Chapter 12

# REFLECTION OF LIGHT

## 12.1 Reflection of light

Whenever light strikes an object, it scatters in all directions and makes it possible for us to see the object. However, when parallel rays of light fall on a polished surface, they go in a definite direction.

To make a mirror, one side of the glass strip is silvered and to protect it, a dark colored layer, is painted over it. (fig. 12.1)

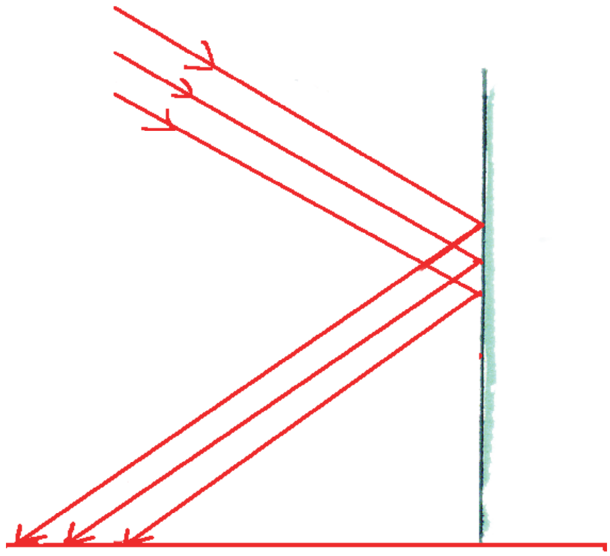


Fig.12.1 Mirror

Activity - 1

**Materials required : -** Two plane mirrors, one smooth black paper, one white paper, gum, and blade.

Wrap a piece of black paper on the mirror as shown in fig. 12.2 and paste it with gum. On the reflecting side of the mirror make three equidistant parallel slits on this paper with a blade. Put the white paper on a plane surface chosen at a place having both light and shadow. Keep the mirror in your hand in such a way that the slits are towards the sun. Arrange the reflected rays on the paper placed in the shadow. Put another plane mirror in the path of these rays. Ensure that the rays coming from the slits are falling on this mirror. Are the rays falling on this mirror going in the other direction? Observe the path of the incident and the reflected rays. Thus we can see that, when rays of light strike any shining surface they are diverted to a definite direction and this phenomena is called reflection of light (Fig. 12.2). Light rays A,B,C are called the incident light rays and A',B',C' are called the reflected light rays.

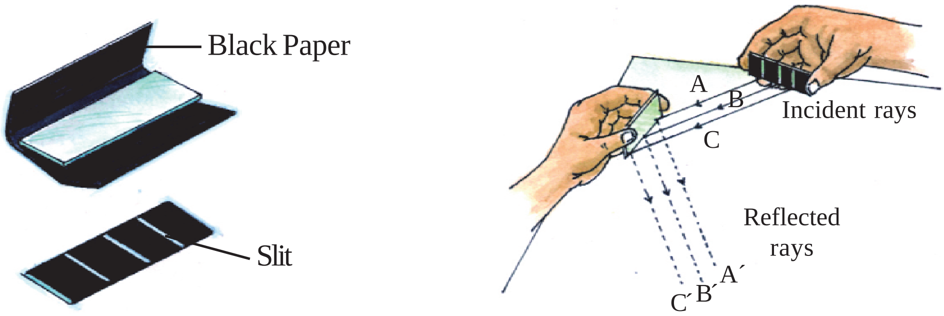



Fig.12.2

Now, let us discuss the conclusions drawn from activity-1.

## 12.2 Reflection by a Plane Mirror

In fig.12.3, MM' represents the position of the mirror. The incident ray of light is incident on point O, which is known as point of incidence. A perpendicular line 'ON' is drawn at the incident point is called the normal, ∠AON formed between the incident line AO and the normal is known as incident angle, while the angle formed by the reflected line OA´ with the normal is known as angle of reflection ∠A´ON.

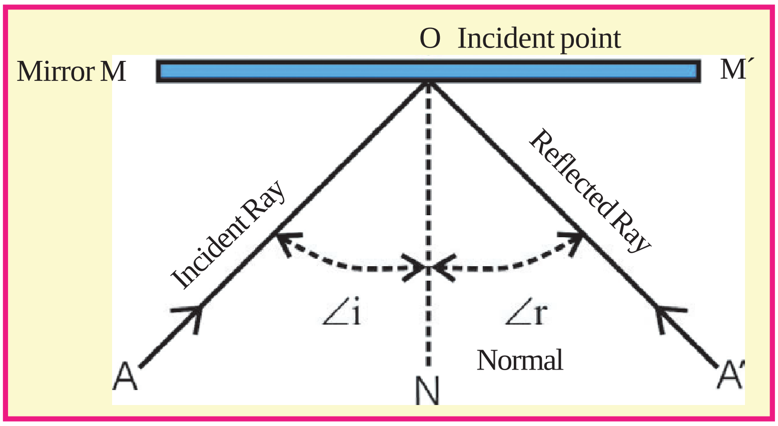



Fig.-12.3. Formation of angle of incidence and angle of reflection by the mirror

### Activity - 2

**Materials required :-** Plane mirror, clip, four drawing pins, four all pins, white paper, scale, protractor, drawing board, and pencil.

1. Fix the white paper on the drawing board with the help of drawing pins.
2. Draw a straight line MM´ on the paper as shown in figure 12.4.
3. Mark the centre of MM´ as point O.
4. Draw a line 'ON' perpendicular to the line MM' at the point O.
5. Make an angle ∠PON = 30° with the help of protractor at point O.
6. Fix two pins at point P and Q on line PO at a distance of 3cm from each other, as shown in figure 12.4.

7. Now fix the plane mirror with the help of clips on the white paper in such a way that the shining surface of the mirror is aligned along the line MM'.
8. See the images of pins on the right side of PO in the mirror.
9. Place two pins in line with the images according to the figure.
10. Now remove these pins. Make small circles around the points and mark these points as R and S. Join R, S and O (Fig. 12.4).
11. Measure angle ∠SON with the help of protractor.

Is the measured angle equal to ∠PON? Are the light ray A incident on O, reflected light ray A´ and normal at the point O in the same plane or not?

Try this experiment with different values for ∠PON say 35°, 40°, 45°. Measure ∠SON, and complete the table 12.1.

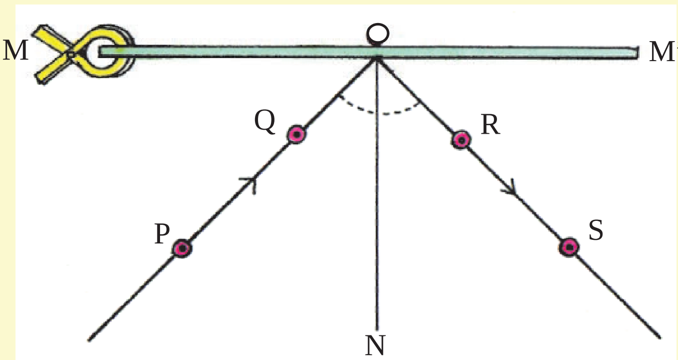



Fig.12.4 Verification of Laws of Reflection

Table - 12.1

| S.No. | Angle of Incidence | Angle of Reflection | Difference |
|---|---|---|---|
| 1. | 30° | 30° | 0° |
| 2. | 35° | --------------- | ------------ |
| 3. | 40° | --------------- | ------------ |
| 4. | 45° | --------------- | ------------ |

Think about the conclusions of activity-2, these are the laws of reflection.

## Laws of Reflection

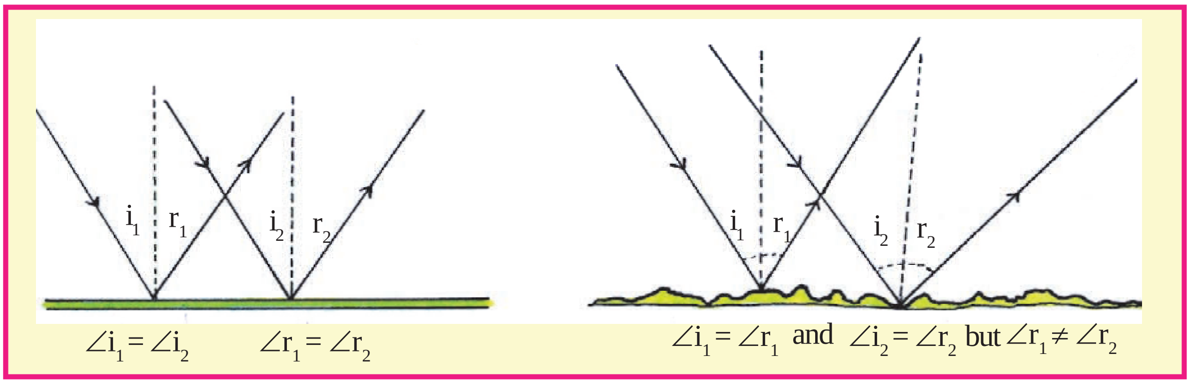
1. The incident ray, the normal at the point of incidence and the reflected rays are in the same plane.
2. The angle of incidence and the angle of reflection are equal.

By using plane mirror, we can also see those objects, which are not in front of our eyes. Let us see how this is possible.

## 12.3 Regular and Diffused Reflection

When light rays fall on polished plane surface, they change their direction in a well defined manner i.e., reflected rays are also parallel and this phenomenon is known as regular reflection and the image thus formed is clear and sharp (fig. 12.5).

When parallel rays fall on an unpolished or uneven surfaces, they too get reflected but the reflected rays are not parallel i.e., are not in a well defined direction. They scatter in all directions. This is called diffused reflection or scattered reflection and gives rise to deformed and unclear image. (fig.12.6).




(a) Regular Reflection
Fig. 12.5

(b) Diffused Reflection
Fig. 12.6

## 12.4 Image Formed by Plane Mirrors

We see our image in the plane mirror everyday. Have you ever thought how and where these images are formed! In figure 12.7, an object A is placed in front of the plane mirror. Rays AN and AN' coming from object A get reflected by the plane mirror in NR and N´R´ directions.

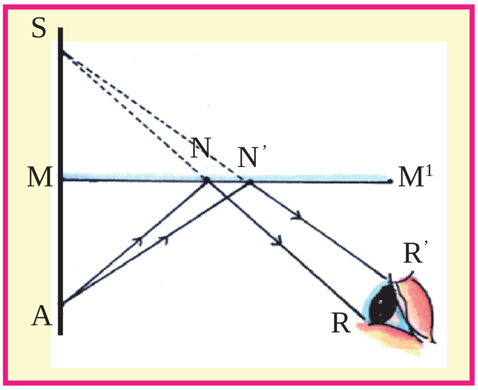



Fig.12.7

When reflected rays enter our eyes, it seems that they are coming from a point S behind the mirror. Thus appears to be the S is the image of object A. Since the light rays are not actually coming from point S but only appear to be coming from S therefore, S is called the virtual image. Virtual image cannot be obtained on the screen because in reality no light rays meet at that place, while real image can be obtained on the screen because it really has light rays converging at that place.

Now it is clear that -

1. Size of the image will be the same as that of the object.
2. The image is formed as far behind the mirror as the object is placed in front of.

## 12.5 Lateral Inversion

Stand in front of a mirror; you will see your image. Raise your hand, which hand does your image raise? Image formed by the word 'KAMAL' is shown in fig.12.8. This is lateral inversion.

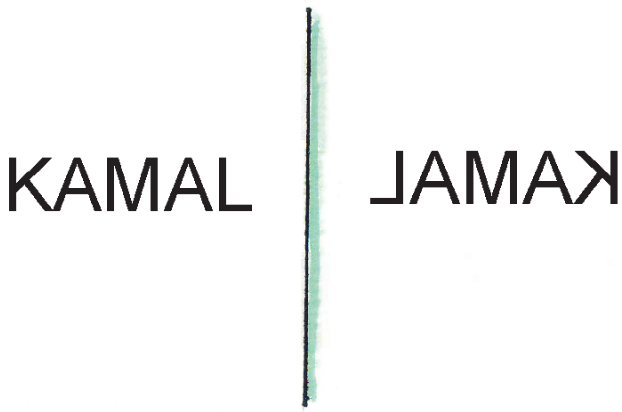



Fig-12.8 Lateral Inversion

In lateral inversion, the left side of the object appears on the right and the right side appears on the left as happens in the image seen in the plane mirror.

### Answer these

1. What is the difference between regular and diffused reflection?
2. Write down the laws of reflection.
3. What are the features of images formed by the plane mirror?

## 12.6 Spherical Mirrors

Try to see your face in a large shining spoon. What do you observe? You will see your own image but bigger in size. If we reverse the side of the spoon then the image becomes smaller. Here the spoon works like a mirror with a curved surface. A spherical mirror is actually a part of a hollow glass sphere (fig 12.9). It has two surfaces or faces. The inner face is called concave and outer face is called the convex.

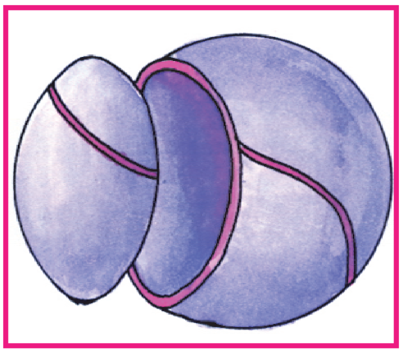
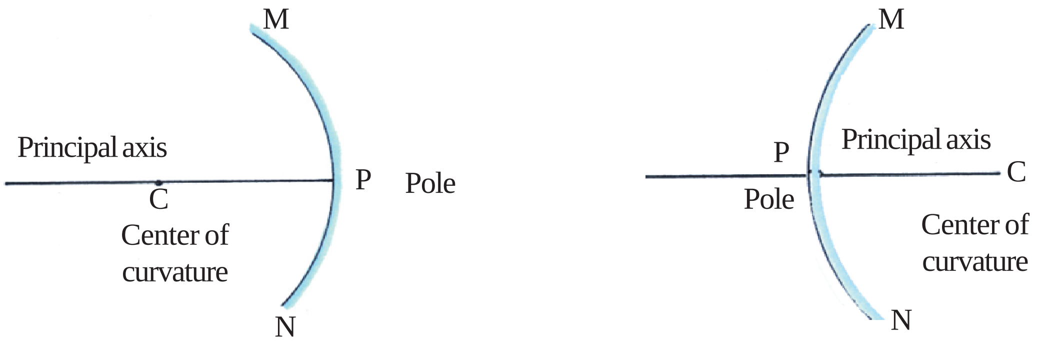


Fig.12.9 Convex Mirror

If the inner side of the spherical mirror is silvered and reflecting then it is called a 'concave mirror' and if the outer side is silvered and reflecting then it is called a 'convex mirror'.

Fig 12.10 shows a concave mirror MN. The central point P is called the pole of the mirror. The centre of the sphere, of which the given spherical mirror is a part is called its centre of curvature, let us call it C. The centre of curvature of a concave mirror is in front of the mirror, whereas that of a convex mirror is behind the mirror. The straight line joining the points C and P is called the principal axis of the mirror.




(a) Concave Mirror (b) Convex Mirror

Fig12.10

## Activity - 3

Take a concave mirror and point it towards the sun. The mirror will reflect the sunlight. Try to direct the light reflected by the mirror on a sheet of paper. Move the sheet of paper until you find that the reflected light appears as a bright point on it. Adjust the distance on the paper so that the point is sharpest. If you hold the mirror and the sheet steady for a few minutes the paper would begin to burn. This bright point is infact the image of the sun on the sheet of paper, this point is called as the focus of the mirror (fig 12.11). This image is real since it is formed on the screen (paper).

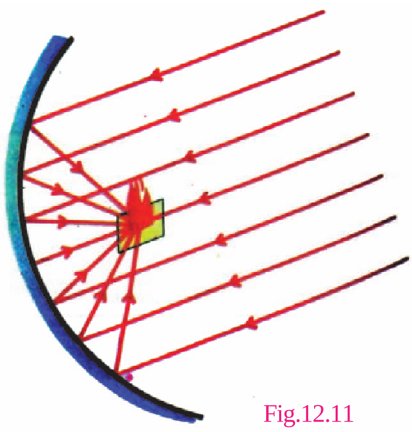


Fig.12.11

### 12.6.1 Laws of image formation from spherical mirror

Following laws are used to find the position of the image formed by the spherical mirror-

**Law 1** :- Any ray parallel to the principal axis, after reflection passes through the focus (fig. 12.12)

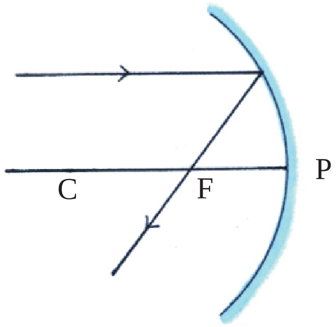



Fig. 12.12

**Law 2.**: Any ray passing through the focus becomes parallel to the principal axis after reflection (fig. 12.13).

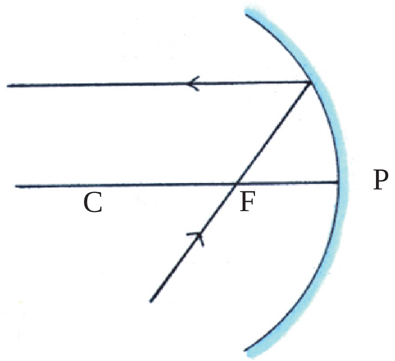



Fig 12.13

**Law 3.**: Any ray passing through the centre of the curvature is reflected back along the same path (fig. 12.13).

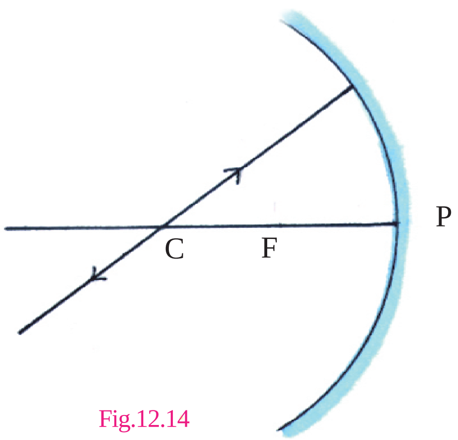



Fig.12.14

## Activity - 4

**Materials required :-** Concave mirror, object (say candle), gum, two wooden blocks, white paper, matchbox, four pins.

Fix the concave mirror on a wooden block with the help of two pins as shown in fig.12.15. Paste a white paper on the other wooden block, so that it works like a screen. Keep a lighted candle on the block with white paper as shown in figure 12.15. Move the blocks carrying the mirror and candle forward and backward in such a way that the image of the candle is adjusted at the brightest. This image is inverted and is of the size of candle (object). In this position, the candle and its image are at the centre of curvature of the mirror. Measure its distance from the mirror; this distance is equal to the radius of curvature. Focal distance is half of the radius of the curvature. Now you also know the focal length.

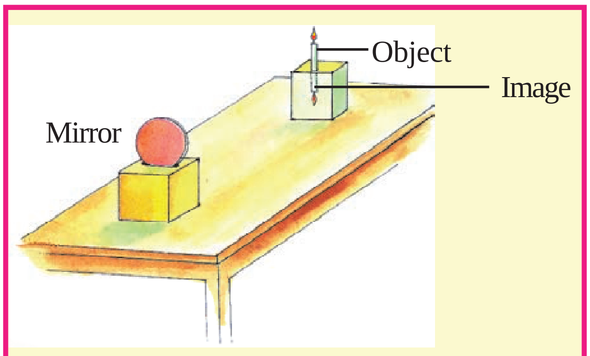


Fig.12.15

### 12.6.2 Image Formed By a Concave Mirror

#### Activity - 5

**Materials required :-** Concave Mirror, Clip, Object (candle), gum, wooden block, white paper, match box.

In the above experiment, put the candle on a block in front of the mirror and on the other block make a screen of the wooden box wrapped in white paper. Put the object in front of the mirror in different positions, move the screen in front of the mirror in such a way that the image formed by the mirror is on the screen. Write in the table: - the position, nature and size of the images of the object formed in different positions. And check these with the following figures (12.16 a, b, and c, d).

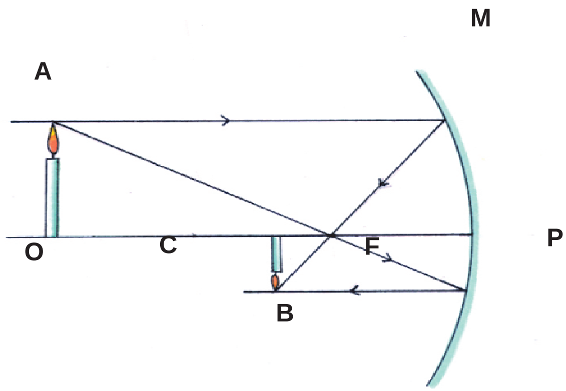


Fig.12.16 (a)

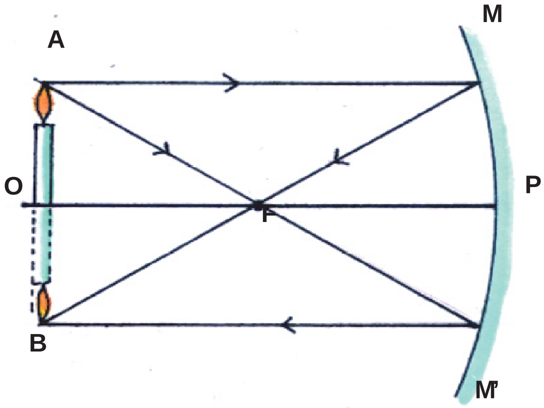



Fig.12.16 (b)

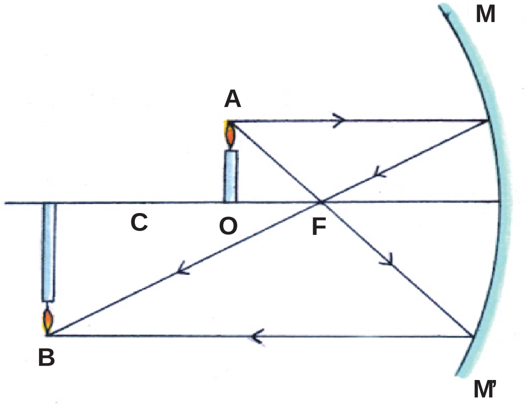



Fig.12.16 (c)

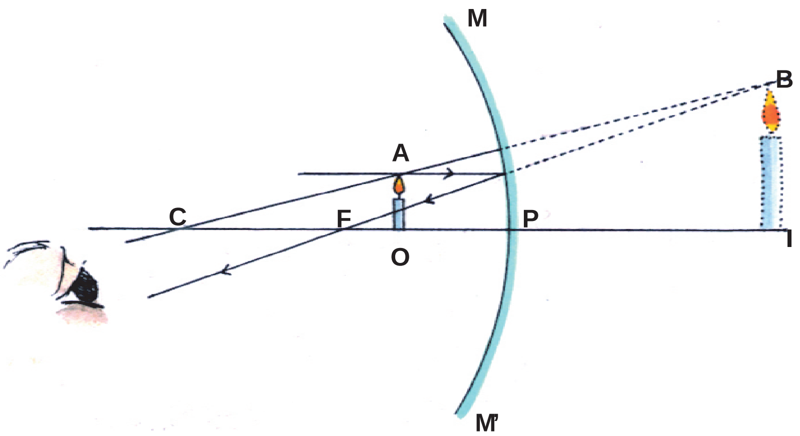



Fig.12.16 (d)

Table - 12.2

| S.No | Position of The Object | Position Of the Image | Nature Of the Image | Size of the Image |
|---|---|---|---|---|
| 1. | Away from C (Fig 12.16a) | ---------- | ----------- | ----------- |
| 2. | At C (Fig 12.16b) | At C | Real and Inverted | Equal to the object |
| 3. | In between C & F (Fig 12.16c) | --------- | ---------- | --------- |
| 4. | In between F & P (Fig 12.16d) | Formed behind the mirror & can not be obtained on the screen. Therefore see it in the mirror | Virtual | Magnified |

### 12.6.3. Image formed by the Convex Mirror

Convex mirrors always form an image that is smaller, upright and virtual (fig. 12.17).

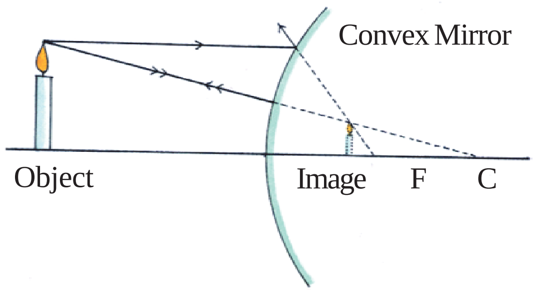



Fig. 12.17

### 12.6.4. Use of Spherical Mirrors

Although a convex mirror forms a smaller image than the object, it forms image of a larger area. That is why convex mirrors are used in cycles and automobiles to enable the driver to see the vehicles behind them. Concave mirrors are used in torches and search lights to throw the light to a long distance. They are also used by dentists to diagnose by looking at the enlarged image of the teeth.

### 12.7 Images formed by lenses

You might have seen a magnifying glass. It is used to read very small print. (fig.12.18). You might have also used it to observe the body parts of a cockroach or an earthworm.

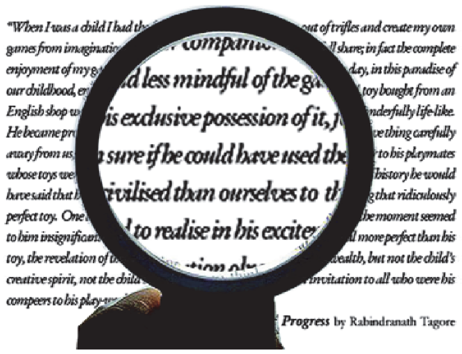



**Fig. 12.18 Magnifying glass**

Lenses are widely used in spectacles, telescopes and microscopes. A transparent medium covered by two surfaces is called a lens. Those lenses which feel thicker in the middle than at the edges are convex lenses (fig 12.19 a) and those which feel thinner in the middle than at the edges are concave lenses (fig. 12.19 b). Lenses are transparent and light can pass through them. Generally a convex lens converges (bends inward) the light falling on it. Therefore, it is called a converging lens. On the other hand, a concave lens diverges (bends outward) the light and is called a diverging lens.

**Fig. 12.19 (a) Convex lens** **(b) Concave lens**

We have seen in the case of mirrors that for different positions of the object the nature and size of the image change. Is it true for lenses also?

## Activity - 6

**Materials required: -** A Convex lens, stand, candle, paper and match box.

Take a convex lens and fix it on a stand. Place it on a table. Place a lighted candle at a distance of about 50 cm from the lens.(fig.12.20). Try to obtain the image of the candle on a paper screen placed on the other side of the lens. You may have to move the screen towords or away from the lens to get a sharp image of the flame. What kind of image did you get? It is real or virtual?

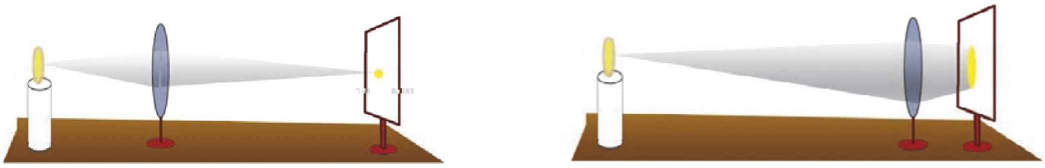


**Fig. 12.20 Image formed by a convex lens for the candle flame placed at different distance from it.**

Now vary the distance of the candle from the lens. Try to obtain the image of the candle flame every time on the paper screen by moving it. Record your observation and tabulate it. Did you get in any position of the object an image which was erect and magnified? Could this image be obtained on a screen? Is the image real or virtual? In a similar manner study the images formed by a concave lens. You will find that the image formed by a concave lens is always virtual, erect and smaller in size than the object.

### 12.8 Sunlight-White or Coloured?

Have you ever seen a rainbow in the sky? You might have noticed that is appears usually after the rain, when the sun is low in the sky. The rainbow is seen as a large arc in the sky with many colours (fig.12.21).

**Fig. 12.21 A Rainbow**

Generally there are seven colours in a rainbow. They are- violet,indigo,blue, green, yellow, orange, red. You might have also seen that when you blow soap bubbles they appear colourful. Similarly, when light is reflected from the surface of a compact disk (CD), we may see many colours. On the basis of these experiences, we could say that sunlight is a mixture of different colours.

## Answer these

1. What do you understand by the centre of curvature?
2. Draw a labelled diagram showing the path of the ray reflected from a concave mirror when the incident ray is parallel to the principal axes.
3. State two uses of concave mirrors.
4. Which type of lens always forms a virtual image?

## We have learnt

- When a light ray falls on a polished surface, they change their direction in a well defined manner. This is called reflection of light.
- There are two laws of reflection :-
  - (i) The incident ray, the normal at the point of incidence and the reflected rays are in the same plane,
  - (ii) The angle of incidence and the angle of reflection are equal.
- In a plane mirror, the reflected rays appear to come from some object kept behind the mirror. This is called a virtual image of the object.
- Spherical mirrors are of two types: concave and convex.
- The centre of the sphere of which the spherical mirror is a part, is called the centre of curvature of the mirror.
- The point through which the incident rays parallel to the principal axis, pass through or appear to pass through after reflection from the mirror, is called focus of the spherical mirror.
- When the reflected rays actually meet in front of the mirror, they form a real image. A real image can be obtained on a screen.
- Any incident ray that is parallel to the principal axis, after reflection passes through or appears to pass through the focus.

- Any ray passing through the focus or appearing to pass through the focus becomes parallel to the principal axis after reflection.
- Any ray passing through or appearing to pass through the centre of curvature of a concave mirror is reflected back along the same path.
- Convex mirror always forms a smaller and virtual image.
- Image formed by a convex lens can be real or virtual.
- A concave lens always forms erect, virtual and smaller image than the object.
- White light is composed of seven colours.

## Questions for practice

**1. Choose the correct answer-**

**1. Angle of reflection is the -**

(i) angle between the incident ray and the normal drawn on the surface of mirror

(ii) angle between the reflected ray and the normal drawn on the surface of mirror

(iii) angle between the reflected ray and surface of the mirror

(iv) angle between the incident ray and surface of the mirror

**2. Angle of incidence for plane mirror is-**

(i) equal to the angle of reflection

(ii) less than the angle of reflection

(iii) more than the angle of reflection

(iv) none of these

**3. Nature of the image formed by the plane mirror-**

(i) virtual and straight

(ii) equal to the object

(iii) image formed by lateral inversion

(iv) none of these

**4. Focal distance of the spherical mirror is-**

(i) equal to the radius of curvature

(ii) half of the radius of curvature

(iii) one-fourth of the radius of curvature

(iv) none of these

**5. When you drive your vehicle, then to see the objects behind us we use-**

(i) concave mirror

(ii) spherical mirror

(iii) convex mirror

(iv) none of these

**(2) Match the following:-**

| | |
|---|---|
| Regular reflection | Inverted object |
| Diffused reflection | Straight image |
| Real image | Shining surface |
| Virtual image | Image of same size |
| Plane mirror | Rough surface |

**(3) Answer the following questions**

1. What do you understand by lateral inversion?
2. What is reflection?
3. How will you find the centre of curvature of a concave mirror?
4. Write two uses of a convex mirror.
5. Focal distance of a concave mirror is 20 cm. Find its radius of curvature.
6. Find the nature, position and size of the images formed by a concave mirror, when-

   (i) object is at the centre of curvature

   (ii) object is in between the focus and the centre of curvature
7. Which mirror will you use if you want of see a magnified image of an object ?
8. You have a concave mirror with 20 cm of radius of curvature. To find a real and equal image of an object, where will you place it.
9. Write two differences between convex and concave lens.

## Do these also

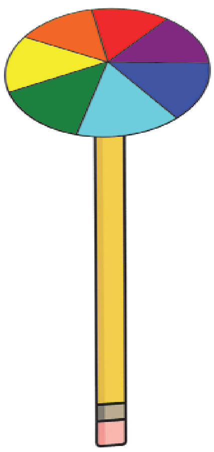
**1. Make your kaleidoscope**

Take three identical plane mirror strips. Join them with rubber bands to make a triangular tube. Remember that the silvered surface of the mirrors should be facing inward. Cover the mouth of the tube with a translucent piece of paper. Tie the paper to the tube with a rubber band. Put a few pieces of coloured glasses (like broken bangles) inside the tube. Lift the tube up so that light can enter it from below. Look inside through the open mouth. What do you see? Can you say why this happens? Shake the Kaleidescope and look again. You can see many beautiful shapes in it.

**2. Newton's colour disc :-**

**Materials required -** Piece of cardboard, paints of seven colours, pencil.

Take a circular cardboard disc of about 10 cm diameter. Divide this disc into seven segments. Paint the seven rainbow colours on these segments as shown in fig.12.22 a. You can also paste, coloured papers on these segments. Make a small hole at the centre of the disc. Fix the disc loosely on the tip of a refill of a ball pen. Ensure that the disc rotates freely. Rotate the disc in the daylight. When the disc is rotated fast, the colours get mixed together and the disc appears to be whitish (Fig.12.22 (b)). Such a disc is popularly known as Newton's disc. This can also be made by fixing a marble on a C.D. This activity also concludes that white light is made up of different colours.



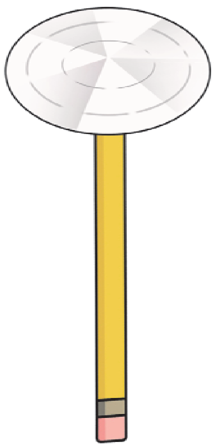


Fig 12.22 (a) A disc with seven colours. Fig 12.22 (b) It appears white on rotating.