

# 15

## Light

**Y**ou might have seen a beam of sunlight when it enters a room through a narrow opening or a hole. You may have also seen beams of light from the headlamps of scooters, cars and engines of trains [Fig. 15.1 (a)]. Similarly, a beam of light can be seen from a torch. Some of



(a) Rail engine



(b) Light house

**Fig. 15.1** Beams of light

you may have seen a beam of searchlight from a light house or from an airport tower [Fig. 15.1 (b)].

What do these experiences suggest?

### 15.1 LIGHT TRAVELS ALONG A STRAIGHT LINE

Boojho recalls an activity he performed in Class VI. In that activity he looked



**Fig. 15.2** Looking at a candle through a straight and a bent pipe



**Fig. 15.3** Reflection of objects in water

at a lighted candle first through a straight pipe and then through a bent pipe (Fig. 15.2). Why was Boojho not able to see the candle flame through a bent pipe?

This activity showed that light travels along straight lines.

How can we change the path of light? Do you know, what happens when light falls on a polished or a shiny surface?

## 15.2 REFLECTION OF LIGHT

One way to change the direction of light is to let it fall on a shiny surface. For example, a shining stainless steel plate or a shining steel spoon can change the direction of light. The surface of water can also act like a mirror and change the path of light. Have you ever seen the reflection of trees or buildings in water (Fig. 15.3)?

Any polished or a shiny surface can act as a mirror. What happens when light falls on a mirror?

You have learnt in Class VI that a mirror changes the direction of light that falls on it. This change of direction by a mirror is called **reflection of light**. Can you recall the activity in which you got the light of a torch reflected from a mirror? Let us perform a similar activity.

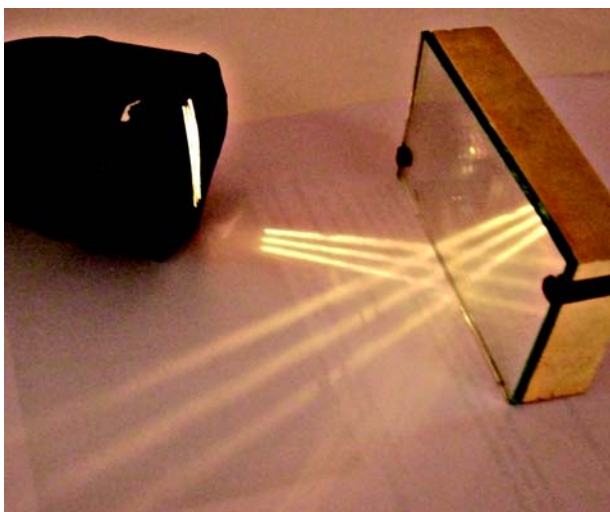
### Activity 15.1

Take a torch. Cover its glass with a chart paper which has three slits as shown in Fig. 15.5. Spread a sheet of chart paper

Paheli remembers the story of the lion and the rabbit from the *Panchtantra*, in which the rabbit fooled the lion by showing him his reflection in water (Fig. 15.4).



**Fig. 15.4** Reflection of the lion in water



**Fig. 15.5** Reflection of light from a mirror

on a smooth wooden board. Fix a plane mirror strip vertically on the chart paper (Fig. 15.5). Now direct the beam of light on the mirror from the torch with slits. Place the torch in such a way that its light is seen along the chart paper on the board. Now adjust its position so that the light from the torch strikes the plane mirror at an angle (Fig. 15.5).

Does the mirror change the direction of light that falls on it? Now move the torch slightly to either side. Do you find any change in the direction of reflected light?

Look into the mirror along the direction of the reflected light. Do you



Paheli wants to know, what makes things visible to us? Boojho thinks that objects are visible only when light reflected from them reaches our eyes. Do you agree with him?

see the slits in the mirror? This is the image of the slits.

This activity shows how light gets reflected from a plane mirror.

Let us play around with the images formed in mirrors and know a little more about them.

## Activity 15.2

### CAUTION

Handle the lighted candle with care. It is better if this activity is performed in the presence of a teacher or an elder person.

Place a lighted candle in front of a plane mirror. Try to see the flame of the candle in the mirror. It appears as if a similar candle is placed behind the mirror. The candle, which appears behind the mirror, is the **image** of the candle formed by the mirror (Fig. 15.6). The candle itself is the **object**.

Now move the candle to different positions in front of the mirror. Observe the image in each case.



**Fig. 15.6** Image of a candle in a plane mirror





Boojho noted in his notebook: Is it not surprising that my image is of the same size as me whether the mirror is small or large?

Was the image upright in each case? Did the flame appear on top of the candle as in the object? Such an image is called **erect**. An image formed by a plane mirror is erect and of the same size as the object.

Now place a vertical screen behind the mirror. Try to obtain the image of the candle on this screen. Can you get the image on the screen? Now place the screen in front of the mirror. Can you get the image on the screen now? You will find that the image of the candle

cannot be obtained on the screen in either case.

What about the distance of the image from mirror? Let us perform another activity.

### Activity 15.3

Take a chess board. If a chess board is not available, draw on a chart paper 64 (8 8) squares of equal size. Draw a thick line in the middle of the paper. Fix a plane mirror vertically on this line. Place any small object, such as a pencil sharpener, at the boundary of the third square counting from the mirror (Fig. 15.7). Note the position of the image. Now shift the object to the boundary of the fourth square. Again note the position of the image. Did you find any relation between the distance of the image from the mirror and that of the object in front of it?



**Fig. 15.7** Locating image in a plane mirror



Paheli made a note in her notebook: In a plane mirror the image is formed behind the mirror. It is erect, of the same size and is at the same distance from the mirror as the object is in front of it.

You will find that the image is at the same distance behind the mirror as the object is in front of it. Now verify this by placing the object anywhere on the chart paper.

### 15.3 RIGHT OR LEFT!

When you see your image in a plane mirror, is it exactly like you? Have you ever noticed that there is one interesting difference between you and your image in a mirror? Let us find out.

#### Activity 15.4

Stand in front of a plane mirror and look at your image. Raise your left hand. Which hand does your image raise (Fig. 15.8)? Now touch your right ear. Which ear does your hand touch in your image? Observe carefully. You will find that in the mirror the 'right' appears 'left' and the 'left' appears 'right'. Note that only sides are interchanged; the image does not appear upside down.

Now write down your name on a piece of paper and hold it in front of a plane



**Fig. 15.8** Left hand appears on the right side in the image



**Fig. 15.9** An ambulance

mirror. How does it appear in the mirror?



Boojho saw an ambulance on the road. He was surprised to see that the word 'AMBULANCE' in front was written in a strange manner.

Can you now understand why the word 'AMBULANCE' is written as in Fig. 15.9? When the driver of a vehicle ahead of an ambulance looks in her/his rear view mirror, she/he can read 'AMBULANCE' written on it and give way to it. It is the duty of every one of us to allow an ambulance to pass without blocking its way.

You might have observed that in the side mirror of a scooter or a car the images of all the objects appear smaller than the objects themselves. Have you ever wondered why it is so?

## 15.4 PLAYING WITH SPHERICAL MIRRORS

Paheli and Boojho were waiting for their dinner. Boojho lifted a stainless steel plate and saw his image in it. Oh! This plate acts as a plane mirror. My image is erect and is of the same size. Paheli saw her image using the back of a steel spoon. iBoojho look here! I can also see my erect image though it is smaller in size. This spoon also acts as a mirror of some kind, said Paheli.

You can also use a spoon or any curved shining surface to see your image.

### Activity 15.5

Take a stainless steel spoon. Bring the outer side of the spoon near your face and look into it. Do you see your image in it (Fig. 15.10)? Is this image different from what you see in a plane mirror? Is this image erect? Is the size of the image the same, smaller or larger?



**Fig. 15.10** Image from the outer side of a spoon

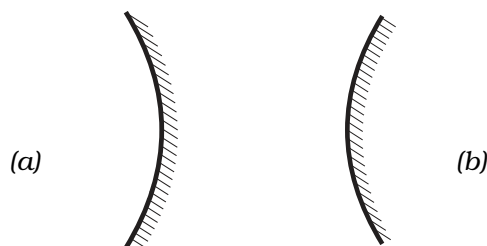
Now look at your image using the inner side of the spoon. This time you may find that your image is erect and larger in size. If you increase the distance of the spoon from your face, you may see your image inverted (Fig. 15.11). You can also compare the image of your pen or pencil instead of your face.



**Fig. 15.11** Image from the inner side of a spoon

The curved shining surface of a spoon acts as a mirror. The most common example of a curved mirror is a spherical mirror.

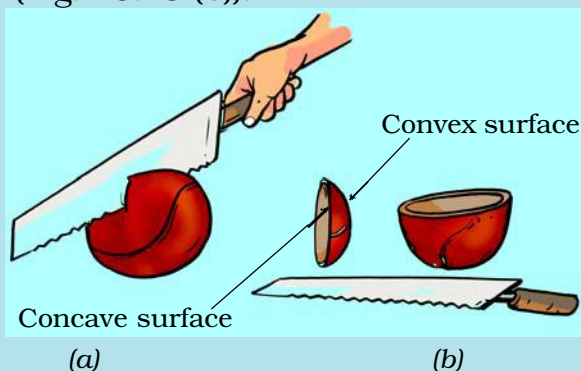
If the reflecting surface of a spherical mirror is concave, it is called a concave mirror. If the reflecting surface is convex, then it is a convex mirror (Fig. 15.12).



**Fig. 15.12** A concave and a convex mirror

Why are concave and convex mirrors called spherical mirrors?

Take a rubber ball and cut a portion of it with a knife or a hack-saw blade [Fig. 15.13 (a)]. **(Be careful. Ask an elder person to help you in cutting the ball).** The inner surface of the cut ball is called concave and the outer surface is called convex (Fig. 15.13 (b)).



**Fig. 15.13** A spherical mirror is a part of a sphere

The inner surface of a spoon acts like a concave mirror, while its outer surface acts like a convex mirror.

We know that the image of an object formed by a plane mirror cannot be obtained on a screen. Let us investigate if it is also true for the image formed by a concave mirror.

### Activity 15.6

#### CAUTION

You will conduct Activity 15.6 in the sunlight. Be careful, never look directly towards the sun or its image as it may damage your eyes. You may look at the image of the sun when it is thrown on a screen or a wall.



**Fig. 15.14** A concave mirror forms a real image of the sun

Take a concave mirror. Hold it facing the sun. Try to get the light reflected by the mirror on a sheet of paper. Adjust the distance of the paper until you get a sharp bright spot on it (Fig. 15.14). Hold the mirror and the sheet of paper steady for a few minutes. Does the paper start burning?

This bright spot is, in fact, the image of the sun. Notice that this image is formed on a screen. An image formed on a screen is called a **real image**. Recollect that in Activity 15.2 the image formed by a plane mirror could not be obtained on a screen. Such an image is called a **virtual image**.

Now let us try to obtain on the screen the image of a candle flame formed by a concave mirror.

### Activity 15.7

Fix a concave mirror on a stand (any arrangement to keep the mirror steady would do) and place it on a table (Fig. 15.15). Paste a piece of white paper on a cardboard sheet (say about





**Fig. 15.15** Real images formed by a concave mirror

15cm 10cm). This will act as a screen. Keep a lighted candle on the table at a distance of about 50 cm from the mirror. Try to obtain the image of the flame on the screen. For this, move the screen till a sharp image of the flame is obtained. Make sure that, the screen does not

obstruct the light from the candle falling on the mirror. Is this image real or virtual? Is it of the same size as the flame?

Now move the candle towards the mirror and place it at different distances from it. In each case try to obtain the image on the screen. Record your observation in Table 15.1. Is it possible to obtain the image on the screen when the candle is too close to the mirror (Fig. 15.16)?

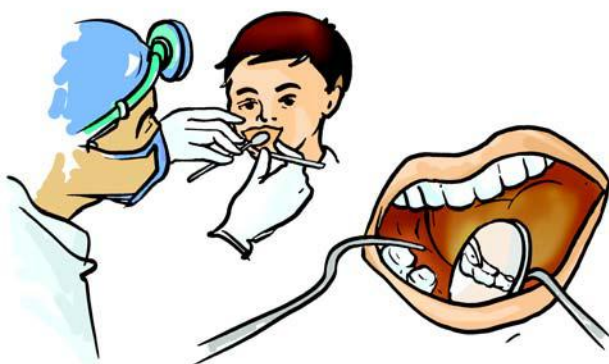
We see that the image formed by a concave mirror can be smaller or larger in size than the object. The image may also be real or virtual.

Concave mirrors are used for many purposes. You might have seen doctors using concave mirrors for examining eyes, ears, nose and throat. Concave mirrors are also used by dentists to see an enlarged image of the teeth (Fig. 15.17). The reflectors of torches, headlights of cars and scooters are concave in shape (Fig. 15.18).



**Fig. 15.16** Virtual image formed by a concave mirror





**Fig. 15.17** A dentist examining a patient

Boojho observed his image in the shiny surface of the bell on his new bicycle. He found that his image was erect and smaller in size. He wondered



**Fig. 15.18** Reflector of a torch

if the bell is also a kind of spherical mirror. Can you recognise the type of the mirror?

Note that the reflecting surface of the bell is convex.

### Activity 15.8

Repeat Activity 15.7 now with a convex mirror in place of a concave mirror (Fig. 15.19). Record your observations in a Table similar to Table 15.1.

Could you get a real image at any distance of the object from the convex



**Fig. 15.19** Image formed by a convex mirror

**Table 15.1 Image formed by a concave mirror for object placed at different distances from it**

| Distance of the object from the mirror | Smaller/larger than the object | Character of the image |              |
|--|--------------------------------|------------------------|--------------|
|  |                                | Inverted/ erect        | Real/virtual |
| 50 cm                                  |                                | Ö                      | Ö            |
| 40 cm                                  |                                | Ö                      | Ö            |
| 30 cm                                  |                                |                        |              |
| 20 cm                                  |                                |                        |              |
| 10 cm                                  |                                | Ö                      |              |
| 5 cm                                   |                                |                        |              |



**Fig. 15.20** Convex mirror as side view mirror

mirror? Did you get an image larger in size than the object?

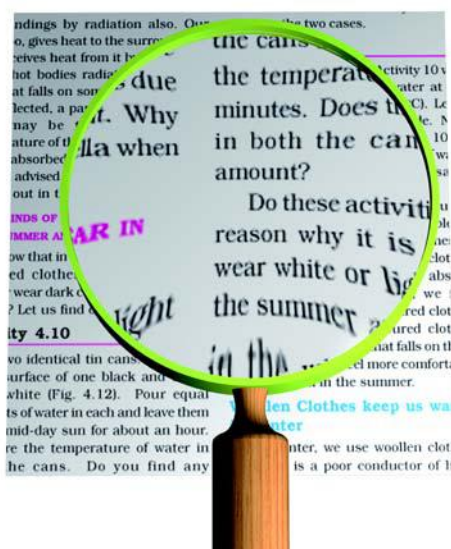
Can you now recognise the mirrors used as side mirrors in scooters? These are convex mirrors. Convex mirrors can form images of objects spread over a large area. So, these help the drivers to see the traffic behind them (Fig. 15.20).

### 15.5 IMAGES FORMED BY LENSES

You might have seen a magnifying glass. It is used to read very small print (Fig. 15.21). You might have also used it to observe the body parts of a cockroach or an earthworm. The magnifying glass is actually a type of a lens.

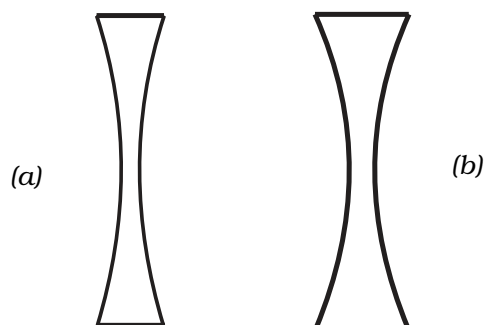
Lenses are widely used in spectacles, telescopes and microscopes. Try to add a few more uses of lenses to this list.

Get some lenses. Touch and feel them. Can you find some difference just by touching? Those lenses which feel thicker in the middle than at the edges are convex lenses [Fig. 15.22 (a)]. Those



**Fig. 15.21** A magnifying glass

which feel thinner in the middle than at the edges are concave lenses [Fig. 15.22 (b)]. Notice that the lenses are transparent and light can pass through them.



**Fig. 15.22** (a) A convex lens and (b) a concave lens

Let us play with lenses.

#### CAUTION

It is dangerous to look through a lens at the sun or a bright light. You should also be careful not to focus sunlight with a convex lens on any part of your body.

### Activity 15.9

Take a convex lens or magnifying glass. Put it in the path of sunrays. Place a sheet of paper as shown (Fig. 15.23). Adjust the distance between the lens and the paper till you get a bright spot on the paper. Hold the lens and the paper in this position for a few minutes. Does the paper begin to burn?

Now replace the convex lens with a concave lens. Do you see a bright spot



**Fig. 15.23** Real image of the sun by a convex lens

on the paper this time, too? Why are you not getting a bright spot this time?

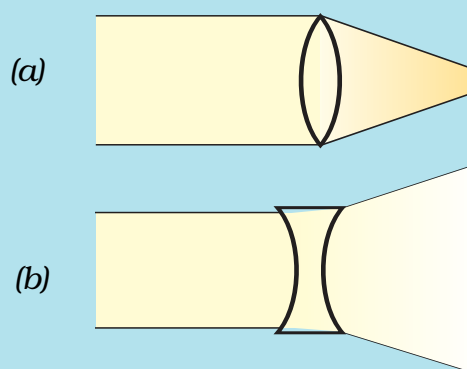
We have seen in the case of mirrors that for different positions of the object the nature and size of the image change. Is it true for lenses also?

Let us find out.

### Activity 15.10

Take a convex lens and fix it on a stand as you did with the concave mirror. Place it on a table. Place a lighted candle at a distance of about 50 cm from the lens [Fig. 15.25 (a)]. Try to obtain the image

A convex lens converges (bends inward) the light generally falling on it [Fig. 15.24 (a)]. 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. 15.24 (b)].



**Fig. 15.24**

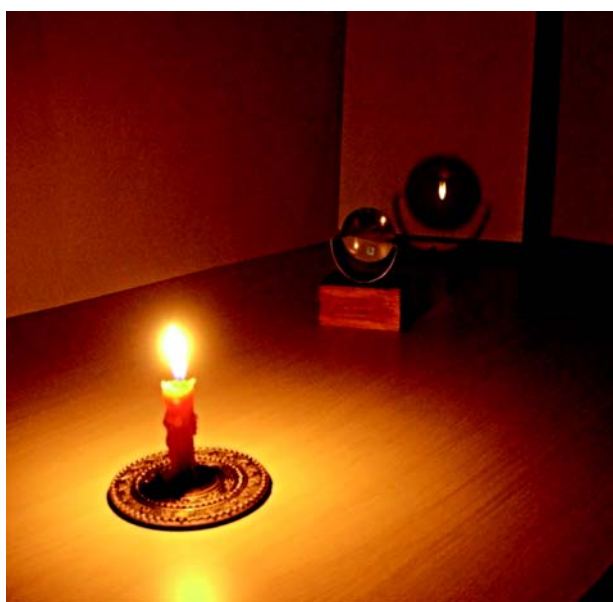
of the candle on a paper screen placed on the other side of the lens. You may have to move the screen towards or away from the lens to get a sharp image of the flame. What kind of image did you get? Is it real or virtual?

Now vary the distance of the candle from the lens [Fig. 15.25 (b)]. Try to obtain the image of the candle flame every time on the paper screen by moving it. Record your observations as you did in Activity 15.7 for the concave mirror.



It means that we can see the image formed by a lens from the side opposite to that of the object.





(a)



(b)

**Fig. 15.25** Image by a convex lens for object placed at different distance from it



**Fig. 15.26** Virtual image formed by the convex lens



**Fig. 15.27** Image formed by a concave lens

Did you get in any position of the object an image which was erect and magnified (Fig. 15.26). Could this image be obtained on a screen? Is the image real or virtual? This is how a convex lens is used as a magnifying glass.

In a similar fashion 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 (Fig. 15.27).

## 15.6 SUNLIGHT — WHITE OR COLOURED?

Have you ever seen a rainbow in the sky? You might have noticed that it appears usually after the rain when the sun is low in the sky. The rainbow is



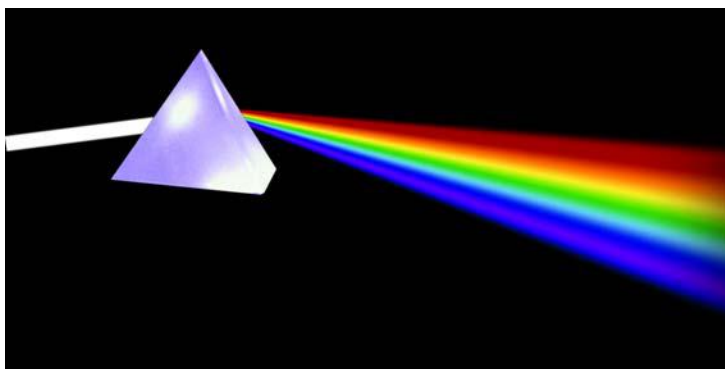
**Fig. 15.28** A rainbow

seen as a large arc in the sky with many colours (Fig. 15.28).

How many colours are present in a rainbow? When observed carefully, there are seven colours in a rainbow, though it may not be easy to distinguish all of them. These are red, orange, yellow, green, blue, indigo and violet.



Does this mean that the white light consists of seven colours?



**Fig. 15.30** A prism splits sunlight into seven colours



**Fig. 15.29** A CD placed in sun

You might have seen that when you blow soap bubbles, they appear colourful. Similarly, when light is reflected from the surface of a Compact Disk (CD), you see many colours (Fig. 15.29).

On the basis of these experiences, could we say that the sunlight is a mixture of different colours? Let us investigate.

### Activity 15.11

Take a glass prism. Allow a narrow beam of sunlight through a small hole in the window of a dark room to fall on one face of the prism. Let the light coming out of the other face of the prism fall on



Paheli wants to tell you that you can see a rainbow only when your back is towards the sun.

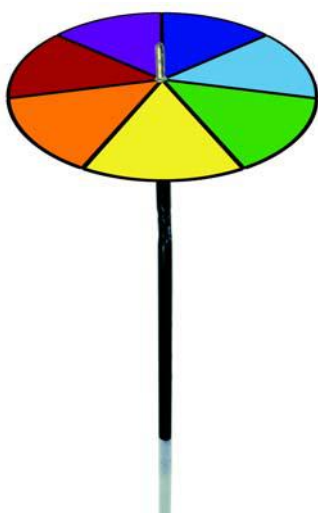
a white sheet of paper or on a white wall. What do you observe? Do you see colours similar to those in a rainbow (Fig. 15.30)? This shows that the sunlight consists of seven colours. The sunlight is said to be white light. This means that the white light consists of seven colours. Try to identify these colours and write their names in your notebook.

Can we mix these colours to get white light? Let us try.

### Activity 15.12

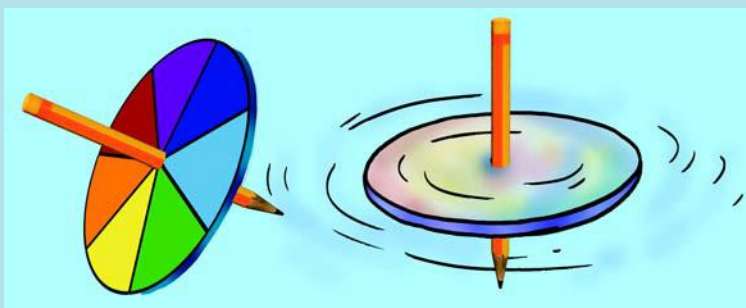
Take a circular cardboard disc of about 10 cm diameter. Divide this disc into

seven segments. Paint the seven rainbow colours on these segments as shown in Fig. 15.31 (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 [Fig. 15.31 (a)]. 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. 15.31 (b)]. Such a disc is popularly known as Newton's disc.



**Fig. 15.31** (a) A disc with seven colours (b) It appears white on rotating

Paheli has a brilliant idea! She has prepared a small top with a small circular disc with seven rainbow colours painted on it (Fig. 15.32). When the top rotates it appears nearly white.



**Fig. 15.32** A top with seven colours



## Keywords

Concave lens

Concave mirror

Convex lens

Convex mirror

Erect image

Magnified image

Magnifying glass

Prism

Rainbow

Real image

Rear view mirror

Side mirror

Spherical mirror

Virtual image

## What you have learnt

- Light travels along straight lines.
- Any polished or a shining surface acts as a mirror.
- An image which can be obtained on a screen is called a real image.
- An image which cannot be obtained on a screen is called a virtual image.
- The image formed by a plane mirror is erect. It is virtual and is of the same size as the object. The image is at the same distance behind the mirror as the object is in front of it.
- In an image formed by a mirror, the left side of the object is seen on the right side in the image, and right side of the object appears to be on the left side in the image.
- A concave mirror can form a real and inverted image. When the object is placed very close to the mirror, the image formed is virtual, erect and magnified.
- Image formed by a convex mirror is erect, virtual and smaller in size than the object.
- A convex lens can form real and inverted image. When the object is placed very close to the lens, the image formed is virtual, erect and magnified. When used to see objects magnified, the convex lens is called a magnifying glass.
- A concave lens always forms erect, virtual and smaller image than the object.
- White light is composed of seven colours.

## Exercises

1. Fill in the blanks:

- (a) An image that cannot be obtained on a screen is called \_\_\_\_\_.
- (b) Image formed by a convex \_\_\_\_\_ is always virtual and smaller in size.
- (c) An image formed by a \_\_\_\_\_ mirror is always of the same size as that of the object.
- (d) An image which can be obtained on a screen is called a \_\_\_\_\_ image.
- (e) An image formed by a concave \_\_\_\_\_ cannot be obtained on a screen.

2. Mark 'T' if the statement is true and 'F' if it is false:

- (a) We can obtain an enlarged and erect image by a convex mirror. (T/F)
- (b) A concave lens always form a virtual image. (T/F)
- (c) We can obtain a real, enlarged and inverted image by a concave mirror. (T/F)
- (d) A real image cannot be obtained on a screen. (T/F)
- (e) A concave mirror always form a real image. (T/F)

3. Match the items given in Column I with one or more items of Column II.

| Column I             | Column II  |
|----------------------|--|
| (a) A plane mirror   | (i) Used as a magnifying glass.                              |
| (b) A convex mirror  | (ii) Can form image of objects spread over a large area.     |
| (c) A convex lens    | (iii) Used by dentists to see enlarged image of teeth.       |
| (d) A concave mirror | (iv) The image is always inverted and magnified.             |
| (e) A concave lens   | (v) The image is erect and of the same size as the object.   |
|                      | (vi) The image is erect and smaller in size than the object. |

4. State the characteristics of the image formed by a plane mirror.

5. Find out the letters of English alphabet or any other language known to you in which the image formed in a plane mirror appears exactly like the letter itself. Discuss your findings.

6. What is a virtual image? Give one situation where a virtual image is formed.
7. State two differences between a convex and a concave lens.
8. Give one use each of a concave and a convex mirror.
9. Which type of mirror can form a real image?
10. Which type of lens forms always a virtual image?

**Choose the correct option in questions 11–13**

11. A virtual image larger than the object can be produced by a
  - (i) concave lens
  - (ii) concave mirror
  - (iii) convex mirror
  - (iv) plane mirror
12. David is observing his image in a plane mirror. The distance between the mirror and his image is 4 m. If he moves 1 m towards the mirror, then the distance between David and his image will be
  - (i) 3 m
  - (ii) 5 m
  - (iii) 6 m
  - (iv) 8 m
13. The rear view mirror of a car is a plane mirror. A driver is reversing his car at a speed of 2 m/s. The driver sees in his rear view mirror the image of a truck parked behind his car. The speed at which the image of the truck appears to approach the driver will be
  - (i) 1 m/s
  - (ii) 2 m/s
  - (iii) 4 m/s
  - (iv) 8 m/s

**Extended Learning — Activities and Projects**

1. Play with a mirror

Write your name with a sketch pen on a thin sheet of paper, polythene or glass. Read your name on the sheet while standing in front of a plane mirror. Now look at your image in the mirror.

2. A burning candle in water

Take a shoe box, open on one side. Place a small lighted candle in it. Place a clear glass sheet (roughly 25 cm 25 cm) in front of this candle (Fig. 15.33). Try to locate the image of the candle behind



**Fig. 15.33** Candle burning in water



the glass sheet. Place a glass of water at its position. Ask your friends to look at the image of the candle through the sheet of glass. Ensure that candle is not visible to your friends. Your friends will be surprised to see the candle burning in water. Try to explain the reason.

3. Make a rainbow

Try to make your own rainbow. You can try this project in the morning or in the evening. Stand with your back towards the sun. Take a hosepipe or a water pipe used in the garden. Make a fine spray in front of you. You can see different colours of rainbow in the spray.

4. Visit a laughing gallery in some science centre or a science park or a village *mela*. You will find some large mirrors there. You can see your distorted and funny images in these mirrors. Try to find out the kind of mirrors used there.

5. Visit a nearby hospital. You can also visit the clinic of an ENT specialist, or a dentist. Request the doctor to show you the mirrors used for examining ear, nose, throat and teeth. Can you recognise the kind of mirror used in these instruments?

6. Role play

Here is a game that a group of children can play. One child will be chosen to act as object and another will act as the image of the object. The object and the image will sit opposite to each other. The object will make movements, such as raising a hand, touching an ear, etc. The image will have to make the correct movement following the movement of the object. The rest of the group will watch the movements of the image. If the image fails to make the correct movement, she/he will be retired. Another child will take her/his place and the game will continue. A scoring scheme can be introduced. The group that scores the maximum will be declared the winner.

**You can read more on the following website:**

[www.glenbrook.k12.il.us/gbssci/phys/mmedia/optics/ifpm.html](http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/optics/ifpm.html)

### Did you know?

The mirrors can be used as weapons. Archimedes, a Greek scientist, is said to have done just that more than two thousand years ago. When the Romans attacked Syracuse, a coastal city-state in Greece, Archimedes used mirrors arranged as shown in Fig. 15.34. The mirrors could be moved in any direction. They were positioned such that they reflected the sunlight on the Roman soldiers. The soldiers were dazzled by the sunlight. They did not know what was happening. They got confused and ran away. This was an example of triumph of ideas over military might.



**Fig. 15.34** Archimedes mirrors