Chapter 14

Reflection of Light

Points to be Studied

14.1 Reflection of light
14.2 Laws of Reflection
14.3 Regular and diffused reflection
14.4 Reflection from a plane mirror
14.5 Spherical mirror
14.6 Concave mirror and the images formed by it
14.7 Convex mirror and the images formed by it

We have studied in earlier classes that light travels in a straight line. If an opaque object is placed in the path of light then it cannot penetrate through it but what happens, when a bright object like plane mirror is placed in its path? Let us know about it.

14.1 Reflection of light

Activity-1

Take a plane mirror and stand in front of a building in open space during the day. Let the sunlight falls on the mirror. Now rotate the mirror in such a way that a spot of light falls on the wall of the building with no sunlight. Why is the spot of light formed on the wall? When incident light of sun falls on a plane mirror then mirror changes the direction of the incident light that falls on it.

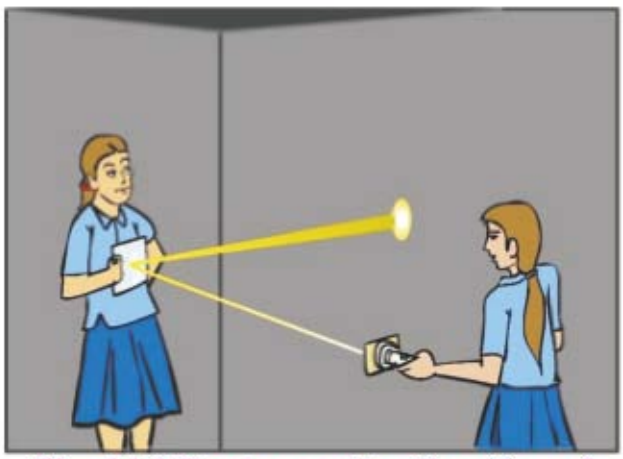

Fig. 14.1 To change the direction of light using a plane mirror.

You can perform similar activity in a dark room. Take cardboard and make a hole in it using a nail. Stand in the middle of room and cover the glass of torch by this card board. Ask your friend to stand in the corner of the room with plane mirror in his hand. Switch on the torch and place it such that the light falls on the plane mirror. Adjust the direction of the torch in such a way that a spot of light

falls on the wall of the room. It can be concluded that plane mirror changes direction of light that falls on it. In this activity light travels in air, strikes the plane mirror and returns back in the same medium.

Place a bucket full of water near the wall of a room and focus light on the water surface. You will see that water surface acts like a mirror and can turn the path of incident light. Take a shining steel plate or spoon and watch the reflection of light caused by it.

So, we can say that-

> The phenomenon of reflection of light-rays after colliding with a mirror or any other object back into the same medium is called reflection of light.

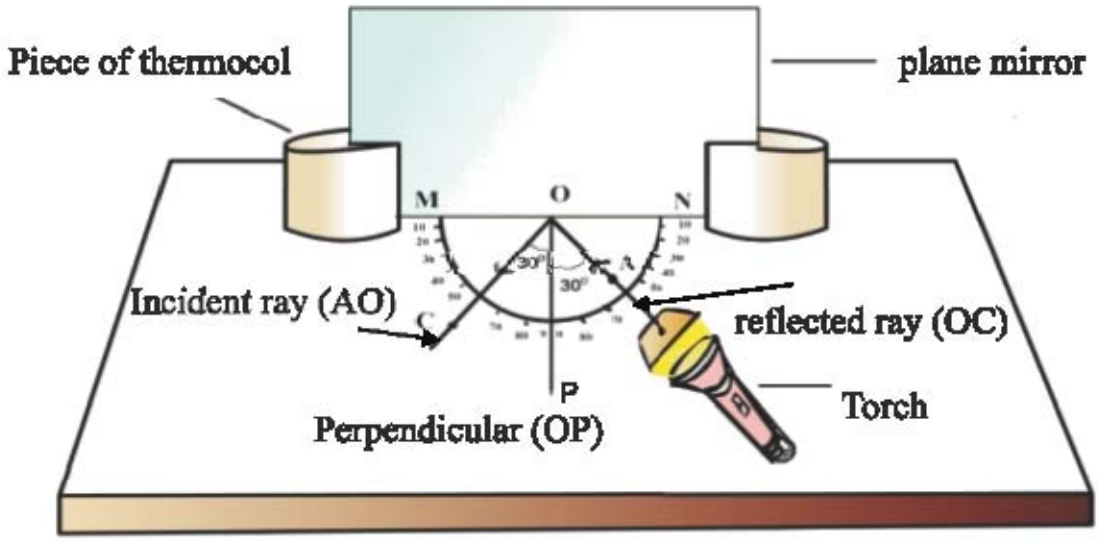

Fig 14.2 Reflection of Light.

14.2 Laws of Reflection

Activity 2

Take a drawing board and fix a white paper with the help of drawing-pins. Draw a straight line MN on it by a pencil. Mark a point O at the centre of MN. Draw a perpendicular line OP on MN from point O. Mark the angle like 90°, 80°, 70°, ...10°, 0° on both side of point O as shown in figure 14.2. Place plane mirror parallel to straight line MN with help of thermocol. Cover the glass of a torch with black coloured drawing sheet which has a slit in it as shown in figure. Switch on the torch and focus the light passing through slit on the mirror in such a way that it appears as a straight line on the paper. Adjust the position of torch in such a way that its light strikes on the plane mirror with an angle of 25°from the

normal OP. The light ray reflected back from mirror will also appear on white paper. Put a mark A with pencil on incident light ray. Light ray AO that comes from torch and strikes the plane mirror is called **Incident light** ray. Similarly mark a point C on the reflected light ray. This ray of light (reflected ray) that comes back after striking the mirror is called **Reflected ray (OC).**

Join the points A and O and point O and C.

The angle AOP formed between Incident ray AO and normal OP is called the **Incident angle i.**

The angle POC formed between reflected ray OC and normal OP is called the **Reflected angle r.**

Measure both the angles. Are these equal?

Similarly, repeat the above process by making different angles with normal and note down the values of incident and reflected angles in table 14.1.

Table 14.1

Sr. No.	Incident angle (i)	Reflected angle (r)
1	25°	
2	30°	
3	35°	
4	40°	
5	45°	

From the above observation you will conclude that -

The values of incident angle and reflected angle are always equal.

Incident angle i = Reflected angle r

This is first Law of Reflection.

You also see here that incident ray AO, reflected ray OC and normal OP all are present on the plane of paper.

Therefore, we can say that incident ray AO, reflected ray OC and perpendicular OP all exist in same plane.

This is the second Law of Reflection.

14.3 Regular and Diffused Reflection

When parallel rays of light are incident on plane mirror then reflected rays are parallel to each other in any specific direction. This type of reflection is called **Regular Reflection.** Regular reflection occurs by plane mirrors or other smooth and bright surfaces.

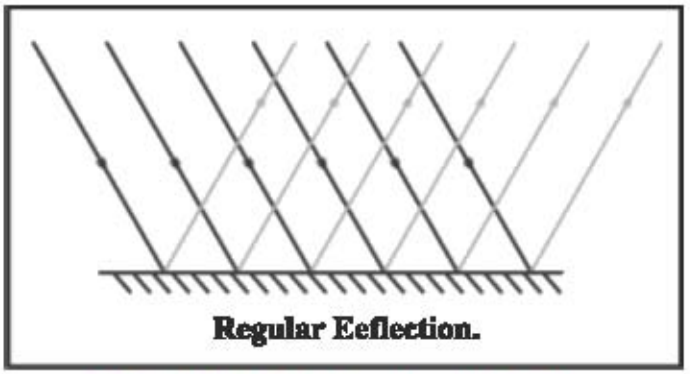

Fig. 14.3(a) Regular Eeflection.

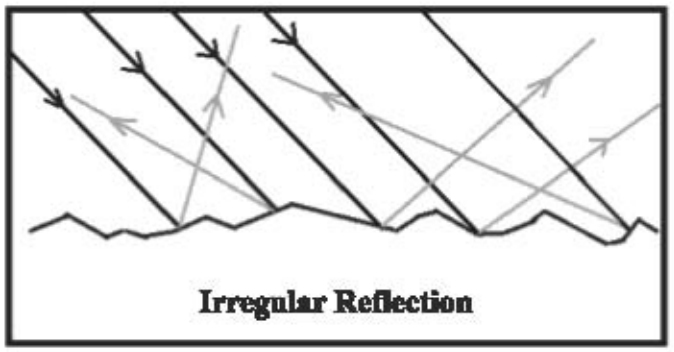

Fig. 14.3(b) Irregular Reflection

When the incident rays fall on a rough surface they are parallel to each other but after reflection they are no longer parallel but are reflected in different directions. This type irregular reflection is called diffused reflection. Diffused reflection is caused by irregular surface of the reflector. Diffused reflection occurs on the irregular surfaces such as- books, surface of table, etc. The presence of light under a tree and inside the room is because of diffused reflection.

Good and Moderator Reflectors

Those surfaces which reflect most of incident light rays that fall on it are called good reflectors e.g. smooth and polished surface of an object, mirror etc.

Those surfaces which reflect only a small amount of incident light-rays are called moderate reflectors.

14.4 Reflection from a plane mirror?

Activity-3

Place a vertical plane mirror in between a thermocol as shown in fig.14.4. Place a pencil in vertical position (or pen or any object) at a little distance in front of the mirror. See its image in the mirror. Now place the pencil at different positions in front of the mirror and in each see the position of image. How is the image seen? Erect or inverted? When compared to the

Fig. 14.4 Image from plane mirror?

object of the image (pencil) is small or big?

Image formed by a plane mirror is upright and is equal in size to the object.

Activity -4

Draw a straight line on a plane white paper. Now starting from it, draw 3 cm sided squares one by one as shown in fig. 14.5. Place a plane mirror vertically clamped into a thermocol perpendicular to the straight line. Place a pen or pencil in vertical position in the centre of any square in front of the mirror. Observe the image and find out how far is it from the mirror?

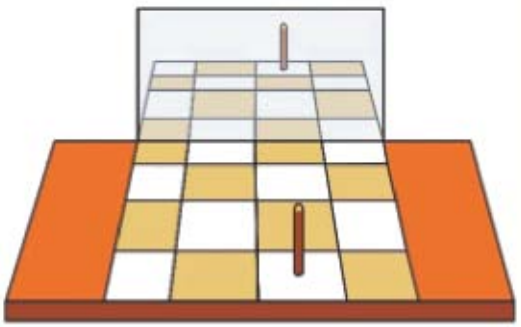

Fig. 14.5

You will see that **image formed behind the mirror is at a distance equal to the distance of object from the mirror.**

Place a white paper sheet at the back of the mirror at a distance from mirror equal to the distance you see an image. Does the image of an object appear on screen? You will find that the point at which you see the image without screen will not be seen if you put a screen at the same place. Thus this image is virtual.

The image which cannot be obtained on screen is called **Virtual Image.** These images seem to form at a point but practically no image is formed at that point. Conversely, image formed at any point which can be taken on screen is called **Real Image.**

Lateral Transformation - Standing in front of plane mirror observe your image when you extend your right hand. You find that the left hand of your image is extended.

Fig. 14.6(a) Lateral Transformation in Plane Mirror

Fig. 14.6(b) Ambulance

In plane mirror, the left part appears as right in the image and right part appears as left in the image. This event is called lateral transformation. Due to lateral transformation, words are written in a specific manner at the front side of ambulance so that image formed in side glass of the vehicle ahead of the ambulance is accurate and the driver of the vehicle views it as AMBULANCE and will easily give side to the ambulance to overtake it.

How is image formed by a plane mirror?

Let us find out.

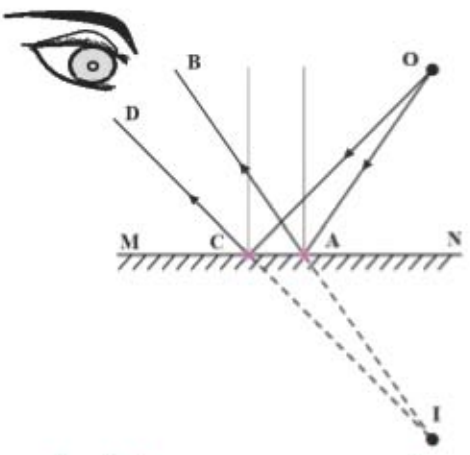

Fig. 14.7 Image Formation by Plane Mirror

Activity 5

A point of light source 'O' is placed in front of plane mirror MN. Moving from point O, two rays , OA and OC are incident on the mirror as shown in fig. 14.7. Draw perpendicular points A and C on the surface of mirror MN. Draw reflected rays at point A and C and mark them as AB and CD respectively. Extend them further. They do not meet on extension in the forward direction. Now extend them backwards. They meet at a point, mark this point as I. Point A is Virtual image of object O. For our eyes placed at point E, these reflected rays appear to come from the point I. Since, the reflected rays do not meet at A but only appear to do so, we can say that the image is virtual. Virtual image cannot be obtained on screen.

It is due to reflection we are able to view the objects.

When light strikes at different points on an object and reflected rays reach our eyes then image of each point of the object is formed in our eye due to which we are able to see the object.

Multiple images

As you have seen a single image of an object is formed by a plane mirror, but how many images are formed when an object is placed in between two parallel mirrors? You might have gone to a saloon to get a haircut. You sit in front of plane mirror and another plane mirror is placed at your backside. These two mirrors are parallel to each other. Due to mirror placed at your

Fig. 14.8 Multiple Images

back you see multiple images of yourself. Thus, infinite number of images is formed of an object placed between two parallel mirrors.

If the mirrors are positioned at any angle to each other and an object is placed in between them, then how many images of an object will be formed?

Let us experiment.

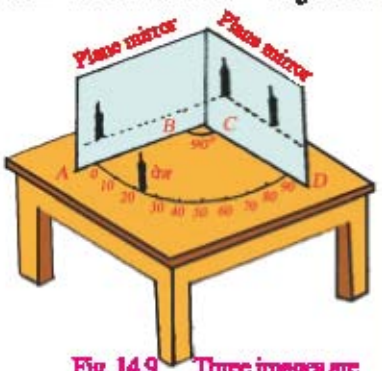

Fig. 14.9 Three images are formed from object placed in between two plane mirror

Activity-6

Make a semi circle on drawing-board with help of a compass as shown in fig.14.9. Mark angles from 0° to 90° on it. Place two plane mirrors along the lines A, B and C,D in such a way that these mirrors are at right angles to each other. Now place a pen in between the two mirrors and tell how many images of pen are formed? You will find that three images are formed for an object placed in between mirrors at right angles. Now find out the number of images formed by the two mirrors at different angles to each other as given in table 14.2. Divide 360° by angle θ and one from it. Is this value equal to number of images formed?

Table 14.2

S. No.	Angle between mirrors θ	Number of images formed	360 / θ	360 / θ -1
1	90	3	4	3
2	60			
3	45			
4	30			
5	0			

On the basis of above study we can say that the formula (N) for number of images formed for an object placed between two parallel mirrors at a certain angle is-

$$\text{Number of Images (N)} = \left(\frac{360}{\text{angle between the mirrors}} \right) - 1$$

After dividing 360° with an angle, if an integer is not obtained then to find out the image numbers next integer is taken for e.g. if the value of the angle is 50°then (360/50)-1 = 6.2 which is not an integer which has seven as the next integer. So the number of images formed will be seven for two mirrors an angle of 50°. If the angle in between two mirrors is zero i.e. both are parallel to each other then number of images formed will be infinite(∞).

Till now you have learnt that-

- **Image formed by a plane mirror is always virtual and erect.**
- **Size of the image is equal to the size of the object.**
- **Image formed behind the mirror is at a distance equal to the distance of the object from the mirror.**
- **In addition to it, image is laterally transformed.**

If the reflecting surface is not plane but is curved then what kind of image formation takes place?

Let us perform.

14.5 Spherical Mirror

Activity 7

Take a table spoon and try to see your face on its surface. Can you see the image? Is it small or big? Gradually take away the spoon from your face and observe the image. How is it transformed? Now, revert the spoon and repeat the process to view your face on the outward surface. How is the image seen now? Compare the properties of the image obtained on both surfaces.

Curved surface of a bright spoon is assumed as a curved mirror. The most commonly used form of curved mirror is spherical mirror. The reflector surfaces of these mirrors may be assumed as a part of a sphere. Mirrors having spherical reflecting surfaces are called spherical mirrors.

Spherical mirrors are two types -

1. **Concave mirror (divergent mirror) and**
2. **Convex mirror (convergent mirror)**

What is their shape?

Let us find out.

Activity 8

Take the spherical hollow ball and cut a spherical part AOB along the circumference perpendicular to XY axis as shown 14.10 (A).Observe the AOB part. One of its parts is depressed inwards whereas the opposite part is bulged outward. Both the inwards and outwards parts are curved. What are these parts called?

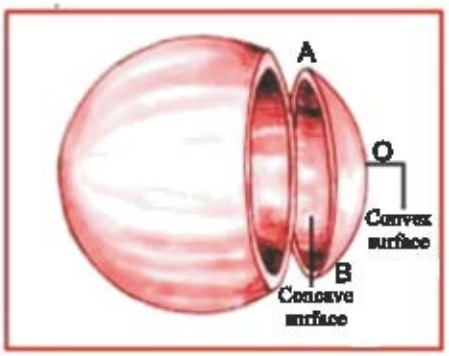

Fig. 14.10 (a) Parts obtained after cutting a rubber ball

Any outwardly bulging curved surface is **Convex** and inwardly depressed curved surface is **Concave.** If the same process is performed for a transparent spherical hollow glass then get a transparent curved part of the glass which has two opposite planes, one convex and another concave.

A spherical mirror in which the outwardly curved part works as reflector is called **Convex mirror.**

The bulged inward part i.e., the centre of the of spherical mirror works as reflector is called **Concave mirror.**

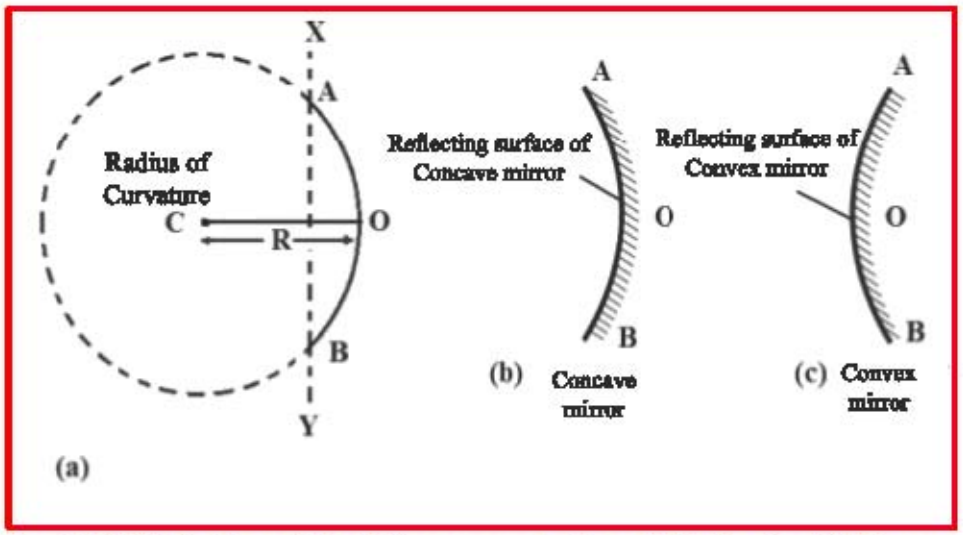

Fig. 14.10 (b) Graphical Representation of Spherical Mirrors

Thus, we can say that the inward or outward reflecting surfaces for a spherical mirror can be curved towards inside or outside. The graphical representation of these mirrors is shown in figure 14.10(b). In these figures,

backside of mirrors is shadowed. Now you may have understood that inwardly curved surface of the spoon behaves almost as a concave mirror and outwardly buldged curved surface as a convex mirror.

Reflecting surface of a spherical mirror is a part of sphere. Its centre C is called **Radius of curvature.** The centre O of reflecting surface of spherical mirror is called pole. The reflecting surface of spherical mirror which is a portion of sphere has **Radius** R which is called the **Radius curvature** of mirror. It is shown by OC in F fig. 14.10 (B). The line joining the pole O and centre of curvature C of the mirror is called **Principle axis.**

A concave mirror is convergent

Why is a concave mirror called convergent mirror?

Let us learn by doing.

Activity - 9

Hold a concave mirror in your hand and face the reflecting surface of the mirror towards the sun. Focus the light reflected by the mirror on a black paper sheet placed near the mirror. Gradually move the paper sheet backward and forward till you get a bright sharp spot of light on the sheet. Hold the mirror and the sheet for few minutes in the same position. What do you observe?

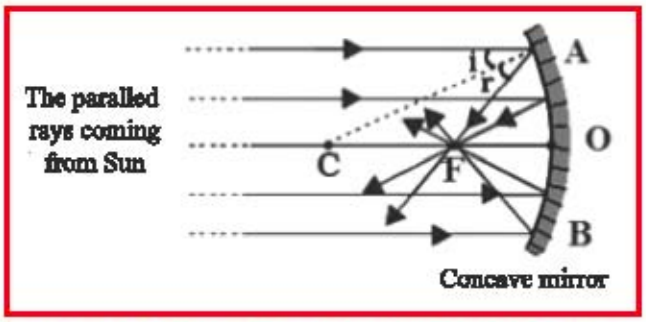

Fig.14. 11 Concave mirror and its image formation

First smoke appears from the paper and at the end it catches fire. Why does it burn?

Warning - Do not look directly towards the sun or towards sunlight reflected from a mirror. It may damage your eyes.

The parallel rays coming from sun are converged as a bright sharp spot by a concave mirror. So, it is also called as Convergent mirror. Actually, bright spot of light on paper sheet is the image of the sun. It is the focus point of concave mirror.

After reflection, incident rays parallel to principal axis are concentrated on a point on the principle axis. This point is called as Focus F the concave mirror. The distance between focus and pole is called Focal length of a concave mirror. It is half of the radius of curvature i.e., f=R/2.

Heat is generated by focussing sun light at a point due to which the paper starts to burn. The distance of image (bright sharp point) from mirror's position is approximately equal to focal length of mirror. By measuring it with a ruler, calculate the approximate focal distance of mirror.

Convex mirror is divergent.

Why a convex mirror is called divergent mirror?

Let us learn by doing.

Activity 10

Hold a convex mirror in your hand and face its reflecting surface of the mirror towards the sun. Focus the light reflected from the mirror on a black paper sheet placed near the mirror. Gradually move the paper sheet backward and forward. Are you able to get a bright sharp spot of light on the paper? The parallel rays coming from sun are not converged at spot by the convex mirror but are spread (diverged). That is why, the convex mirror is called a **Divergent mirror.**

Incident rays from a convex mirror parallel to principal axis seem to come from a point on principle axis after reflection. This point is called **Focus of convex mirror.** How is the image formed by a concave mirror? Let's learn by doing.

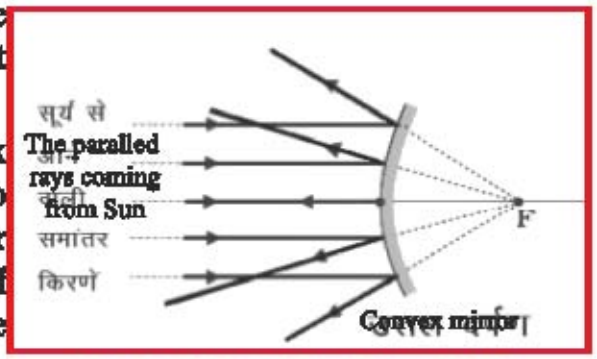

Fig14.12 Diverging Property of a Convex Mirror

Image Formation by a Concave Mirror

Activity 11

Take a concave mirror. Focus sunlight on a paper after reflection by mirror to get a bright sharp spot. Actually, bright spot of light on the paper is the image of the sun. It is very small, real, and inverted. By measuring the distance of image (bright sharp spot) from position of mirror, calculate the approximate focal length of mirror.

Draw a point O with help of chalk on a table. Place a concave mirror on a stand at point O. Now adjust the concave mirror on line in such a way that pole of mirror is located at point O. Now mark a point F equal to the focal length in front of the stand and a point C at a distance double to it. Keep a burning the candle at a little distance from it. Paste a white paper on a hard board approximately 15 cm long and 10 cm wide. This will work as a screen. Gradually move the mirror

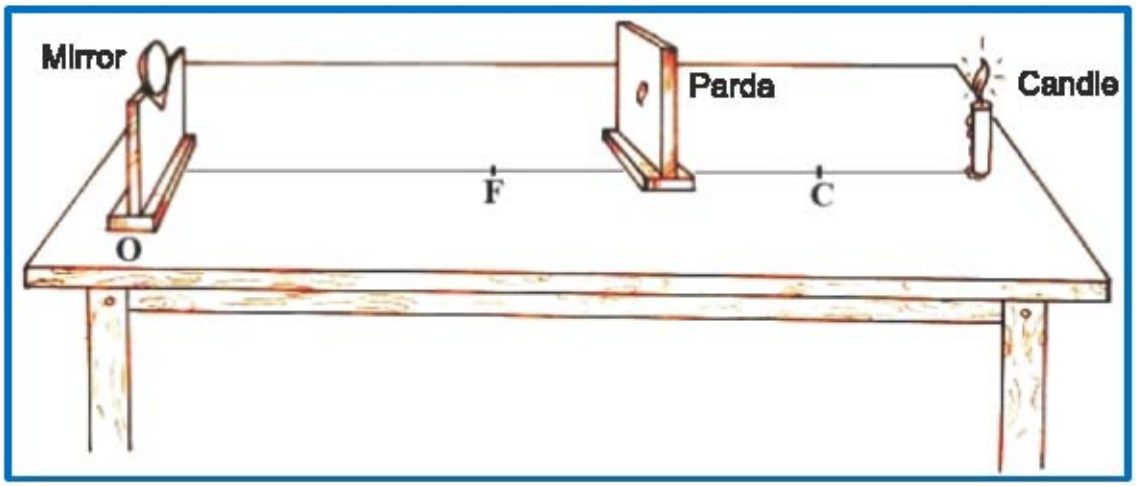

Fig. 14.13 Concave Mirror and its Image Formation

backwards and forwards till you get a bright sharp spot of candle flame on it. Look carefully at the image. It is inverted and small and formed in between the focus F and the centre of radius of curvature C.

Repeat this activity for several different positions of the candle and write down the observations in table 14.3.

In the situation when the position of candle is in between F and mirror, you will not be able to get image. Find out the position of image in this situation. Then view the virtual image directly in the mirror.

Table 14.3

Sr. No	Position of object	Position of image	Image size	Nature of image
1	A little distance from C			
2	At C			
3	In between F and C			
4	At F			
5	In between F and mirror			

Now, repeat the same activity by taking a convex mirror in place of a concave mirror. You will find that no image formation occurs on screen by using a convex mirror. The image is always obtained at the backside of the mirror, which is erect, virtual and small and can be viewed in a mirror.

Uses of Concave mirrors

1. Generally concave mirrors are used in torch, search lights and headlights of vehicles to obtain a powerful beam of parallel light.
2. Concave mirrors are used to obtain large and clear image for shaving??
3. Large sized concave mirrors are used to focus sun rays in solar cookers and solar heaters.
4. Concave mirrors are used by dentists to view an enlarged image of patient's teeth.

Uses of Convex mirrors

Convex mirrors are mostly used as side glass of vehicles. These mirrors are clamped at the side of vehicles and driver can view the vehicle at its rear side so that he can drive safely. The primary importance of convex mirrors is due to its ability to form an erect image though the size of the image is small. Thus viewing area is much more because they are curved towards the outer side. Therefore as compared to plane mirror, convex mirrors provide a larger rear view to the driver.

What have you learnt

- The reflection of light-rays after striking a bright surface or a mirror back in same medium is called reflection of light.
- The angle of incidence is equal to the angle of reflection. This is the first law of reflection.
- Incident ray, reflected ray and perpendiculum the normal drawn at the point of incidence to the reflecting surface, lie in same plane. This is the second law of reflection.
- When parallel rays of light are incident on a plane mirror then the reflected rays of light are also parallel to each other. It is called regular reflection.
- The parallel light-rays incident on an irregular surface after being reflected are not parallel to each other but are reflected in different directions. It is called irregular/diffused reflection.
- Virtual image cannot be obtained on screen.

- Image formed by plane mirror is always erect, virtual and equal to size of an object. In plane mirrors, left part of the object is seen as right in image and right part is seen as left in image. This phenomenon is called lateral transformation.
- Spherical mirrors are of two types - concave mirror (divergent mirror) and convex mirror (convergent mirror).
- Convex mirror is that spherical mirror in which the outer curved surface works as reflector.
- Concave mirror is that spherical mirror in which inner curved surface works as reflector.
- Image formed by a convex mirror is always small, erect and virtual.
- Concave mirrors are used in torch, search lights and headlights of vehicles, for making shave, in solar cookers and heaters and by dentists.

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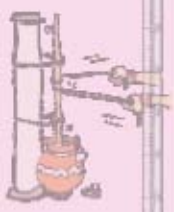
Exercises

Choose the correct answer

1. Image formed by concave mirror for a object placed away from centre curvature is -
   (A) At centre of curvature
   (B) at focal point
   (C) At infinity
   (D) in between focal point and centre of radius curvature ( )
2. To see the rear view of vehicles the following is used-
   (A) Convex mirror (B) Concave mirror
   (C) Plane mirror (D) all the above ( )
3. Image formed for an object placed in front of a plane mirror is-
   (A) At distance equal to distance between object and the plane mirror.
   (B) At twice the distance
   (C) At half the distance
   (D) At four times the distance ( )



Fill in the blanks with suitable words

1. Imaged formed by convex mirror is erect, small, ...
2. Infinite number of images are formed by two plane mirrors having..... angle in between them.
3. We use .....mirror to see our image.

Short answer questions

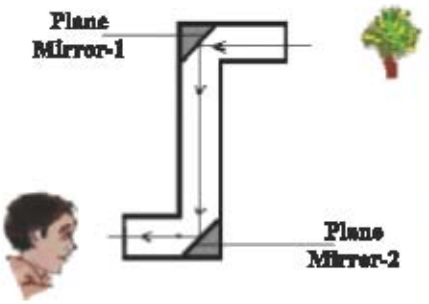
1. Define reflection.
2. A concave mirror has focal length of 20 cm. Calculate its radius of curvature.
3. Write down the laws of reflection.
4. What will you call the right part of an object's image as left part by plane mirror?
5. What is the difference between concave and convex mirror on the basis of constitution and images formation?

Long answer questions

1. Explain the process of image formation with a diagram for an object placed in front of a plane mirror.
2. Differentiate between virtual and real images.
3. Explain the regular and diffused reflection with the help of a diagram.

Activity based work

As shown in figure, make a simple periscope with two mirrors arranged in Z shaped box. Put its upper part towards the scene and view through the bottom. By this method, you can easily see the scenes of upper parts while remaining at bottom position.



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