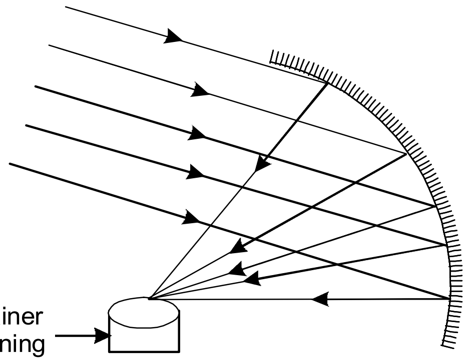
(i) They are used as shaving mirrors.

(ii) They are used as reflectors in car head-lights, search lights, torches and table lamps.

(iii) They are used by doctors to concentrate light on body parts like ears and eyes which are to be examined.

(iv) Large concave mirrors are used in the field of solar energy to focus sun-rays on the objects to be heated.

Solar Cookers : When a parallel beam of sunlight falls on a concave mirror, this beam is brought to the focus of the mirror (see figure). As a result of this, the temperature of an object (say a container containing uncooked food) placed at the focus increases considerably. Hence the food in the container is cooked.



Spherical Reflector type solar cooker

5.8 MIRROR FORMULA

The mirror formula is a relation relating the object distance (**u**), the image distance (**v**) and the focal length (**f**) of a mirror.

The mirror formula is : $\boxed{\frac{1}{u}+\frac{1}{v}=\frac{1}{f}}$

Above equation is known as mirror formula and is valid for both concave and convex mirrors. However, the quantities must be substituted with proper signs.

5.8.1 Power of Mirror

A spherical mirror has infinite number of focus. Optical power of a mirror (in Diopter) $= -\frac{1}{f(\text{in metre})}$

5.8.2 Magnification of Concave Mirror

The linear magnification of a spherical mirror is the ratio of height of the image (h_2) formed by the mirror to the height of the object (h_1) i.e.

Linear magnification, $m = \frac{\text{Height of image}}{\text{Height of object}} = \frac{h_2}{h_1}$

The linear magnification is a number that simply tells us how much taller the image is than the object. For example, if m = 1, it means that the image and the object are of the same height. Another formula for magnification is :

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

The arbitrary minus sign given to linear magnification has nothing to do with the relative sizes of the object and the image but we can use it to tell whether the image is erect or inverted w.r.t. object.
NOTE: Always draw a rough ray diagram while solving a numerical problem. Otherwise we will be confused as to which distance should be taken as +ve & which –ve.
For virtual image : m is +ve [as virtual image is erect therefore, h_2 is +ve as well as h_1 is +ve]
For real image : m is –ve [as real image is always inverted therefore, h_2 is –ve while h_1 is +ve]

5.9 REFRACTION

The phenomenon of bending of light at the surface separating the two media of different optical densities.

1. When a ray of light goes from a rarer medium to a denser medium, it bends towards the normal.
2. When a ray of light goes from a denser medium to a rarer medium it bends away from the normal.

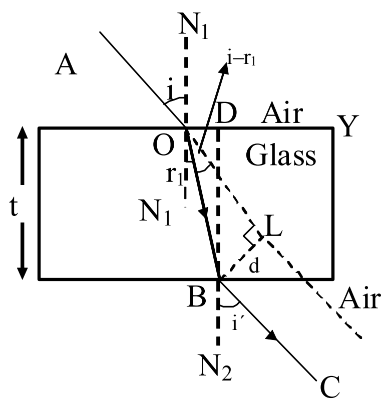
- The refraction of light takes place on going from one medium to another because the speed of light is different in the two media.
- The greater is the difference in speeds of light in the two media, the greater will be the refraction or bending of light.

5.9.1 Optically rarer medium and optically denser medium

Speed of light is different in two media.
A medium in which the speed of light is more is known as optically rarer medium (or less denser medium)
A medium in which the speed of light is less, is known as optically denser medium.

- The optical density of a substance should not be confused with its density.

5.9.2 Refraction through a Glass Slab



Angle i = Angle i'

i.e incident ray and Emergent ray are parallel.

Lateral shift(d) : It is the perpendicluar distance between the incident ray and emergent ray.

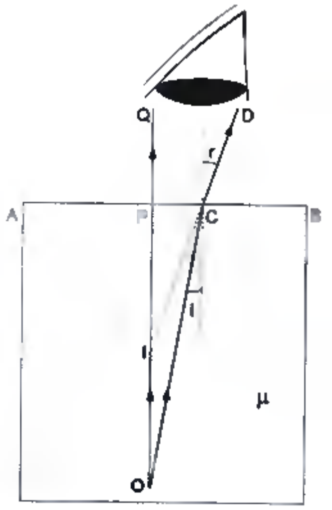
5.9.3 Phenomena based on refraction

(A) Apparent Depth:

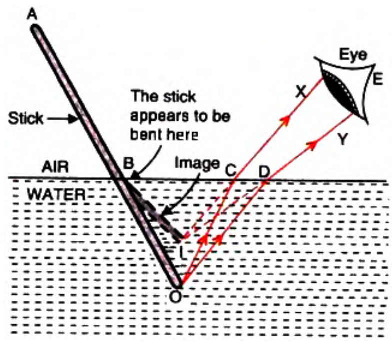
Consider an object O placed in a medium

Since the object is actually at O, PO is the real depth of the object below the surface. And because the object appear to be at I, PI is its apparent depth.

This is because the coin appears slightly above its real position due to refraction of light.



(B) A straight object like a pencil kept partly immersed in water in a glass tumbler. Then the part of the pencil inside water appears to be bent relative to the part that is above water.
The part of the pencil inside water also appears to be thicker if viewed from the side.



(C) Twinkling of stars
We have seen that the density of the air decrease with height above the earth's surface. This cause light from stars and other heavenly bodies to bend as it passes through the atmosphere. As a result, we see the star at a position that is slightly shifted from its actual position. But when we look at starts, while often they do not appear steady. They disappear for a fraction of a second before reappearing (the intensity of light from them fluctuates) or their positions seem to shift slightly in random direction. We call this the twinkling of starts.It is due to phenomenon of Atmoshperic refraction.

5.10 REFRACTION BY SPHERICAL LENSES

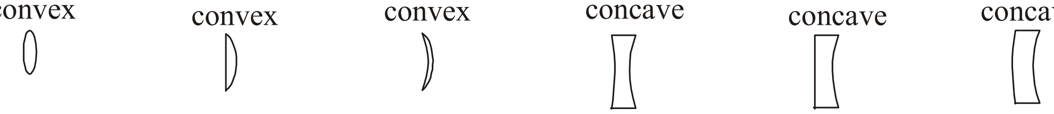
5.10.1 Lens

A piece of a transparent medium bounded by at least one spherical surface is called lens.

Types of Lens

LENS

- Convex or coverging (thick in the middle and thin at the edges)
  - Double convex
  - Plano convex
  - Concavo convex
- Concave or diverging (Thin in the middle and thick at the edges)
  - Double concave
  - Plano concave
  - Convexo concave



5.10.2 Terms associated with Spherical Lenses

(i) **Principal axis** : Line passing through the optical centre and joining the centres of curvature of the two curved surface.

(ii) **Optical centre (O)**: It is a point lying within a lens through which the ray of light pass undeviated.

(iii) **Principal focus (F)** : It is a point on the principal axis of the lens where all the rays of light coming parallel to the principal axis either converge actually (convex lens) or appear to diverge (concave).

(iv) **Focal length (f)** : The distance between the optical centre and the principal focus.

For a convex lens : f = +ve. For a concave lens : f = –ve

5.10.3 Sign convention for spherical Lenses

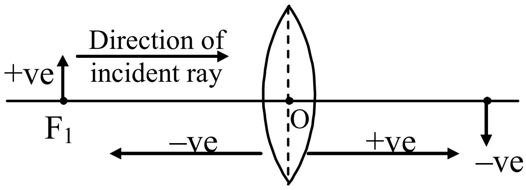
(i) All the distances are measured from the optical centre of the lens.

(ii) The distance measured in the same direction as that of incident light are taken as positive.

(iii) The distance measured against the direction of incident light are taken as negative.

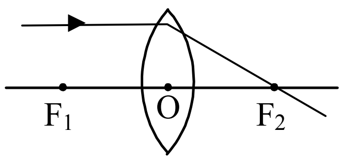
(iv) The distances measured upward and perpendicular to the principal axis are taken as positive.

(v) The distances measured downward and perpendicular to the principal axis are taken as negative.

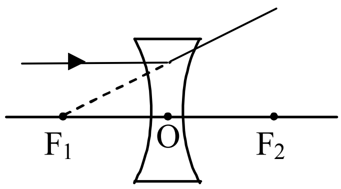


5.10.4 Rules for image formation by a Lens

(i) A ray of light travelling parallel to the principal axis, after refraction passes through (convex lens) or appears to come from (concave lens) its second principal focus.

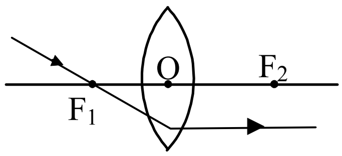


(a) Convex lens

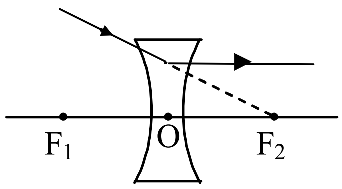


(b) Concave lens

(ii) A ray of light initially travelling through (convex lens)or along the dirction of first principal focus after refraction, travels parallel to the principal axis.

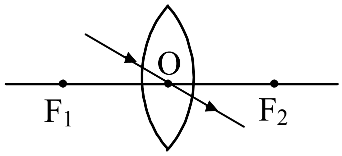


(a) Convex lens

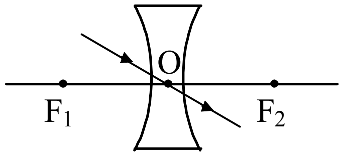


(b) Concave lens

(iii) A ray of light which passes through the optical centre, does not suffer any refraction.



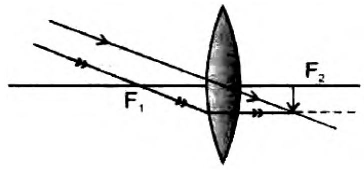
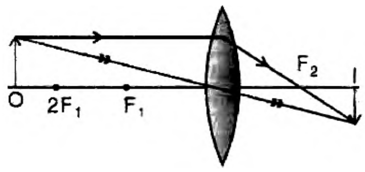
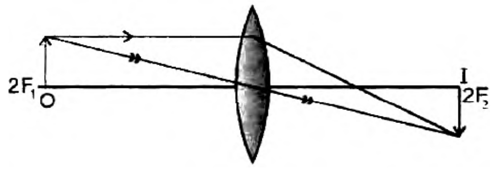
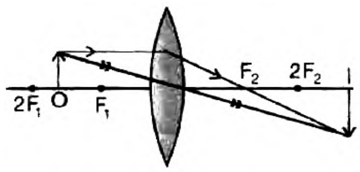
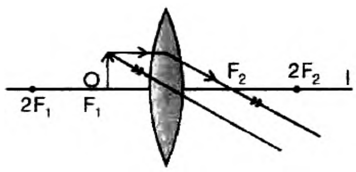
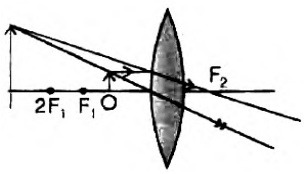
(a) Convex lens



(b) Concave lens

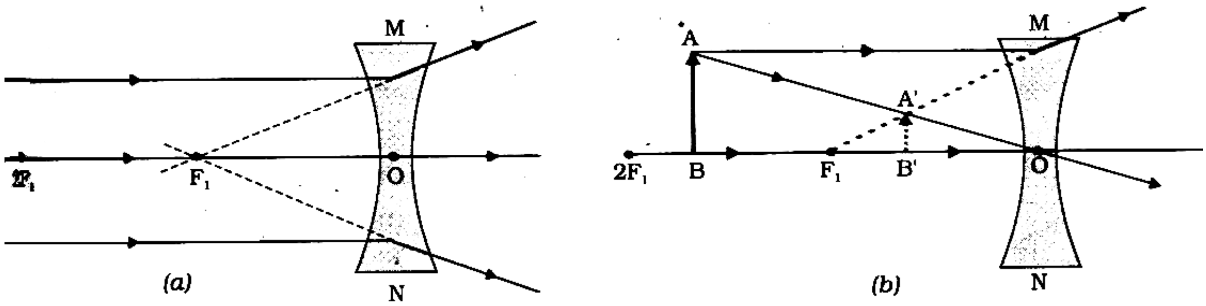
5.11 IMAGE FORMATION IN LENSES USING RAY DIAGRAMS

(A) Image formed by a Convex Lens

Position of object	Details of Image	Figure
At infinity	Real, inverted, diminished (m < < – 1), At F	
Between infinity and 2F	Real, inverted, diminished (m < – 1), between F and 2F	
At 2F	Real, inverted, equal in size (m = – 1), At 2F	
Between 2F and F	Real, inverted, enlarged (m > – 1), Between 2F and ∞	
At F	Real, inverted, enlarged (m >> – 1), At infinity	
Between Focus and Pole	Virtual, erect, enlarged (m > +1), Between ∞ and Object, on same side of object	

(B) Image formed by a Concave Lens

	Position of the object	Position of the image	Relative size of the image	Nature of the image
(a)	At infinity	At the focus F_1	Highly diminished, point-sized	Virtual and erect
(b)	Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect



The position, size and the nature of the image formed by a concave lens for various positions of the object

5.11.1 Power of Lens (P)

Reciprocal of focal lengthis called power of lens.

$$\therefore \quad P = \frac{1}{f(\text{in meter})} = \frac{100}{f(\text{in cm})}$$

SI unit of power is dioptre (D).

(i) Power of a convex lens is +ve.

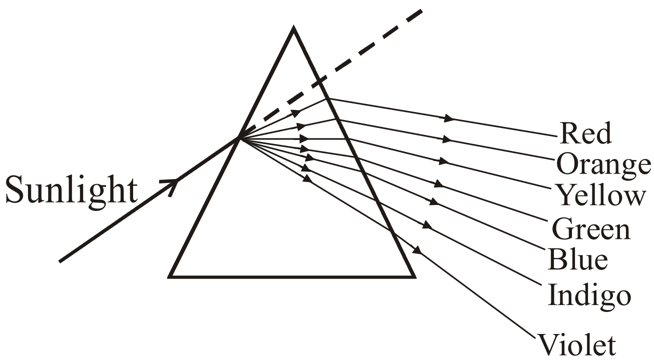
(ii) Power of a concave lens is -ve.

- Power of a lens is the measure of its degree of convergence or divergence of light rays falling on it.

5.12 DISPERSION BY A PRISM

It has been known for a long time that when a narrow beam of sunlight, (usually called white light) is incident on a glass prism, the emergent light is seen to be consisting of several colours.

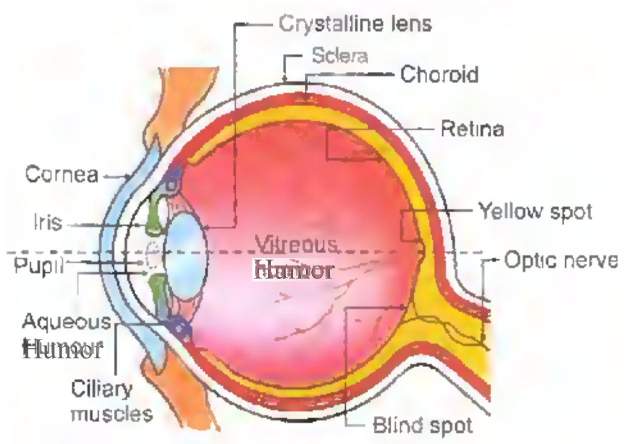
There is actually a continuous variation of colours, but broadly, the different colours that appear in sequence are: violet, indigo, blue, green, yellow, orange and red (given by the acronym VIBGYOR). The red light bends the least, while the violet light bends the most shown in figure.



"The phenomenon of splitting of light into its constituent colours is known dispersion. The pattern of colour components of light is called the spectrum of light".

5.13 HUMAN EYE

Construction : The eye is nearly spherical in shape having a diameter of about 25mm (1 inch). The walls of eyeball consists of two major layers. The outer covering is known as sclerotic layer. It is a tough, opaque white substance. It forms the white of the eye. The front of this coating forms a curved section known as cornea. The cornea protects the eye and helps in refraction of light. The second layer also called the inner layer is known as the choroid. It is black to prevent internal reflection and protects the light - sensitive parts of the eye.



Structure of eye

1. **Iris :** The iris is a coloured diaphargm behind the cornea. A circular aperture in the centre of the iris is called the pupil. The pupil dilates or contract depending upon the amount of light available.

2. **Eye lens** : It is a transparent, crystalline structure made up of many concentric layers. It is kept in its position by a strong elastic frame called the suspensory ligaments.
   The eye -lens helps to divide the eye chamber into two parts. The front chamber between the cornea and the eye-lens is called the anterior chamber and is filled with a fluid called the aqueous humour. Refractive index of aqueous human is 1.337. The back chamber between the eye lens and the retina is called the posterior chamber and is filled with a jelly-like material called the vitreous humour. Refractive index of vitreous humour is also 1.337.

3. **Retina:** The inside surface of the rear part of the eyeball where the light entering the eye is focussed is called retina. The surface of retina consists of about 125 million light - sensitive receptors. These receptors are of two types rods and cones shapes. When light falls on these receptors, they send electrical signals to the brain through optic nerve.

4. **Rods and Cones Cells** : The cells on the retina are of two shapes : rod-shaped and cone shaped. The rod cells of our retina respond to the intensity of light. While cone shaped cells respond to colours. It should be noted that animals differ from human beings in their colour perception. For example, the bee has some cone shaped cells in the retina of its eye which enable it to see colours beyond indigo and violet parts of the spectrum which is called ultraviolet region. We cannot see colours beyond indigo and violet so we are said to be ultraviolet blind.

5. **Yellow spot** : The most sensitive point on the retina is called the yellow spot. It is situated at the centre of the retina and is lightly raised. It has a little depression called fovea-centralis, which is extremely sensitive to light. Its function is to form an extremely clear image.

6. **Blind Spot :** The least sensitive point is known as the blind spot. There are no rods and cones at the point where optic nerves leave the eyeball to go to the brain.

7. **Sclera :** It is the outermost covering of the eyeball. It is made of white tough fibrous tissues. Its function is to house and protect the vital internal parts of the eye.

8. **Cornea:** It is the front bulging part of the eye. It is made of transparent tissues. Its function is to act as a window to the world i.e. to allow the light to enter in the eyeball.

9. **Choroid:** It is a grey membrane attached to the sclera from the inner side. Its function is to darken the eye from inside and, thus prevent any internal reflection.

10. **Optic Nerve:** It is a bundle of approximately 70,000 nerves originating from the brain and entering the eyeball from behind. Its function is to carry optical messages (visual messages) to the brain.

11. **Ciliary muscles:** It is a ring of muscles which holds the crystalline lens in position. When these muscles relax, they increase the focal length of the crystalline lens and vice versa. Its function is to alter the focal length of crystalline lens so that the images of the objects, situated at different distances, are clearly focussed on the retina.

12. **Vitreous Humour :** It is a dense jelly-like fluid, slightly grey in colour, filling the part of eye between crystalline lens and retina. Its function is (i) to prevent the eyeball from collapsing due to change In atmospheric pressure, (ii) in focussing the rays clearly on the retina.

13. **Aqueous Humour :** It is a watery, saline fluid, filling the part of the eye between the cornea and the crystalline lens. Its function is (i) to prevent front part of the eyeball from collapsing with the change in atmospheric pressure, (ii) to keep the cornea mosit.

14. **Eyelids :** Nature has provided each eye with when eyelids. They prevent any object, such as dust, straw from entering the eye. Eyelids shut out light when you do not want to see.

Working of the Eye: The light rays coming from the object kept in front of us enter the pupil of the eye and fall on the eye lens. The eye-lens is a convex lens, so it converges the light rays and produces a real and inverted image of the object on the retina. The image formed on the retina is conveyed to the brain by the optic nerve and gives rise to the sensation of vision.

Near Point and Far Point: There is a limit to the power of accommodation of the eye. A normal eye can see any object which is at a distance of 25cm to infinity by using its power of accommodation. The point nearest to the eye at which an object is visible distinctly is called the near point of the eye. **The maximum distance upto which the normal eye can see the things clearly is called the far point of the eye. It is infinity for a normal eye.**

The distance of near point from the eye is known as least distance of distinct vision. The distance between the near point and the far point is called the range of vision. Thus, for a normal eye, the range of vision is from 25cm to infinity.

PRACTICAL LEARNING

ACTIVITY - 9

To show the presence of blind spot on the retina.

Fig. 16.14

Take a white cardboard and mark a thick cross on its left hand side. At a distance of 8 cm mark a dot on the right hand side. Hold the cardboard at arms length from your eyes. Close your left eye, and look continuously on the cross. You will see both cross and dot are visible. Move the cardboard slowly towards yourself, keeping the eye on the cross. You will find at some point that the dot disappears. At this moment the image of dot is formed on the blind spot, and hence, it is not visible. Now close your right eye and again keep the cardboard at arm's distance. Now look at the round mark continuously and move cardboard slowly towards you. You will notice at some point, teff cross disappears. At this moment the image of X is formed on the blind spot. **This activity shows that the image of the object formed at the blind spot of the eye can not be seen.**

ACTIVITY - 10

To show pupil controls the light entering the eye.
Take your friend to a dimly lit room. Look into one eye of your friend . Observe the size of pupil which appears as black dot. Now shine a torch for 5 seconds in the eye of your friend. Again observe the size of pupil. You will observe that pupil has become much smaller. Stop shinning the light. You will observe that pupil again increases in size.
Thus, **activity clearly proves that pupil helps in controlling light entering in the eye.**

5.13.1 Accommodation of Eye

The process by which ciliary muscles alter the focal length of the crystalline lens, so as to focus the nearer or the far-off objects clearly on the retina, is called accommodation of the eye.

5.13.2 How Eye Focuses Nearer Objects

In order to focus nearer objects, the ciliary muscles contract. In doing so, they decrease the focal length of crystalline lens. Thus, the images of the objects nearer to the eye are clearly focussed on the retina.

5.13.3 How Eye Sees Far-off Objects

The rays coming from far-off objects are almost parallel and, hence, on passing through lens meet at the principal focus. In order to focus on far-off objects, the ciliary muscles relax. This in turn increases the focal length of the crystalline lens. Thus, the images of the far-off objects are clearly focussed on the retina, which at the moment is on the principal focus of the crystalline lens.

5.13.4 Persistence of Vision

When the light falls on the retina of the eye, the impression of the image lasts for $1/16^{th}$ of a second. So, if the images of objects are received by the eye in less than 1/16th second, the impression of the first image does not fade, when another image is received. This in a way gives continuity, i.e., the eye cannot make out when the first image fades and the second image starts. Thus, to the eye it appears as if the object is in motion.

"This peculiar phenomenon due to which the eye cannot distinguish between stationary objects, when their images are flashed in less than 1/ 16th second on the retina, is called persistence of vision".

Example : The movies which we see or the moving images on the television are due to persistence of vision. In actual practice, any scene consists of a number of pictures in proper sequence. The images of these pictures are made to move in front of eye at a rate of 24 pictures per second ($1^{1/2}$ times faster than persistence of vision). This gives a sense of continuity, and hence, we see moving picture.

Remember

Least Distance of Distinct Vision :

The minimum distance of an object from the eye at which it can be seen most clearly and distinctly without any strain on the eye, is called the least distance of distinct vision. For a person with normal vision, it is about 25 cm and is represented by the symbol D.

Least distance of distinct vision = D = 25 cm.

Colour-Blindness :

The retina of our eye has large number of light sensitive cells having shapes of rods and cones. The rod-shaped cells respond to the intensity of light with different degrees of brightness and darkness whereas the cone shaped cells respond to colours. In dim light rods are sensitive but cones are sensitive only in bright light. The cones are sensitive to red, green and blue colours of light to different extents.

Due to genetic disorder, some persons do not possess some cone-shaped cells that respond to certain specific colours only. Such persons cannot distinguish between certain colours but can see well otherwise. Such persons are said to have colour-blindness. Driving licenses are generally not issued to persons having colour-blindness.

Colour Perception of Animals :

Different animals have different colour perception due to different structure of rod shaped cells and cone shaped cells. For example, bees have some coneshaped cells that are sensitive to ultraviolet. Therefore bees can see objects in ultraviolet light and can perceive colours which we cannot do.

Human beings cannot see in ultraviolet light as their retina do not have cone-shaped cells that are sensitive to ultraviolet light.

The retina of chicks have mostly cone shaped cells and only a few rod shaped cells. As rod shaped cells are sensitive to bright light only, therefore, chicks wake up with sunrise and sleep in their resting place by the sunset.

5.14 DEFECTS OF EYE

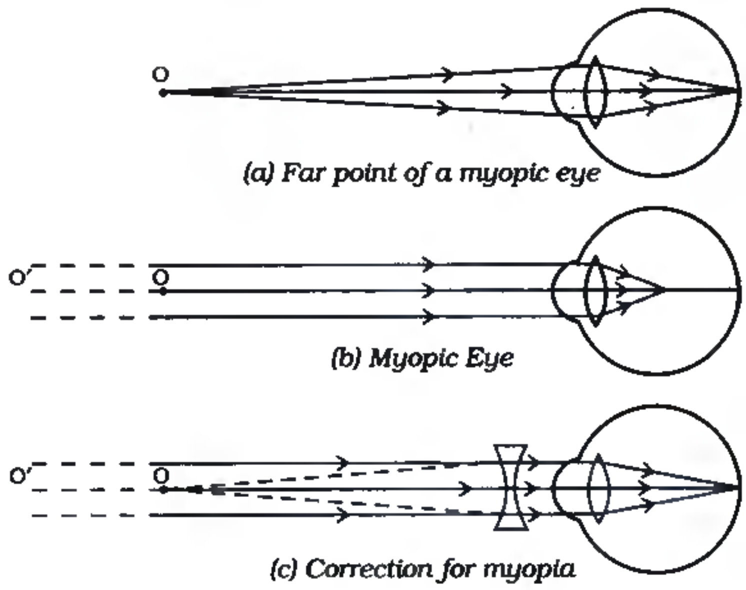
(a) Defect : Myopia

Definition : The defect of eye in which near objects can be seen distinctly but the far objects can not be seen distinctly is known as myopia.

Cause:

(i) The focal length of the lens decreases so that the rays of light coming from infinity get focussed at a point in front of the retina

(ii) The far point of the eye come closer than infinity.



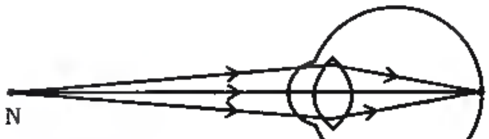
(a), (b) The myopic eye, and (c) correction for myopia with a concave lens

Remedy: By using a concave lens.

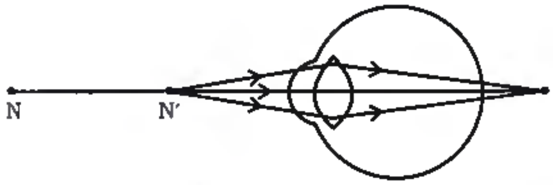
(b) Defect : Hypermetropia

Definition : The defect of the eye in which the distant objects can be seen distinctly but the near objects can not be seen distinctly is known as hypermetropia.

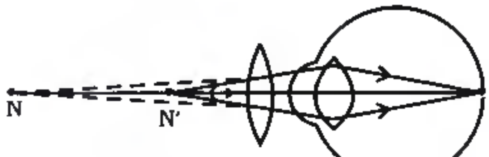
Cause: Due to increase in focal length of eye lens or decrease in radius of curvature of the lens or due to decrease of distance between retina and eye lens.



(a) Near point of a Hypermetropic eye



(b) Hypermetropic eye



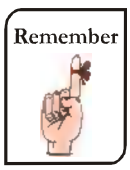
(c) Correction for Hypermetropic eye

(a), (b) The hypermetropic eye, and (c) correction for hypermetropia

Remedy: By using convex lens.

(c) Defect: Presbyopia

Definition: The defect of eye in which a person cannot see either near objects or distant objects distinctly is known as Presbyopia.
Cause: In old age the eye lens becomes hard and it loses its adjusting power of accommodation.
Remedy: By using bifocal lens.
Note: The upper part of bifocal lens is concave and lower part is convex.



Presbyopia:

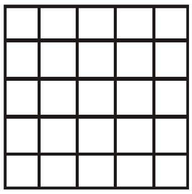
This defects arises with aging. A person suffering from this defect can see neither nearby objects nor distant objects clearly/distinctly. This is because the power of accommodation of the eye decreases due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens. This defect can be corrected by using bi-focal lenses. Its lower part consists of a convex lens and Is used for reading purposes whereas the upper part consists of a concave lens and is used for seeing distant objects.

(d) Defect: Colour blindness

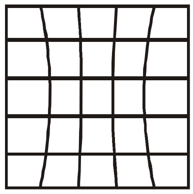
Definition: The defect of the eye in which a person can not differentiate between different colours is known as colour blindness.
Cause: The eye loses the property of differentiating between different colours.
Remedy: Remedy is not possible.

(e) Astigmatism :

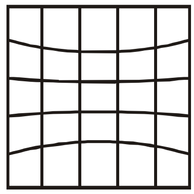
A person suffering from the defect cannot simultaneously focus on both horizontal and vertical lines of a wire gauze.



Normal wire gauge

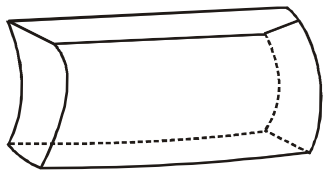


Wire gauge with Distorted vertical lines



Wire gauge with distorted Horizontal lines

This defect arises due to the fact that the cornea is not perfectly spherical and has different curvatures for horizontally and vertically lying objects. Hence, objects in one direction are well focused whereas objects in the perpendicular direction are not well focused. This defect can be corrected by using cylindrical lenses. The cylindrical lenses are designed in such a way so as to compensate for the irregularities in the curvature of cornea .



Cylindrical lens

(f) Cataract:

Sometimes due to the formation of a membrane over the crystalline lens of some people in the old age, the eye lens becomes hazy or even opaque. This is called cataract. It results in decrease or loss in vision of the eye. Cataract can be corrected by surgery leading to normal vision.

5.15 CARE OF EYES

It is necessary that you take proper care of your eyes. If there is any problem you should go to an eye specialist. For caring of our eyes :

- Use suitable spectacles.
- Two little or too much light is bad for eyes. Insufficient light causes eye strain and headaches. Too much light, like that of the sun, a powerful lamp or a laser torch can injure the retina.
- Do not look at the sun or a powerful light directly.
- Never rub your eyes. If particles of dust go into your eyes, wash your eyes with clean water. If there is no improvement, go to a doctor.
- Wash your eyes frequently with clean water.
- Always read at the normal distance for vision. Do not read by bringing your book too close to your eyes or keeping it too far.

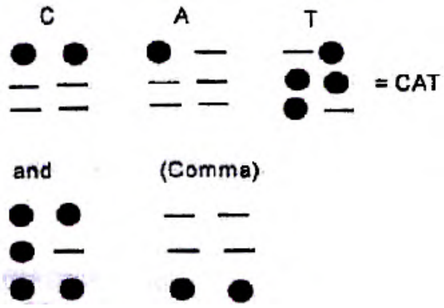
5.16 VISUALLY CHALLENGED PERSONS CAN READ AND WRITE

Some persons, including children, can be visually handicapped. They have very limited vision to see things. Some persons cannot see at all since birth. Such persons try to identify things by touching and listening to voices more carefully. They develop their other senses more sharply.

5.17 BRAILLE SYSTEM

The most popular resource for visually challenged persons is known as Braille. The present system was adopted in 1932. There is Braille code for common languages, mathematics and scientific notation. Many Indian language can be read using the Braille system.

Braille system has 63 dot patterns or characters. Each character represents a letter, a combination of letters, a common word or a grammatical sign. Dots are arranged in cells of two vertical rows of three dots each. Patterns of dots to represent some English alphabets and some common words are shown below.



These patterns when embossed on Braille sheets help visually challenged persons to recognize words by touching. To make them easier to touch, the dots are raised slightly. Visually challenged people learn the Braille system by beginning with letters, then special characters and letter combinations. Methods depend upon recognition by touching. Each character has to be memorized. Braille texts can be produced by hand or by machine. Typewriter like devices and printing machines have now been developed.

Remember

How do you observe coloured objects ?

A red rose appears red in white light. Light falling on a rose has all the colours of a spectrum in it. Of all the colours red light is reflected from the rose which is seen by you. Rest of the colours are absorbed by it. Same is true about different coloured objects. Green object reflect green light rays, blue objects reflect blue light rays and so on. Rest of the colours are absorbed . We identify the colour of an object from the colour of the light an object reflects.

Mixing of Colours of Light

Red, blue and green are the three basic or primary colours of light. All other colours are obtained by the mixing of these colours. Most common example is seen in a television picture. The picture tube in a coloured television set puts out light beams of three basic colours upon the screen as tiny dots. These dots are so closely placed that they get intermingled with one another and are not identified separately. It is only the combined effect from these dots that is seen by us on the screen. The combination effect of the coloured dots from light is as follows:

(i) red + blue overlap to form magenta.

(ii) red + green overlap to form yellow.

(iii) blue + green overlap to form cyan (bright blue).

(iv) red + blue + green overlap to form white.

Why does sky appear blue ?

As the sunlight enters the atmosphere, some of the light is absorbed, some is scattered and the rest reaches the earth. On the way the light may be dispersed into different colours, red reaching the earth and violet going towards the sky. Violet light gets scattered on striking the dust particles in the air, hence the sky appears blue.

Why the sky is red around sunset ?

As we have learn in the above example red and green coloured lights bend towards the earth. The position of the sun being oblique in the morning and evening, we see the sky 'red' in the morning and in the evening.

Learn that

Primary colours of pigments (water colours, paints and pastel colours) are different from the primary colours of light. Primary colours in pigments are Red, blue and yellow (not green).

Some well known visually challenged persons

1. **Ravindra Jain** was completely visually challenged from birth. He obtained his Sangeet Prabhakar degree from Allahabad University. He has shown excellence as a lyricist, singer and music composer.
2. **Helen A Keller**, an American, lost her sight when she was 18 months old. However, because of her determination and courage she completed graduation and became a lecturer and author. She wrote a number of books including **"The Story of My Life"** [1903].

LET US RECAPITULATE

- Light is an invisible energy which causes sensation of vision.
- Light energy always travels in straight lines.
- **Mirror :** A highly polished surface from which reflection takes place.
- **Incident ray :** A ray of light which travels towards a mirror or some other medium.
- **Angle of incidence :** The angle which the incident ray makes with normal at the point of incidence.
- **Angle of reflection :** The angle which the reflected ray makes with normal at the point of incidence.
- **Kaleidoscope :** A toy made by joining three plane mirror strips at an angle of 60°, such that coloured objects placed in it form beautiful hexagonal patterns.
- There are two laws of reflection : (i) incident ray, reflected ray and the normal lie in the same plane at the point of incidence. (ii) angle of incidence is always equal to the angle of reflection..
- A real image is always inverted and can be taken on the screen.
- A virtual image is always erect and cannot be taken on the screen.
- The image formed by a plane mirror is virtual, erect, laterally inverted and is formed as far behind as the object is in front of a plane mirror.
- When the left side of the object appears as the right side of an image or vice versa, the image is said to be laterally inverted.
- **Regular reflection :** The phenomenon due to which a parallel beam of light is reflected as a parallel beam in some other direction.
- **Diffused reflection :** When a parallel beam of light on striking some rough surface gets reflected in different directions.
- A prism breaks white light into seven colours so as to form spectrum, such that the red colour bends least and the violet colour bends most.
- **Dispersion :** The phenomenon due to which white light splits into seven colours.
- **Spectrum :** A band of seven colours formed on the screen, when white light splits into seven colours.
- In human eye, the retina acts as a sensitive screen. It is made of 70,000 nerve endings. On the retina yellow spot is most sensitive to light.
- The point where the optic nerve enters the eye has no nerve endings. It is insensitive to light and is called blind spot.
- **Cornea :** A transparent tissue in front of the eye which allows the light to pass through.
- **Iris :** A circular diaphragm which controls the amount of light entering the eye.
- **Ciliary muscles :** A ring of muscles which alter the focal length of the eye lens by expanding or contracting.
- **Retina :** A hemispherical light sensitive screen at the back of the eye on which image is formed.
- The three defects in the eye are: (i) short-sightedness (myopia), (ii) long-sightedness (hypermetropia) and (iii) presbyopia.
- Temporary blindness is caused in the eye due to crystalline lens becoming opaque. It can be cured by replacing the crystalline lens by an artificial lens surgically.
- **Braille :** A special script developed for visually challenged people for reading.

CONCEPT APPLICATION LEVEL - I [NCERT Questions]

Q.1 Suppose you are in a dark room. Can you see objects in the room? Can you see objects outside the room? Explain .

Ans. We can see an object only if light from any source enters our eyes. The light may be emitted by the object or may have been reflected by the object. Thus, we cannot see an object which is placed in a dark room if it does not emit light of its own. Whereas an object outside the dark room can be seen if there is either light outside the dark room or the object emits its own light.

Q.2 Differentiate between regular and diffused reflection. Does diffused reflection mean the failure of the laws of reflection?

Ans.

Regular reflection	**Diffused reflection**
1. Occurs from shiny and smooth surfaces.	1. Occurs from unpolished and rough surfaces.
2. Reflected rays are parallel to each other.	q2. Reflected rays are not parallel to each other.

No, diffused reflection doesn't means the failure of the law of reflection.

Q.3 Mention against each of the following whether regular or diffused reflection will take place when a beam of light strikes. Justify your answer in each case.

(a) Polished wooden table **(b) Chalk powder**

(c) Cardboard surface **(d) Marble floor with water spread over it**

(e) Mirror **(f) Piece of paper**

Ans. **(a)** **Polished Wooden Table:** Regular reflection will take place. This is because polished wooden table will have a plane surface.

(b) **Chalk Powder :** Diffused reflection. Because the surface of the chalk powder is not smooth.

(c) **Cardboard Surface:** Diffused reflection. Since cardboard has a rough surface.

(d) **Marble Floor with Water Spread Over it:** Regular reflection as it will act like a plane surface.

(e) **Mirror:** Regular reflection. Because mirror has a shiny surface which is even.

(f) **Piece of Paper:** Diffused reflection. Surface of paper is rough.

Q.4 State the laws of reflection.

Ans. There are two laws which govern reflection:

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

(ii) The angle of incidence is always equal to the angle of reflection.

Q.5 Describe an activity to show that the incident ray, the reflected ray and the normal at the point of incidence lie in the same plane.

Ans. First of all we take a chart paper or stiff paper. Let the sheet project a little beyond the edge of the table.

fig. 16.2 (b)

Fig. 16.2 (a), (b) : Incident ray, reflected ray and the normal lie in the same plane

We use a sheet of stiff paper or a chart paper. Let the sheet project a little beyond the edge of the Table. Cut the projecting portion of the sheet in the middle. Look at the reflected ray. Make sure that the reflected ray extends to the projected portion of the paper. Bend that part of the projected portion on which, the reflected ray falls. Bring the paper back to the original position. When the whole sheet of paper is spread on the table, it represents one plane. The incident ray, the normal and the reflected ray are all in this plane when you bend the paper you create a plane different from the plane in which the incident ray and the normal lie. Then you fail to see the reflected ray. What does it indicate? It indicates that the incident ray, the normal at the point of incidence and the reflected ray all lie in the same plane. This is law of reflection.

Q.6 Fill in the blanks in the following :

(a) A person 1 m in front of a plane mirror seems to be ____________ m from his image.

(b) If you touch your ____________ ear with right hand in front of a plane mirror it will be seen in the mirror that your right ear is touched with ____________.

(c) The size of the pupil becomes ____________ when you see in dim light.

(d) Night birds have ____________ cones than rods in their eyes.

Ans. (a) 2.00 (b) left, left hand (c) large (d) less

Q.7 Angle of incidence is equal to the angle of reflection:

(A) Always **(B) Sometimes**

(C) Under special conditions **(D) Never**

Ans. (A) Always.

Q.8 Image formed by a plane mirror is
(A) virtual, behind the mirror and enlarged.
(B) virtual, behind the mirror and of the same size as the object.
(C) real at the surface of the mirror and enlarged.
(D) real, behind the mirror and of the same size as the object.

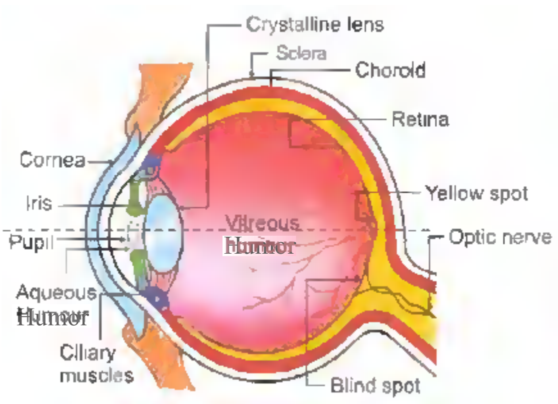
Ans. (B) Virtual, behind the mirror and of the same size of the object.

Q.9 Describe the construction of a kaleidoscope.

Ans. In kaleidoscope, the idea of formation of a number of images with the help of plane mirrors placed at an angle to one another and it is used to make numerous beautiful patterns.

Q. 10 Draw a labelled sketch of the human eye.

Ans.



Human eye

Q.11 Gurmit wanted to perform activity 16.8 (NCERT) using a laser torch. Her teacher advised her not to do so. Can you explain the basis of the teacher's advise?

And. Light is harmful for human eyes because its intensity is very high. It can cause damage to retina and lead to the blindness. Hence, it is advisable not to look at a laser beam directly.

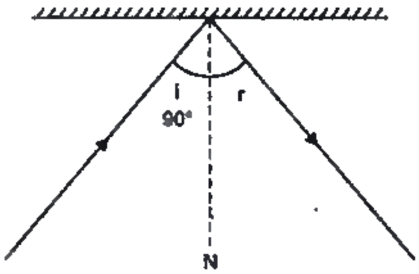
Q.12 Explain how you can take care of your eyes.

Ans. It is necessary that we take proper care of our eyes. If there is any problem we should go to an eye specialists have a regular checkup. We must:

(i) Use suitable spectacles if advised.
(ii) Too little or too much light is bad for the eyes. Insufficient light causes eyestrain and headaches. As too much light, like that of the sun or powerful lamps can injure retina, which is very delicate.
(iii) Do not look at the sun or a powerful light directly.
(iv) Never rub your eyes if any small particle or dust goes into it. Wash your eyes with clean water. If condition does not improve, then contact a doctor.
(v) Wash your eyes frequently with clean water.
(vi) Always read at the normal distance for vision.

Q.13 What is the angle of incidence of a ray if the reflected ray is at an angle of 90° to the incident ray?

Ans.



Given that, $\angle i + \angle r = 90°$ ...(1)

We know that, $\angle i = \angle r$ (Laws of reflection)

Replacing $\angle r$ in equation (1) with $\angle i$

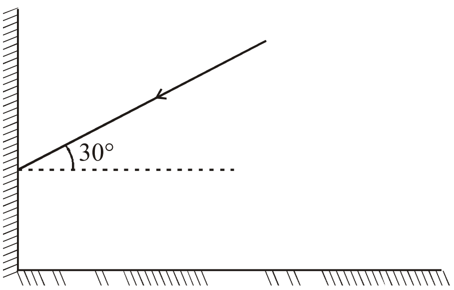
$\angle i + \angle i = 90°$ or $2\angle i = 90°$

or $\angle i = \frac{90°}{2}$ or $\angle i = 45°$.

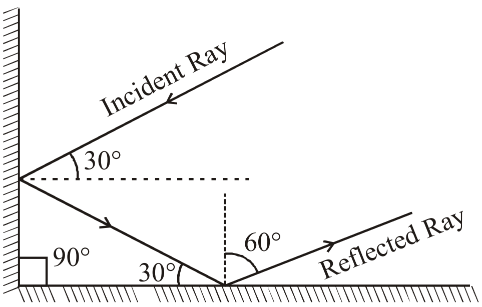
Q.14 How many images of a candle will be formed if it is placed between two parallel plane mirrors separated by 40 cm?

Ans. Infinite number of images will be formed.

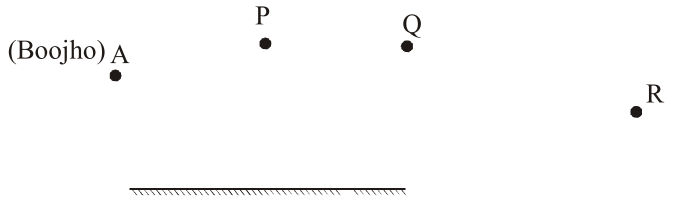
Q.15 Two mirrors meet at right angles. A ray of light is incident on one at an angle of 30° as shown in Fig. Draw the reflected ray from the second mirror.



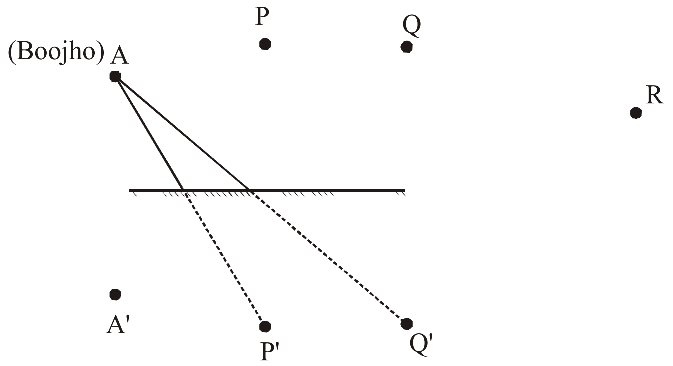
Ans.



Q.16 Boojho stands at A just on the side of a plane mirror as shown in Fig. Can he see himself in the mirror? Also can he see the image of objects situated at P, Q and R?



Ans. A plane mirror forms a virtual image behind the mirror. The image is as for behind the mirror as the object is in front of it. A cannot see his image because the length of the mirror is to short on his side. However he can see the object placed at P and Q but cannot see the object R.



Q.17 (a) Find out the position of the image of an object situated at A in front of the plane mirror (Fig.).
(b) Can Paheli at B see this image?
(c) Can Boojho at C see this image?
(d) When Paheli moves from B to C, where does the image of A move?

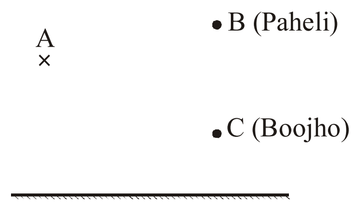


fig.(i)

Ans. (a) see figure (ii)

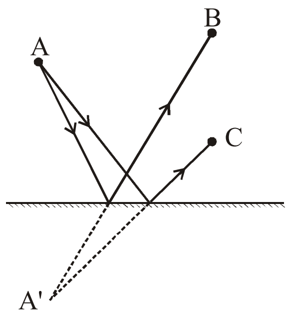


fig.(ii)

Conclusion : Image of the object placed at 'A' behind the mirror. The distance of the image from the mirror is equal to the distance of A from the mirror. Image is as shown in figure.

(b) Yes
(c) Yes
(d) No change in the position of A with respect to mirror.

CONCEPT APPLICATION LEVEL - II

Q.1 What makes things visible?

Ans. When light from an object reflects and enters our eyes then we see that object.

Q.2 Do we see all objects due to reflected light?

Ans. Almost everything we see around us, can be seen due to reflected light. for example Moon, which receives light from the Sun and reflects it. That's why we see the Moon.

Q.3 Define the following terms:
(i) Illuminated objects (ii) Luminous objects

Ans. (i) Illuminated objects: The objects, which shine in the light of other objects are called illuminated objects.
(ii) Luminous objects: The objects, which emits their own light are called luminous objects.

Q.4 What happens when light falls on a mirror?

Ans. Mirror is silvered from one side, so it does not allow the light to pass through it. It reflects almost whole of the light falls on it.

Q.5 What change in the path of light takes place when light falls on a shiny surface? What is this called?

Ans. The light reflects back in the same plane, when light falls on a shiny surface. This is known as reflection of light.

Q.6 How many reflected rays can there be for a given single incident ray falling on a plane mirror?

Ans. For one incident ray there is only one reflected ray.

Q.7 What is reflected ray?

Ans. The ray that get reflected from the surface of a shiny surface is known as the reflected ray.

Q.8 Define "Mirror".

Ans. A smooth shining surface which is silvered from one side and which rebounds the light back in same plane is called a mirror.

Q.9 What is incident ray?

Ans. The ray of light which strikes any surface is called the incident ray.

Q.10 What are the angles of incidence and reflection?

Ans. **Angle of Incidence:** The angle between the normal and the incident ray is called the angle of incidence.
Angle of Reflection: The angle between the normal and the reflected ray is called the angle of reflection.

Q.11 What are the characteristics of image formed by plane mirror?

Ans. Characteristics of image formed by plane mirror are:

(i) This mirror forms erect image.

(ii) Image formed is of the same size as the object.

(iii) The distance of image from the mirror is equal to the distance of object from the mirror.

(iv) It is virtual, it can't be obtained on a screen.

(v) Image is laterally inverted.

Q.12 Define Lateral Inversion.

Ans. Phenomenon of changing side left to right and right to left by the mirror, while forming images is called lateral inversion.

Q.13 Is it possible to have a ray of light?

Ans. A ray of light is an idealization. In reality, we have a narrow beam of light which is made up of several rays. For simplicity, we use the term ray for a narrow beam of light.

Q.14 While standing in front of a plane mirror, if you move your right hand, which hand does your image move?

Ans. If we move our right hand, our image will move left hand. It is because in a plane mirror our "left appears right" and "right appears left". This is called lateral inversion. Hence, we can say that the plane mirror forms laterally inverted images.

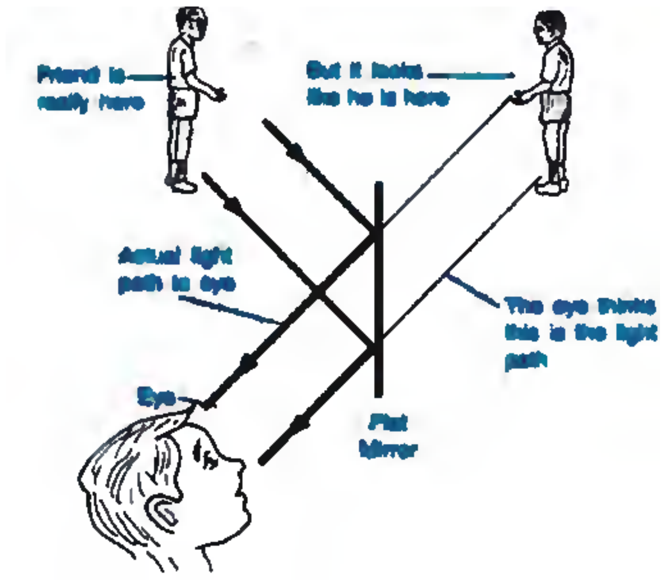
Q.15 Here are given capital letters of English Alphabet. Encircle the letters which will not show lateral inversion on facing a plane mirror.

A	**B**	**C**	**D**	**E**	**F**
G	**H**	**I**	**J**	**K**	**L**
M	**N**	**O**	**P**	**Q**	**R**
S	**T**	**U**	**V**	**W**	**X**
Y	**Z**				

Ans.

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X
Y	Z				

Q.16 Observe the figure given below and fill in the blanks:



(a) Size of your friend is .... to the size of image.

(b) Distance between mirror and image is .... to the distance between your friend and mirror.

(c) Image of your friend is ....

(d) Image of your friend is .... inverted.

Ans. (a) equal

(b) equal

(c) erect/virtual

(d) laterally.

Q.17 Draw a ray diagram to explain the formation of a virtual image in a plane mirror

(i) of a pencil (ii) of a point.

Ans.

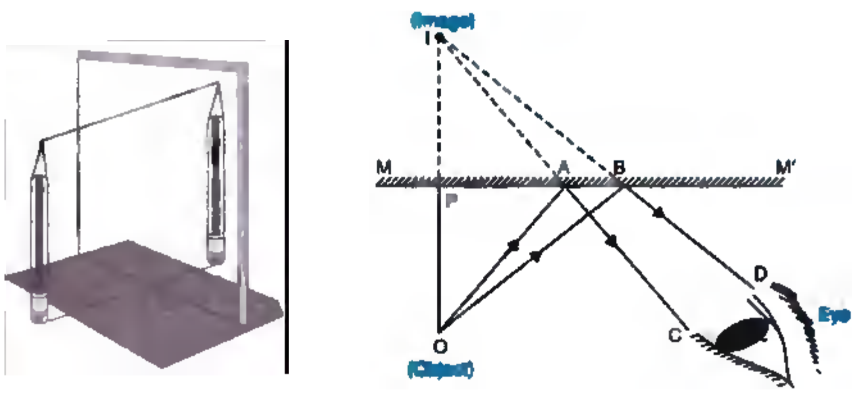
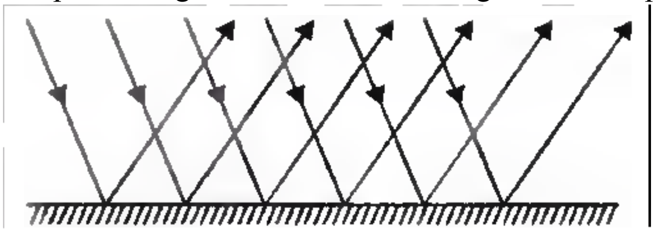


Fig. The image of a pencil formed by a plane mirror is located behind the mirrors

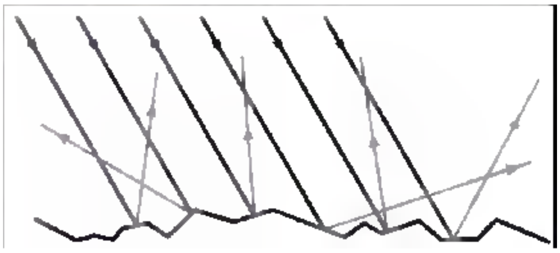
Q. 18 What is regular and diffused reflection?

Ans. When a ray of light falls on a smooth and shiny surface, after reflection from plane mirror, all the rays move parallel to each other then the reflection is called regular reflection. Mirrors do not allow even a small amount of light to pass through them. Mirrors show regular and complete reflection.



Regular reflection

When all the parallel rays reflected from a plane are not parallel, then reflection is diffused or irregular. This is not violation of law of reflection, the reason for diffused reflection is due to irregularities in the reflecting surface (Fig.)



Irregular reflection

Q.19 Why do we need a shiny surface for regular reflection?

Ans. The extent of reflection depends upon the shine and smoothness of the surface. More is the shine and smoothness of the surface, more will be the reflection. That is why, mirror reflect most of the light falling on them. Hence, for regular reflection, shiny surfaces are required.

Q.20 How many plane mirrors are used in Periscope.

Ans. Two.

Q.21 Write the uses of Periscopes.

Ans. Periscopes are used in submarines, tanks and also by soldiers in bunkers to see the things out side.

Q.22 How many mirrors are used in Kaleidoscope?

Ans. Three.

Q.23 What do you mean by multiple images?

Ans. When two mirrors are kept parallel to each other then numerous images are seen in these mirrors of an object. This is known as multiple image.

Q.24 What are the uses of Kaleidoscope?

Ans. Designers of wallpapers and fabrics and artists use kaleidoscope to get ideas for new pattern.

Q.25 How many colours of light consists in White light.

Ans. Seven.

Q.26 How many colours are there in light spectrum.

And. Seven.

Q.27 Define dispersion of light.

And. Spliting of white light into its constituents colours is known as dispersion of light.

Q.28 Give an example of natural dispersion.

Ans. Rainbow is a natural phenomenon showing dispersion.

Q.29 Explain the internal structure of human eye. Also discuss the functions of various parts of the eye.

Ans. Human eye is roughly spherical in shape. It has a white coloured tough outer coat that protects the interior of the eye from any damage. Its transparent front part is called cornea. In the cornea, there is a small opening called the pupil. The size of the pupil is controlled by the iris. The iris is the coloured part of the eye. The iris acts as a shutter or a diaphragm to control the amount of light entering into the eye. Behind the pupil is a convex lens which focuses light on the back of the eye on a layer called retina. Retina contains several nerve cells. Sensations felt by the nerve cells are then transmitted to the brain through the optic nerve.

Q.30 What is the function of eyelids?

Ans. The function of eyelids is to protect eyes from any objects entering into it. Eyelids also shut out light when not required.

Q.31 What is the comfortable distance at which one can read with a normal eye?

Ans. 25 cm

Q.32 How many kinds of nerve endings are found in human eye? What are their functions?

Ans. There are two kinds of nerve endings (i) cones which are sensitive to bright light and (ii) rods which are sensitive to dim light. Besides, cones sense colour. At the junction of the optic nerve and the retina, there are no sensory cells, so no vision is possible at that spot. This is called the blind spot.

Q.33 Explain the function of the muscles attached to the lens of the eye.

Ans. In order to see near objects, muscles attached to the lens contract and the lens becomes thicker. On the other hand, muscles relax and the lens becomes thinner when distant objects are to be seen. This changing of the thickness of the eye lens is called accommodation.

Q.34 What are the two defects of eye in seeing near and far objects? How can these defects be corrected?

Ans. Some persons can see near objects clearly but cannot see distant objects distinctly. On the other hand, some persons cannot see near objects clearly but they can see distant objects distinctly. These defects of the eye can be corrected with the help of using suitable lens.

Q.35 Why in old ages the eye sight becomes foggy? How can this defect may be removed?

Ans. Sometimes, particularly in old age, eyesight becomes foggy. It is due to the eye lens becoming milky and cloudy. When it happens, person is said to have cataract. There is a loss of vision, sometimes extremely severe. It is possible to treat this defect. The opaque lens is removed and a new artificial lens is inserted. Modern technology has made this procedure simpler and safer.

Q.36 Why one should include the vitamin A rich eatables in their diet? What are the main source of vitamin A?

Ans. Lack of vitamin A in foodstuff is responsible for many eye troubles. Most common amongst them is night blindness. One should therefore, include in the diet components which have vitamin A. Raw carrots, broccoli and green vegetable such as spinach (Palak), methi, amarnth and cod liver oil are rich in vitamin A. Eggs, milk, curd, paneer, butter, ghee and fruits such as papaya, banana, mango, apple, dates etc. also contain plenty of vitamin A in them.

Q.37 Write the name of some non-optical aids.

Ans. (i) Tactual aids (using the sense of touch).
(ii) Auditory aids (using the sense of hearing).
(iii) Electronic aids.

Q.38 How a visually challenged person read and write?

Ans. Tactual aids, including Braille writer slate and stylus, help the visually challenged persons in taking notes, reading and writing.

Q.39 Write an essay on "Braille System".

Ans. The most popular resource for visually challenged persons is known as Braille. Louis Braille, himself a blind person, developed a system for visually challenged persons and published in 182l.

The present system was adopted in 1932. There is Braille code for common languages, mathematics and scientific notation. Indian languages such as Hindi, Sanskrit, Marathi, Gujarati, Bengali, Tamil, Telugu and Urdu, can be read using the Braille system. Braille system has 63 dot patterns or characters which represents a letter, combination of letters, common word or grammatical sign.

Visually challenged people learn the above system by beginning with letters and then to special characters and letter combinations. Methods depend upon recognition by touching. Each character has to be memorised. Braille texts can be produced by hand or by machine. To write braille by hands, a slate is used consisting to two metal plates hinged together with a paper in between them. A writer inserts a stylus to make dot patterns through a cell size opening on the upper plate. Type writer like devices and printing machines which use embossed zinc plates to make coded impressions on paper, have also been developed.