09 Light

9.1 Formation of umbra and penumbra

Pay your attention to the Figure 9.1. It shows some instances where umbrae or shadows are formed.

Figure :- 9.1 ▲ Some instances where umbrae / shadows are formed

In our day-to-day life, umbrae or shadows can be seen frequently. How do umbrae or shadows form? Let us do the Activity 9.1 to investigate this.

Activity 9.1

You will need :- A candle, a white screen, a small ball

Method :-

- Place the lighted candle on a table, keep the ball infront of it and obtain the umbra of the ball on a screen or on a wall.

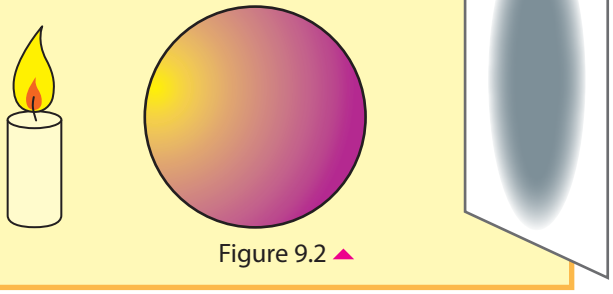


Figure 9.2 ▲

Here the shadow or the umbra of the ball can be clearly observed on the screen.

An umbra of the ball is formed on the screen, because the light emitted from the candle does not pass through the opaque ball.

Let us do Activity 9.2 to study about umbrae further.

Activity 9.2

You will need :- An electric torch, a white screen, a small ball, a translucent glass sheet, a cardboard sheet, a transparent glass

Method :-

- Place the lighted electric torch, the transparent glass sheet and the ball as shown in the Figure 9.3 and obtain the umbra of the ball on a screen or on a wall.
- Observe the nature of the umbra.
- Then replace the transparent glass sheet with the translucent glass sheet and observe the umbra formed.
- Finally replace the translucent glass sheet with the cardboard sheet and see whether an umbra of the ball can be obtained.

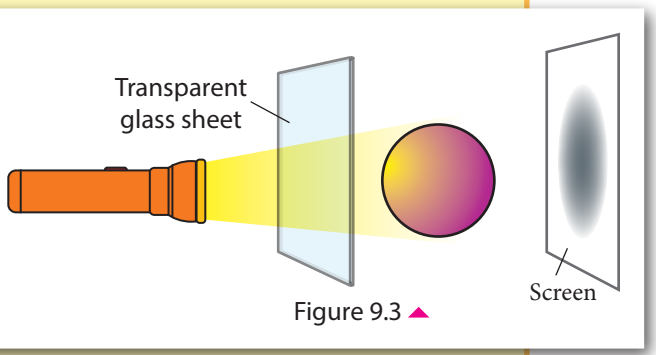


Figure 9.3

Compare your observations with those given below.

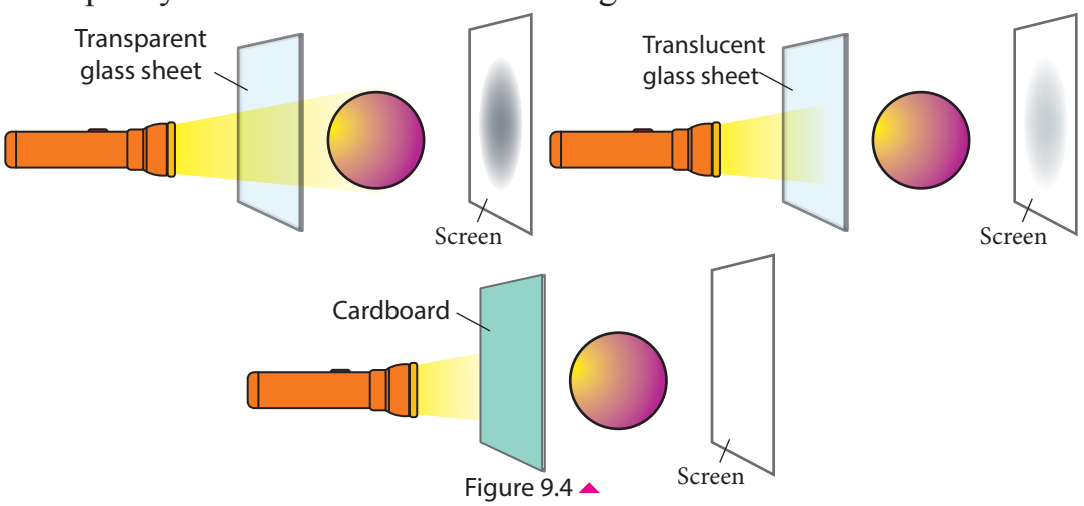


Figure 9.4

A sharp umbra is formed on the screen when transparent glass sheet is placed before the ball. A blurred umbra is formed when translucent glass sheet is placed.

No umbra is formed when cardboard sheet is placed, because light does not travel through a cardboard sheet.

The length and the direction of shadows differ due to the angle and the direction of sunlight falling on objects. In ancient times, the length of umbrae or shadows were used as arbitrary units to measure time.

e.g.:- Sun dial

Figure :- 9.5 ▲ Sun dial

Various artistic creations can be done with umbrae or shadows. Some such creations done with hand and fingers are shown below.

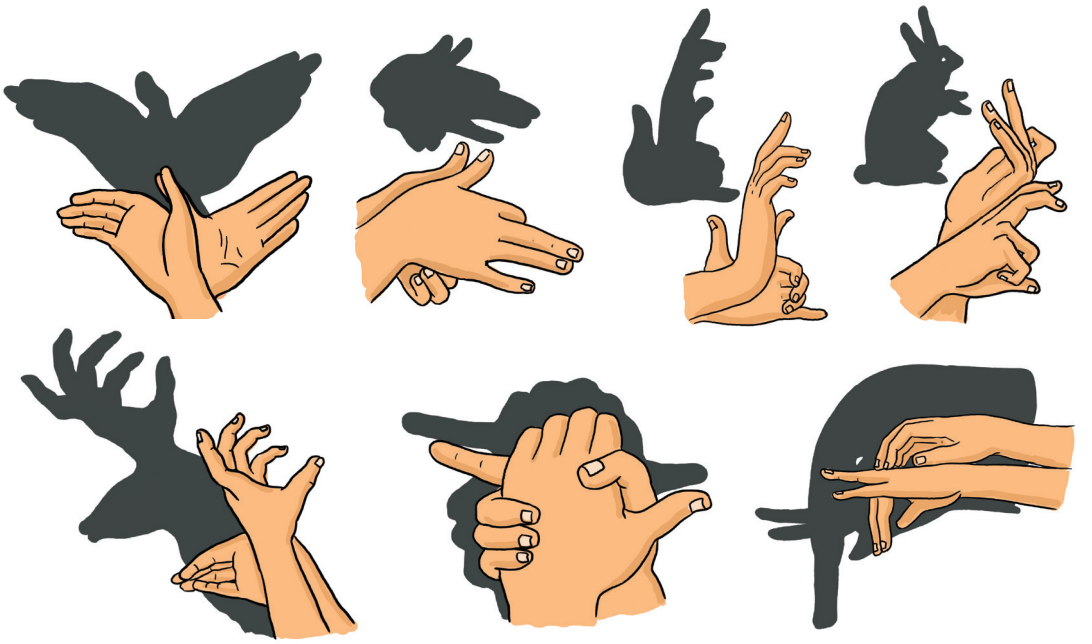


Figure 9.6 ▲ Some creations done with umbrae

Assignment 9.1

Test whether you can do creations like those shown in Figure 9.6. Present a collection of such creations with your friends.

In concerts creations done using shadows are popular in the field of art today. Some such instances are shown in Figure 9.7.

Figure 9.7 ▲ Artistic creations of shadows

Assignment 9.2

Enjoy watching artistic creations of shadows on the internet or in video clips.

Let us do Activity 9.3 to study further about umbrae.

Activity 9.3

You will need:- An electric torch, a screen, a small ball

Method:-

- Place the ball infront of the lighted electric torch and obtain its umbra on a screen or on a wall.
- Identify the dark brown/ light brown umbra and penumbra of the ball.
- Change the distance between the ball and the electric torch and observe how the umbra and penumbra are changing.

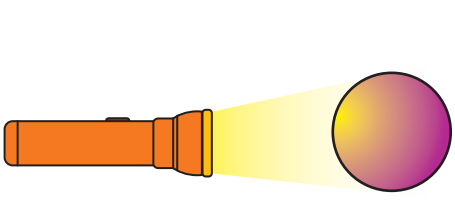


Figure 9.8 ▲

Compare your observations with those given in Figure 9.9

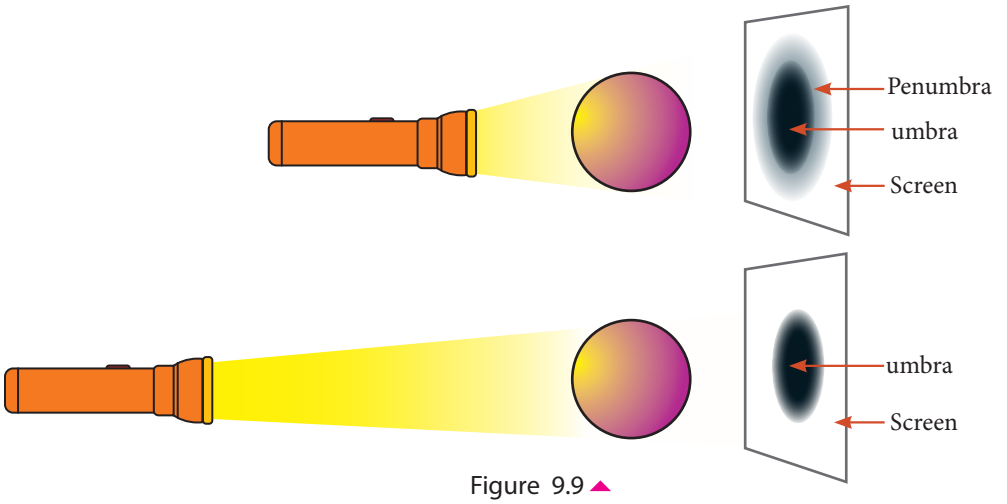


Figure 9.9

When the ball and the electric torch are closer, the umbra on the screen is not sharp and clear. There is a penumbra also around the umbra. When the distance between the ball and the electric torch is increasing, the penumbra gradully disappears. When the electric torch is kept at a considerable distance from the ball, only the umbra can be observed.

So the light source should be far from the object to obtain a clear and sharp umbra.

Let us study further about penumbra

Activity 9.4

You will need:- A piece of polythene, a torch, red and blue marker pens, platignum, a small ball, a screen

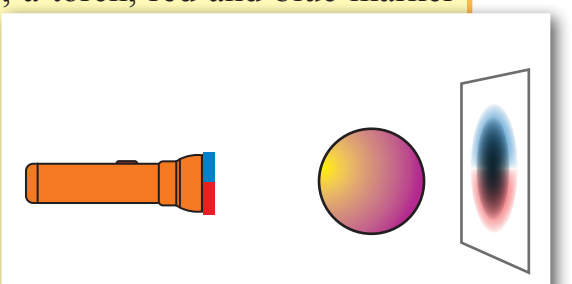


Figure 9.10

Method:-

- Tie the piece of polythene on to the face of the torch and divide it into two semi-circles.
- Colour one of the semi-circles in blue and the other in red.
- Light the torch and obtain the umbra of the ball on the screen.
- Observe the colours of umbra and penumbra well.

Compare your observations with the following.

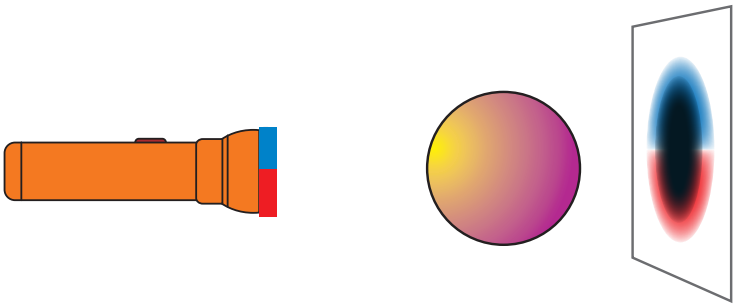
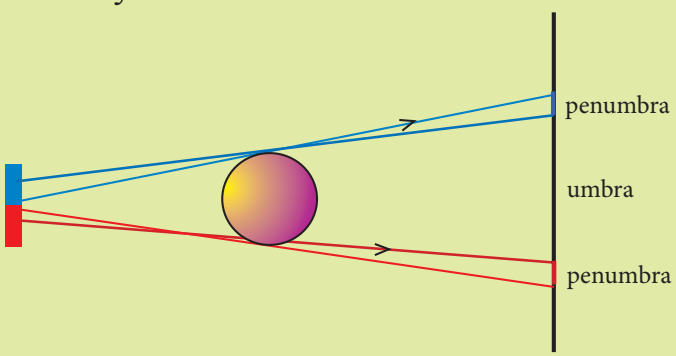


Figure 9.11

The upper part of the penumbra is seen in one colour (blue) and the lower part in the other colour (red).

For extra knowledge

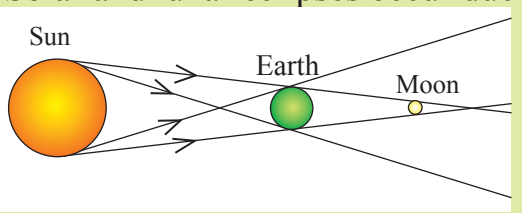
To describe Activity 9.4 further.



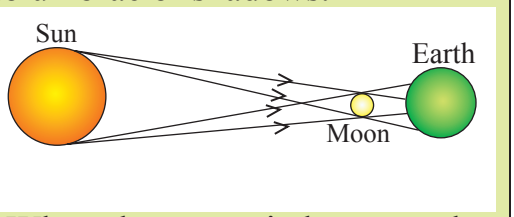
Umbra is formed on the screen, because light does not pass through the ball. Penumbra is formed because of the light rays emitted from the edges of the light source.

Thus, it is clear that penumbra is formed by the light emitted from one part of the light source.

Solar and lunar eclipses occur due to umbrae or shadows.



When the earth is between the sun and the moon, and all the three are in a straight line, the umbra of the earth falls on the moon, causing a lunar eclipse.



When the moon is between the sun and the earth, and all three are in a straight line, the umbra of the moon falls on the earth. So the sun cannot be seen from the earth. This incident is known as a solar eclipse.

9.2 Images formed by plane mirrors

Look at your face through a mirror. You can see your image inside the mirror. How is it formed? Can you recall instances where sunlight is directed on to a wall in the house from outside using a mirror?

Figure 9.12 ▲ Reflection of light

Here, the light that falls on the mirror is turned back to the house.

Figure 9.13 ▲ Reflection of light

The phenomenon of returning the light rays in the same medium after falling on a surface is called reflection of light.

Light reflects well from smooth polished shining surfaces.

Polished shining surfaces act as mirrors. Forming images by mirrors is a result of the reflection of light. The Figure 9.14 shows an image formed by a mirror.

Figure 9.14 ▲ Reflection seen in a plane mirror

A polished shining plane surface is known as a plane mirror.

A plane mirror is drawn in a diagram in the following manner (Figure 9.15).

Figure 9.15 ▲ plane mirror

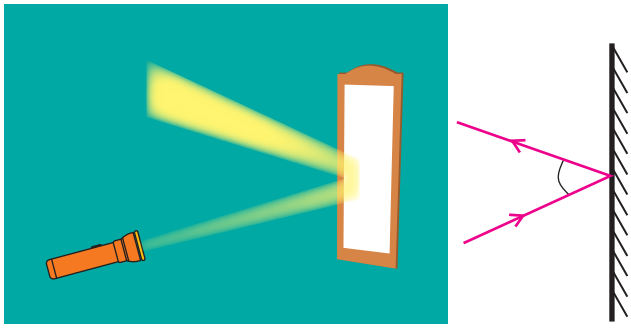


Figure 9.16 ▲ How light is reflected by a plane mirror

The image of a candle, placed in front of a plane mirror is shown in Figure 9.17.
Let us do Activity 9.5 to find out about images formed by plane mirrors.

Figure 9.17

Activity 9.5

You will need:- A plane mirror, a candle, a ruler

Method:-

- Place the ruler perpendicular to the mirror as shown in Figure 9.18. Place the lighted candle at the far end of the ruler.
- Observe the image of the candle formed through the plane mirror.
- Record your observations of the nature of the image in the following table.

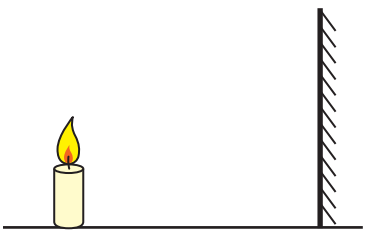


Figure 9.18 An image seen through a plane mirror

Table 9.1

Properties of the image	Observation
Can be obtained on to a screen	
Erect / Inverted	
Size of the image	

If the image can be obtained on to a screen the image is termed as "real". If it cannot be taken on to a screen, then the image is known as " virtual".

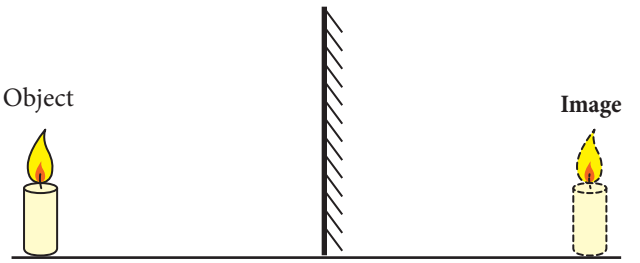


Figure 9.19

Let's do Activity 9.6 to find out about images formed by a sheet of glass.

Activity 9.6

You will need :- A sheet of glass, two candles which are same in size and shape, a ruler, a screen

Method :-

- Place the ruler perpendicular to the sheet of glass and place a lighted candle at the far end of the ruler as shown in figure 9.20

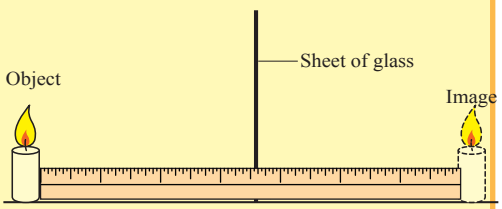


Figure 9.20

- Observe the image of the candle formed through the sheet of glass (It is more suitable to carry out this activity in a dark place)
- Place the other candle, where you see the image as shown in the figure.
- Compare the size of image with the candle.
- Measure the distances between the first candle and the sheet of glass (object distance) and between the second candle and the sheet of glass (image distance)
- Record your observations in the following table.

Table 9.2

Properties of the image	Observation
Size of the image	
Distance between the first candle and the sheet of glass	
Distance between the second candle and the sheet of glass	

Features of an image formed by a plane mirror are given below.

- Cannot be obtained on to a screen (virtual), erect.
- Size of the image is equal to the size of the object.
- Image is formed behind the mirror (Distance from the mirror to the object is equal to the distance from mirror to the image.)
- Left and right sides of the image are inter changed. (lateral inversion)

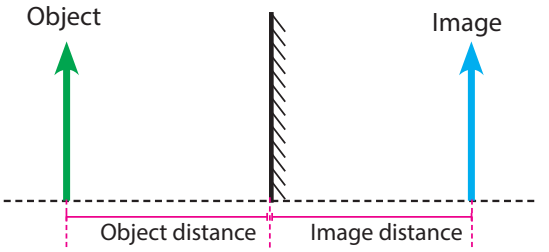


Figure 9.21

Lateral inversion

Activity 9.7

You will need :- A plane mirror, letters O, B, D and P (Write letters on a paper).

Method :- Place each letter cut from a cardboard sheet in front of the plane mirror and observe.

Figure 9.22 (a)


Figure 9.22 (b)

It is observed that the right and left sides of the letters B,D and P are inversed. The right and left side of the letter O is also inversed, but it is not observable because the letter O is symmetrical.

This phenomenon of inversing right and left sides of an object, when observed through a plane mirror is known as lateral inversion.

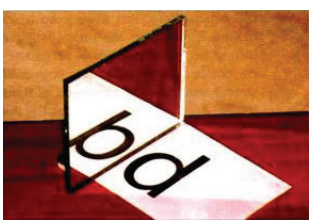



Figure 9.23 Lateral inversion of an image

The phenomenon of lateral inversion is further illustrated in Figure 9.23.

Think of the reason for painting the word AMBULANCE on ambulances.

Assignment 9.3

Tabulate the letters of english alphabet as those which can be identified as laterally inverted and cannot be identified as laterally inverted.

Multiple images

To show the number of items as increased in jewellery shops, plane mirrors are kept behind the items and parallely on either sides. Light is reflected by those mirrors and a large number of images can be observed.

Figure 9.24 ▲ Jewellery shops where multiple images are formed

When two or more plane mirrors are kept at an angle or parallel to each other and an object is kept in between more than one image are formed. Such a formation is known as multiple images.

Let us carry out Activity 9.8 to find out more about this phenomenon.

Activity 9.8

You will need :- A candle, two plane mirrors, a protractor

Method :-

- Keep two plane mirrors at an angle of 90^0 and place a lighted candle between them.
- Count the number of images formed.
- Change the angle between the plane mirrors as 60^0, 45^0 and 30^0 and count the number of images formed in each instance
- Tabulate your observations as indicated below.

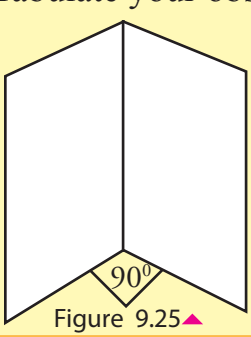


Figure 9.25 ▲

Table 9.3 ▼

Angle between the two plane mirrors (degrees)	Number of images formed
90	
60	
45	
30	

Compare your observation with those in the table below.

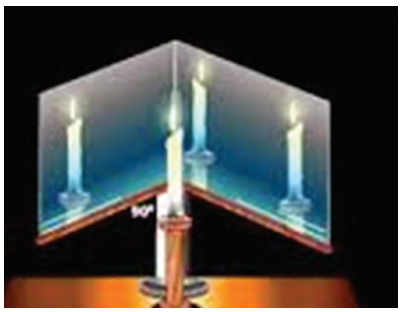


Figure 9.26 ▲ How multiple images are formed

Table 9.4 ▼

Angle between the two plane mirrors (degrees)	Number of images formed
90	3
60	5
45	7
30	11

The number of images formed are increased when the angle between the two plane mirrors decreases.

Assignment 9.4

- Observe the number of images formed, when the angle between two plane mirrors are decreased.
- Mention the number of images formed/the nature of images when an object is kept between the two parallelly placed plane mirrors.
- Discuss your answer with your teacher.

Assignment 9.5

Multiple images formed by plane mirrors are used in day-to-day life. Findout and report several such instances.

Instances where plane mirrors are used

- As mirrors in dressing rooms
- To illuminate various objects in cinematography
- To direct light on to the slide of microscopes
- To construct kaleidoscopes
- To construct periscopes

Kaleidoscope is an instrument in which the formation of multiple images is used. Let us carry out Activity 9.9 to construct a kaleidoscope.

Activity 9.9

You will need :- Three strips of plane mirrors with equal dimensions (6 cm x 2 cm), black paper, gum tape

Method :-

- Keep the strips of plane mirrors triangularly as shown in Figure 9.27. Cover one end with the piece of tissue paper.
- Cover the mirrors with black paper and stick securely with gum tape.
- Put small coloured items like beads, petals into this and observe through the open end. Turn round the instrument to see how the coloured patterns change.

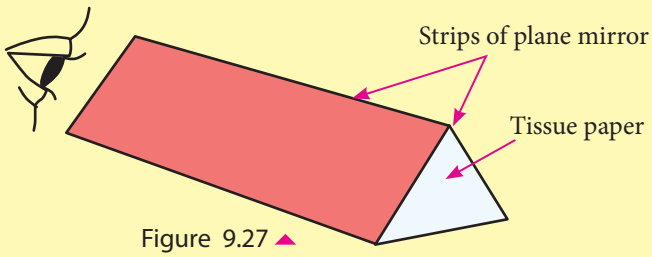


Figure 9.27 ▲

You will be able to observe various patterns. These patterns are formed by the reflection of light from several mirrors. Vivid patterns formed in a kaleidoscope are used to create designs for textile, floor tiles and wall tiles.

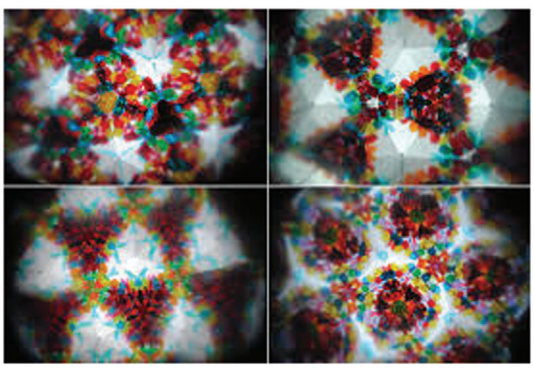


Figure 9.28 ▲ Vivid patterns formed in a kaleidoscope

Periscope is another instrument made using the phenomenon of reflection of light through plane mirrors. Let us carry out the Activity 9.10 to make a periscope.

Activity 9.10

You will need:- Two identical plane mirrors, pieces of cardboard sheet, gum tape

Method:-

- Make tubes of appropriate size, using the piece of cardboard sheet construct the equipment as shown in the figure 9.29. Place the pieces of mirrors at an angle of 45^0 at each bend. Get the assistance of your teacher for this construction.
- Observe objects through the instrument you made.

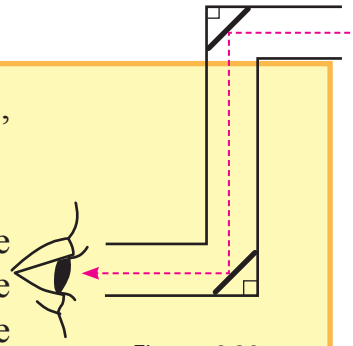


Figure 9.29

An observer positioned in a low level, can use a periscope to observe incidents that occurs in a higher level. This is commonly used in submarines and bunkers.

Assignment 9.6

Find out and record other instances where periscope is used.

Assignment 9.7

Mention other instances where plane mirrors are used in day-to-day life.

9.3 Images formed by curved mirrors

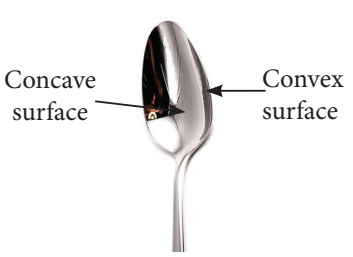


Figure 9.30 Some objects with curved surface

Have you ever seen the image of your face on a metal spoon? The image is seen differently on inner surface and on outer surface of the spoon. This happens because the surfaces of spoon act as curved mirrors.

Mainly there are two types of curved mirrors, named as convex mirrors and concave mirrors. Reflecting surface of a concave mirror is curved inwards and that of a convex mirror is curved outwards.

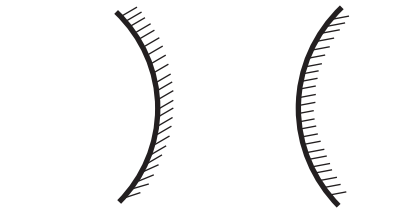


Figure 9.31

A ray of light is denoted by a straight line and the direction is indicated by an arrow head drawn on the straight line.

A beam of light is made up of a bundle of light rays.

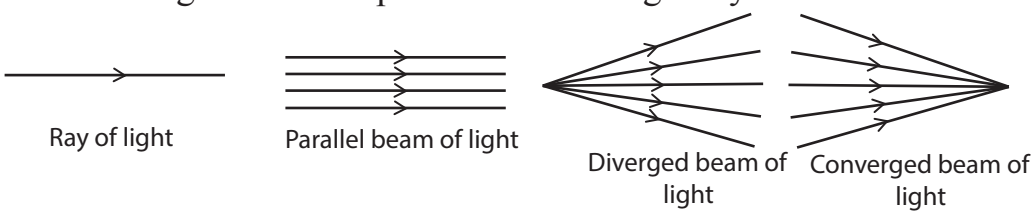


Figure 9.32 light rays and light beams

Concave mirrors

What happens when a narrow, parallel beam of light falls on a concave mirror? Let us do Activity 9.11 to find out this.

Activity 9.11

You will need :- A concave mirror, a plane mirror

Method :-

- Direct a narrow, parallel beam of light on to the reflecting surface of a concave mirror. (This can be done by using a plane mirror)
- Record your observations.

You can observe that the light beam "collects" to a spot infront of the concave mirror.

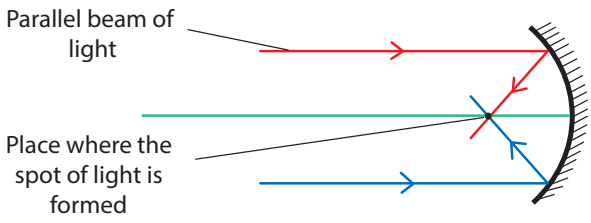


Figure 9.33

This "collection" of a parallel light beam to a single spot in front of the mirror is known as convergence of light. Therefore, concave mirrors can be used to converge light.

What happens when a narrow, parallel beam of light falls on a convex mirror? Let us do Activity 9.12 to find out this.

Activity 9.12

You will need :- A convex mirror, a plane mirror

Method :-

- Direct a narrow, parallel beam of light onto a convex mirror. (A plane mirror can be used for this purpose.)
- Record your observations.

It can be observed that light which falls on a convex mirror, " spreads out" after reflection. This spreading out of light after reflection is known as divergence of light. Therefore, convex mirrors are considered as divergent mirrors.

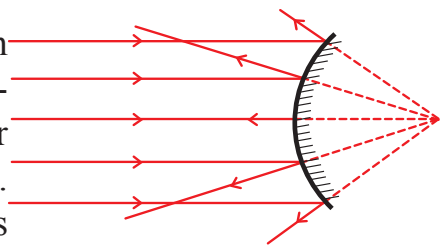


Figure 9.34

Images formed by concave mirrors

Let us do Activity 9.13 to observe the nature of images formed by concave mirrors.

Activity 9.13

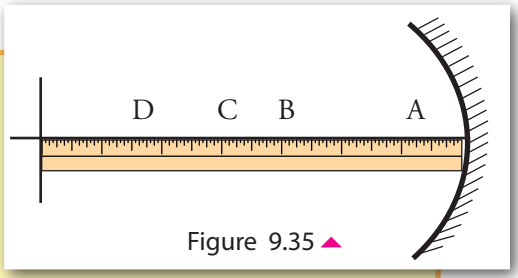


Figure 9.35

You will need :-

A concave mirror, a mirror holder, a candle, a screen, a metre ruler

Method :-

- Place a lighted candle on point A, in front of a concave mirror. The candle should be placed close to the mirror.
- Try to obtain the image formed, onto a screen.
- Observe the nature of the image, with the assistance of your teacher.
- Then, place the lighted candle on points B, C and D respectively and observe the nature of the images formed.
- Tabulate your observation as follows.

Table 9.5

Point where candle is kept	Can/ Cannot be obtained onto a screen	Erect/ Inverted	Size of the image
A			
B			
C			
D			

Compare your observations with those given below.

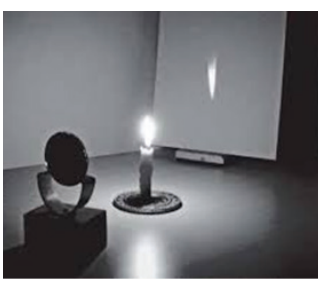


Figure 9.36 Instance of forming images from a concave mirror

Table 9.6

Point where candle is kept	Can/ Cannot be obtained onto a screen	Upright/ Inverted	Size of the image
A	Impossible	Upright	Larger than the object
B	possible	Inverted	Larger than the object
C	possible	Inverted	Equal to the object
D	possible	Inverted	Smaller than the object

Instances where concave mirrors are used in day-to-day life

- As mirrors used for shaving
- For dentists to examine teeth of patients
- Used in reflecting telescopes
- To construct solar cookers


Figure 9.37

Assignment 9.8

Make a list of other instances where concave mirrors are used in day-to-day life.

Convex Mirrors

Let us do Activity 9.14 to observe the nature of images formed by convex mirrors.

Activity 9.14

You will need :-

A convex mirror, a mirror holder, a candle, a screen, a metre ruler

Method :-

- Place a lighted candle on point A, infront of convex mirror.

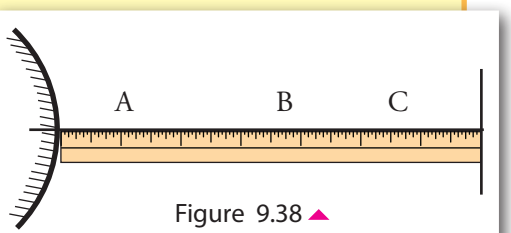


Figure 9.38

- Place the candle close to the mirror.
- Try to obtain the image formed, onto a screen.
- Observe the nature of the image with the assistance of your teacher.
- Then place the lighted candle on points B and C respectively and observe the nature of the images formed.
- Tabulate your observations as follows.

Table 9.7

Point where candle is kept	Can/ Cannot be obtained onto a screen	Upright/ Inverted	Size of the image
A			
B			
C			

Compare your observations with those given below.

Figure 9.39 ▲ Images formed by a convex mirror

Table 9.8

Point where candle is kept	Can/ Cannot be obtained onto a screen	Upright/ Inverted	Size of the image
A	Cannot	Upright	Smaller than the object
B	Can	Upright	Smaller than the object
C	Can	Upright	Smaller than the object

It is clear that the nature of the image does not change when the distance between the object and convex mirror changes.

Let us engage in the Activity 9.15 and study about the images formed by curved mirrors.

Activity 9.15

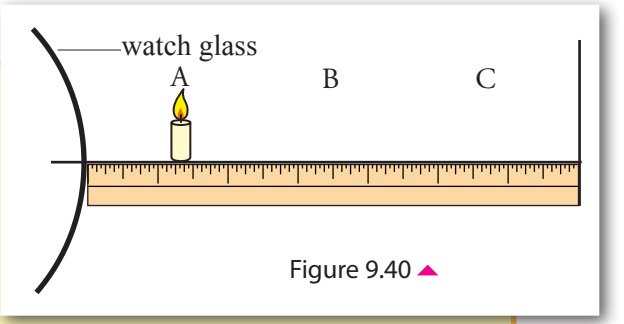


Figure 9.40

You will need:- Two candles which are same in size and shape, watch glass, a screen, mirror holder

Method:-

- Place a lighted candle close to the watch glass in front of the concave surface as shown in Figure 9.40.
- Observe the image formed.
- Try to obtain the image on to a screen (it is appropriate to use a dark place for the above activity)
- Place the other candle, where you see the image and compare the size of the image with the candle.
- Observe the changes of the images placing the candle at B and C.
- Tabulate your observations

Instances where convex mirrors are used in day-to-day life

- As side mirrors of vehicles

The driver can view a large rear area of a vehicle in the side mirror because convex mirror forms smaller, upright images.


Figure 9.41 How rear side of a vehicle is viewed in a side mirror

Assignment 9.9

Make a list of other instances where convex mirrors are used in day-to-day life.

Summary

- Umbrae or shadows can be observed frequently in day-to-day life.
- Umbrae are formed when light does not travel through opaque objects.
- Clear and sharp umbrae are formed, when the object is far from the light source is kept close to the object.
- Smooth, shining surfaces act as mirrors.
- Returning light rays back in the same medium, after striking on a surface is known as reflection of light.
- Images are formed in mirrors due to the reflection of light.
- Images formed in plane mirrors are always upright, equal to the size of object and cannot be obtained on to a screen.
- Parallel beam of light can be converged by a concave mirror, and can be diverged by a convex mirror.
- The nature of images formed by concave mirrors differs according to the distance between the object and the mirror.
- The nature of the images formed by convex mirrors does not differ according to the distance between the object and the mirror.
- Mirrors are used for various purposes in day-to-day life.

Exercise

1. Select the appropriate word from the brackets and fill in the blanks.

I. Clear umbra can be obtained by .....
(a candle/ an electric torch bulb)

II. A ..... mirror is used to diverge a parallel beam of light. (Convex/ Concave)

III. Images formed by plane mirrors are always ..... the object. (equal to/ smaller than)

IV. Images formed by convex mirrors are always ..... (upright/ inverted)

V. ..... mirrors should be used to obtain inverted images. (concave/ convex)

2. Select the correct answer.

1. Which one of the following is not a property of an image formed by a plane mirror?

I. Cannot be taken to a screen II. Upright
III. Equal to the size of object IV. Laterally inverted

2. A property of an image, formed by a convex mirror is;

I. Inverted II. Ability to take onto a screen
III. Smaller than object IV. Larger than object

3. The angle between two plane mirrors, to obtain three images, should be;

I. 60^0 II. 45^0 III. 90^0 IV. 30^0

4. The type of mirrors that should be used to form an inverted image on a screen is;

I. Convex II. Concave
III. Plane IV. All given above

Technical Terms

Umbra	-	ඡායාව	-	நிழல்
Penumbra	-	උපඡායාව	-	அயல்நிழல்
Image	-	ප්‍රතිබිම්බය	-	விம்பம்
Reflection	-	පරාවර්තනය	-	தெறிப்படைதல்
Convex mirror	-	උත්තල දර්පණය	-	குவிவாடி
Concave mirror	-	අවතල දර්පණය	-	குழிவாடி
Plane mirror	-	තල දර්පණය	-	தளவாடி
Convergent	-	අභිසාරී	-	விரிகற்றை
Divergent	-	අපසාරී	-	குவிகற்றை
Periscope	-	පරික්ෂය	-	கலையுருக்காட்டி
Kaleidoscope	-	බහුරූපේක්ෂය	-	சூழ்காட்டி