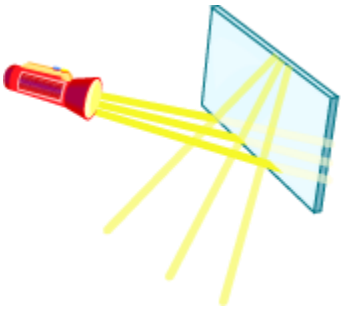
Light

Images Formed By Plane Mirrors

The visibility of objects around us, the formation of images in mirrors, etc. are all optical phenomena related to the **reflection of light**. In this section, we will learn in detail about the reflection of light by plane mirrors.

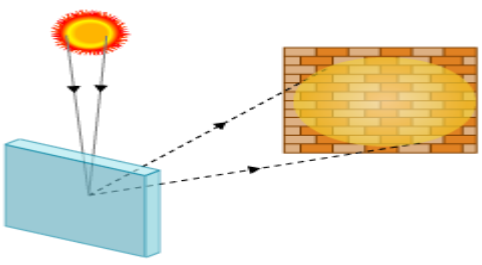
Reflection of light: Image formation



You are aware of the fact that light always travels in a straight line. However, when it falls on a polished surface that acts like a mirror, it changes its direction of propagation. This phenomenon of the changing of the direction of light by a mirror is known as the **reflection of light**. The ray of light that strikes a polished surface is known as the **incident ray**, while the ray of light that represents the incident ray after reflection is known as the **reflected ray**. The given figure shows the change in the direction of light rays falling on a plain mirror from a torch. The light moving toward the mirror is the incident light and that coming from the mirror is the reflected light. Since the surface of mirror is shiny, the light falling from the torch gets reflected by its surface, thereby forming an image of the torch in the mirror.

Images are formed because of the reflection of light from the shiny surface of a mirror.

The reflection of sunlight by a plane mirror is shown in the given figure.



Caution: Do not reflect sunlight at someone's face or eyes directly. This can cause serious damage to the eyes or skin.

Take a wide bath tub and fill it with water. Observe your face in still water by bending over the tub. Now, drop a stone in the water. What will happen to the image of your face? **Is the image still clear?** Discuss the result with your teacher.

The surface of still water acts as a plane mirror because it can form images by reflecting the light falling on it.

Shape and size of images

Observe the image of a pencil by placing it in front of a mirror. You will notice that the top of the lead will appear at the top of the image. Hence, the image is erect. The length of the image will be equal to the length of the pencil itself.

The image formed by a plane mirror is erect, of the same size, and appears to be formed at the same distance behind the mirror as the distance of the object in front of the mirror.

Hang two plane mirrors of different lengths side by side on a wall. Now, observe your image from a distance in the smaller mirror. Notice the size of your image. Now, observe your image from the same distance in the larger mirror. **Will the size of your image increase? Think about it**.

Difference between an object and its image

Which hand is being used by the boy to give a signal in the given image formed behind the mirror?

The image formed in a plain mirror is laterally inverted i.e. **right appears as left** and vice-versa.When you eat in front of a mirror using your right hand, it appears to be your left hand in the mirror. Hence, images are laterally inverted. The boy in the given figure has his right hand up, although it appears in the mirror image that it is his left hand.

Uses of Plane mirrors

Plane mirrors have a wide range of applications. They are used in

- Homes, beauty parlours etc. as looking glasses.
- Getting "multiple reflection" i.e. give an impression of large place with more objects like in jewellery shops.
- Hair cutting saloons to see the face and the back of the head simultaneously.
- Microscope to reflect the light on the objects.
- Solar ovens to reflect the sunlight into the oven.
- Kaleidoscopes to make attractive designs by multiple reflection.

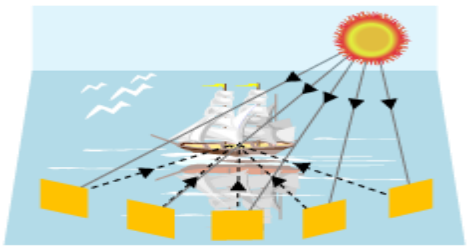
- Write your name on a paper and try to read it behind the mirror where its image is formed.

- A plane mirror is similar to a bar magnet in the sense that when broken into pieces, each piece is a similar plane mirror of smaller size.

- **Interesting Fact:**

- **Burning mirrors of Archimedes**

- Archimedes was a Greek mathematician and scientist. He invented a giant mirror system consisting of three to ten or more plain mirrors. The mirror system was used to set Roman ships afire during battle by reflecting and concentrating sunlight at a point.



Images formed by spherical mirrors

Spherical mirrors form images of an object that may be smaller, larger, or of the same size, erect or inverted, depending on their type and their distance from the object. In general, images formed by any type of mirrors can be classified in two types: real images and virtual images.

Difference between a real image and a virtual image

S. No.	Real Image	Virtual Image
1.	Can be obtained on a screen or wall	Cannot be obtained on a screen or wall
2.	Can be touched	Cannot be touched
3.	Formed in front of the mirror	Formed behind the mirror
4.	Formed by concave mirrors only	Formed by all types of mirrors i.e., plane, convex, and concave
5.	These images are always inverted	These images are always erect

You can distinguish between real and virtual images by checking the orientation (erect or inverted) of images and also by touching them.

Let us learn about the images formed by different spherical mirrors.

So, you have seen that

- the image formed by a convex mirror is **virtual**, **erect**, and of a **smaller size**.
- the image formed by a concave mirror is **virtual**, **erect** and of a **larger size** when placed near the surface of the mirror; and **inverted** and **may be smaller or larger than** the object when placed at a distance from the surface.

Concave mirrors form larger, smaller and of same size real images and also larger virtual images. On the other hand, convex mirrors always form smaller virtual images.

Take a concave mirror and a sharpener. Now, try to see the image of the sharpener in the mirror. Make sure that the sharpener is at a large distance from the concave mirror. Observe the size and the orientation of the image. Now, reduce the distance between the sharpener and the mirror and again notice the size and the orientation of the image. Repeat the observation by reducing the distance and try to complete the following table.

Distance between the sharpener and the concave mirror	Size of the image	Character of the image
20 cm	Smaller	Inverted
15 cm	Equal	
10 cm		
5 cm		

Replace the concave mirror with a convex mirror and follow the same steps. Make a similar table for the convex lens too.

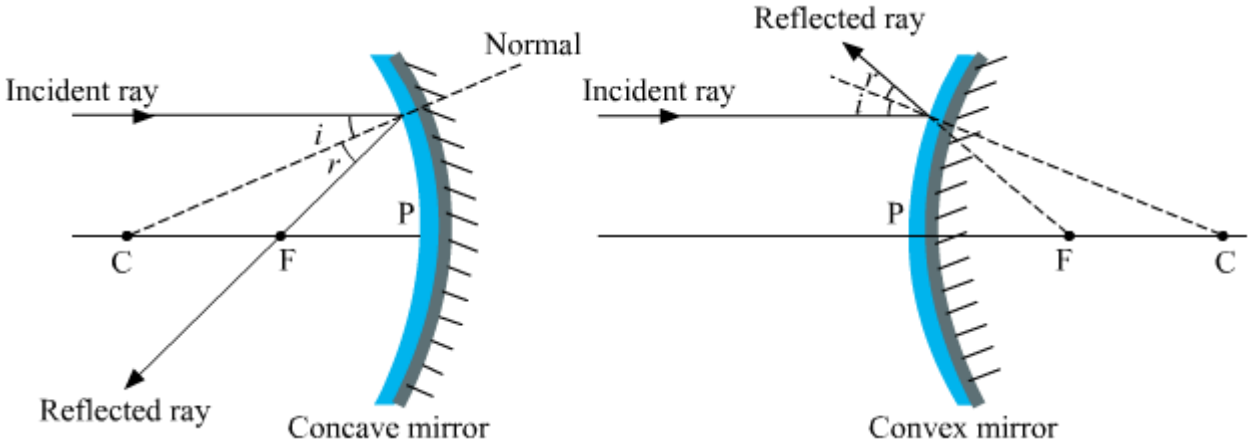
Collect some objects that have shiny surfaces and classify them as plane, convex, or concave mirrors.

Reflection by Spherical Mirrors

The different ways in which a ray of light is reflected from a spherical mirror are as follows:

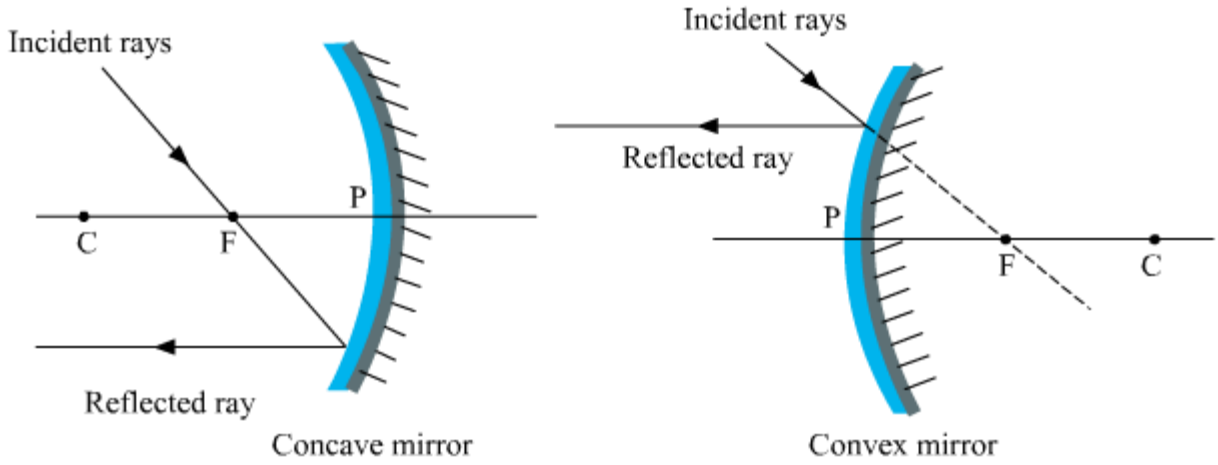
Case I: When the incident light ray is parallel to the principal axis

In this case, the reflected ray will pass through the focus of a concave mirror, or will appear to pass through the focus of a convex mirror.



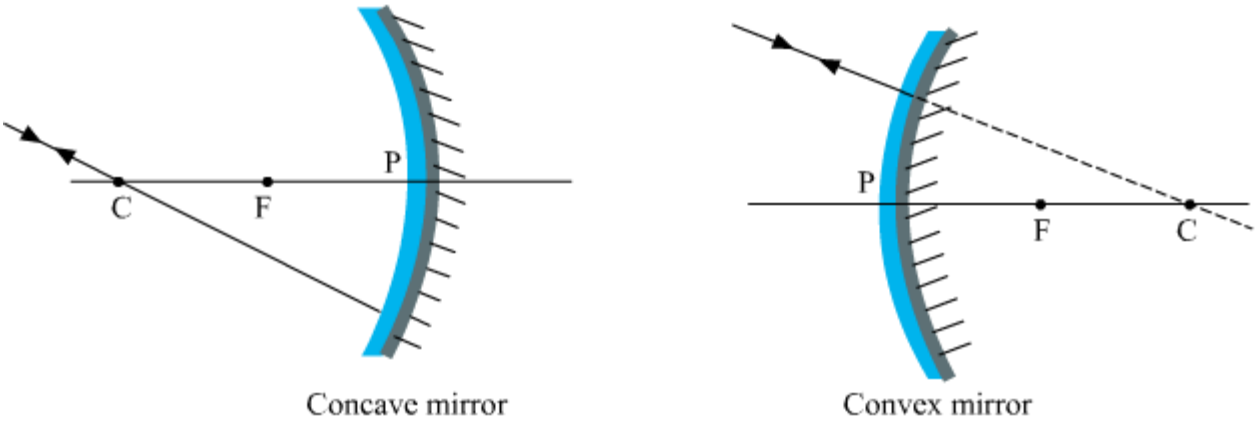
Case II: When the incident light ray passes through the focus of a concave mirror, or appears to pass through the focus of a convex mirror

In this case, the reflected light will be parallel to the principal axis of the spherical mirror.



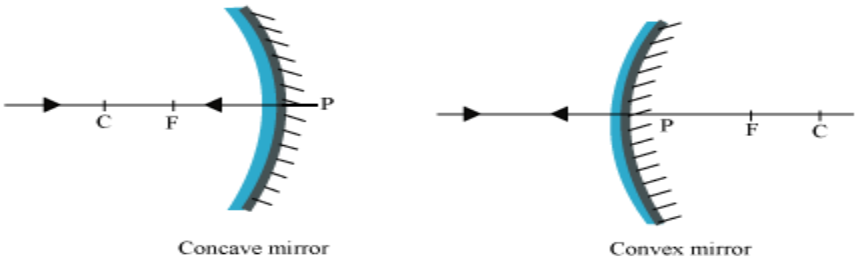
Case III: When the incident ray passes through or appears to pass through the centre of curvature

In this case, after reflecting from the spherical surface, light moves back in the same path. This happens because light is incident perpendicularly on the mirror surface.



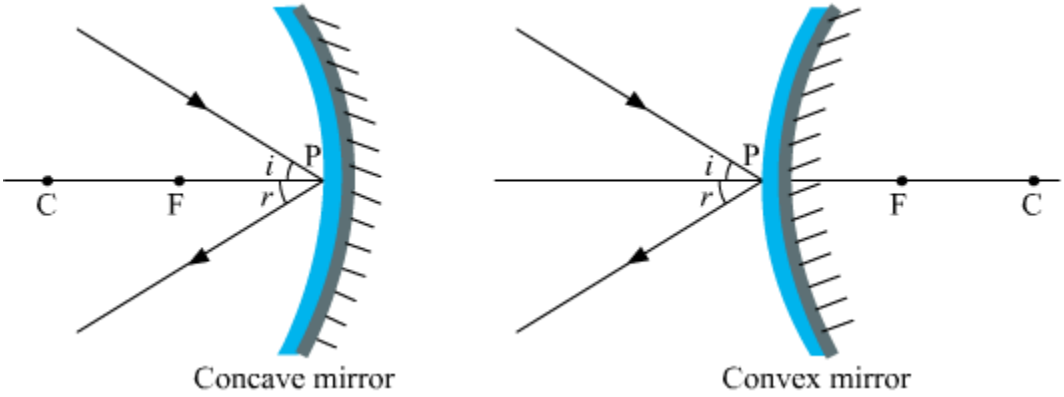
Case IV: When the incident ray is normal to the reflecting surface

In this case, the incident light ray will be reflected back by the reflecting surface of the spherical mirror, as in the case of a plane mirror.



Case V: When the ray incident obliquely to the principal axis.

In this case, the incident ray will be reflected back by the reflecting surface of the spherical mirror obliquely. And making equal angles with the principal axis**.**



Four spherical mirrors of radius of curvature R_1, R_2, R_3 and R_4 ($R_1 > R_3 > R2 > R_4$) are placed against sunlight. A bright spot is obtained on a paper sheet for each mirror. **Which mirror forms the brightest spot at a maximum distance from the pole of the mirror?** Explain.

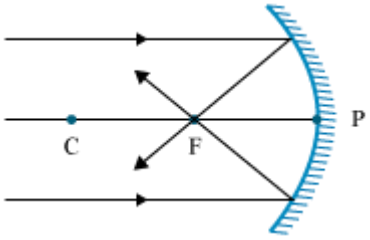
Images formed by Concave Mirrors

A concave mirror can produce both real and virtual images. The nature of an image depends primarily on the distance of the object from the mirror.

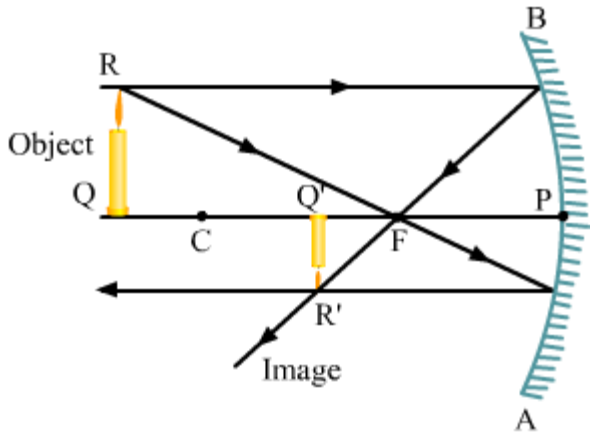
Let us consider the following cases:

I. When the object is at infinity

The light rays coming from infinity are parallel. When parallel light rays are incident on the reflecting surface of a concave mirror, they tend to meet at its focus after reflection. In this case, the image is formed at the focus, and is point-sized. It is also real and inverted.



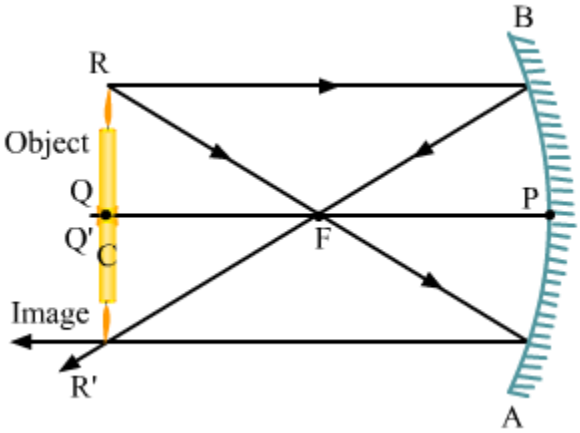
II. When the object is behind the centre of curvature



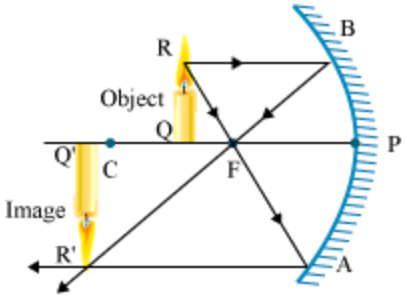
In this case, the image is formed between the focus **(F**) and the centre of curvature **(C)**. This image is real, inverted and diminished.

III. When the object is at the centre of curvature

In this case, the image is formed at the centre of curvature. This image is real, inverted and of the same size as the object.



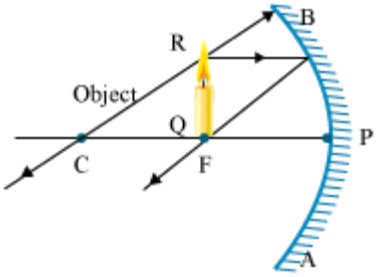
IV. When the object is between the centre of curvature (C) and the focus (F)



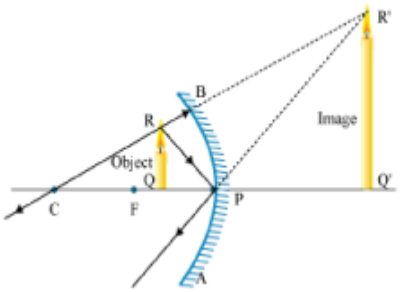
In this case, the image is formed behind the centre of curvature.

V. When the object is at the focus (F)

In this case, the image is formed at infinity. This image is real, inverted and highly enlarged.



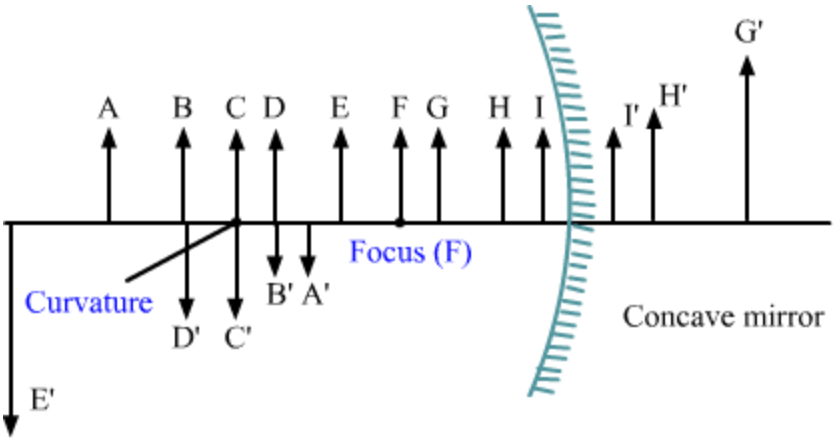
VI. When the object is placed between the focus (F) and the pole (P)



In this case, the image is formed behind the mirror. This image is virtual, erect and magnified.

The discussion is summarised in the table given below.

Object position	**Image position**	**Size of image**	**Nature of image**
At infinity	At F	Point-sized	Real and inverted
Beyond C	Between F and C	Small	Real and inverted
At C	At C	Same as that of the object	Real and inverted
Between C and F	Behind C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between F and P	Behind the mirror	Enlarged	Virtual and erect

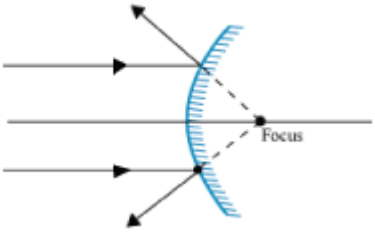


Images Formed by Convex Mirrors

A convex mirror always produces virtual and erect images of very small size. The images formed by a convex mirror are primarily classified in two ways.

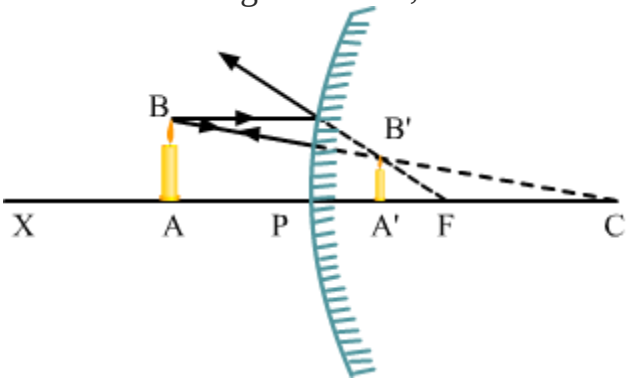
I. When the object is at infinity

In this case, the image appears to form at the focus. This image is virtual, erect and very small in size.



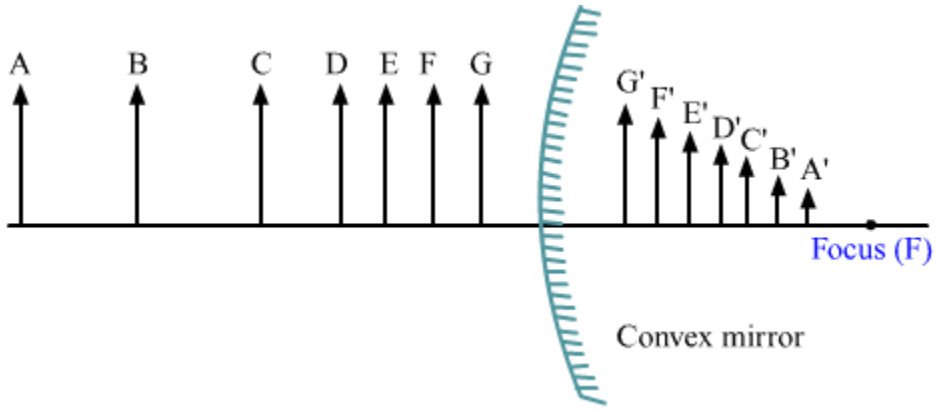
II. When the object is between the pole (P) and a point X (X lies beyond C)

In this case, the image is formed between the pole (P) and the focus (F), behind the mirror. This image is virtual, erect and small in size.



These results are summarised in the following table.

Object position	Image position	Size of image	Nature of image
At infinity	At F	Extremely small	Virtual and erect
Between P and X (X lies beyond C)	Between P and F	Small	Virtual and erect



Uses of Spherical Mirrors

Sanjay went to a dentist's clinic to get his decaying tooth examined. While sitting on the dentist's chair, he observed that the doctor was using a special type of mirror to examine his tooth. He wondered why the dentist had to use a different mirror for the examination.

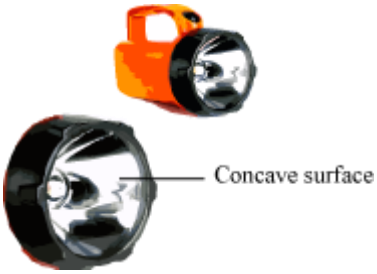
The special mirrors used by dentists are known as dentist's mirror. This mirror is actually a concave mirror and thus, capable of producing a larger image of an object (teeth, in this case). In this section, we will discuss the uses of the properties of concave and convex mirrors in our daily life.

1. Concave mirror

A concave mirror has the capability of forming images that can be smaller or larger in size and virtual or erect, depending on the position of the object.

These mirrors are used in various medical practices. For example, doctors use this mirror for obtaining a relatively larger image of teeth, ear, skin etc.

Concave mirrors are also used in reflectors for torches and headlights in vehicles. This is because these mirrors can reflect rays of light beams as very powerful light rays.



2. Convex mirror

A convex mirror always produces a smaller, virtual, and erect image of an object.

In convex mirror, the length of the image is shorter than that of the object. Hence, it is used as a side view mirror in vehicles because the viewed area must be larger than the surface area of the mirror. The convex mirror forms images of vehicles that are spread over a relatively larger area.

Vehicle mirror

Owing to this property, convex mirrors are also used in security mirrors that we often see in shops, malls, etc.

Image Formed by Spherical Lenses

One day Alok observed the transparent glasses used in his grandfather's spectacles. He found that the thickness of the glasses attached within the spectacles was not uniform. His grandfather told him that these glasses are lenses that help him in viewing objects. He wondered **how a piece of glass could help improve vision**.

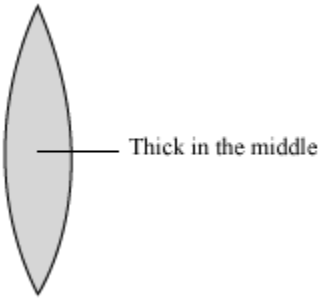
Lenses are transparent optical objects made of glass. These lenses have the ability to converge or diverge the incident light. This property of lens is used in spectacles for the improvement of vision.

Spherical lenses are of two types:

Convex lens

Concave lens

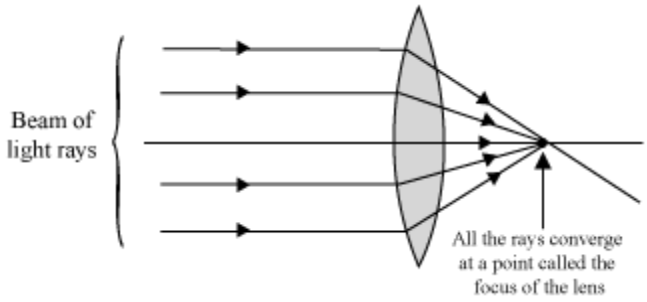
Convex lens



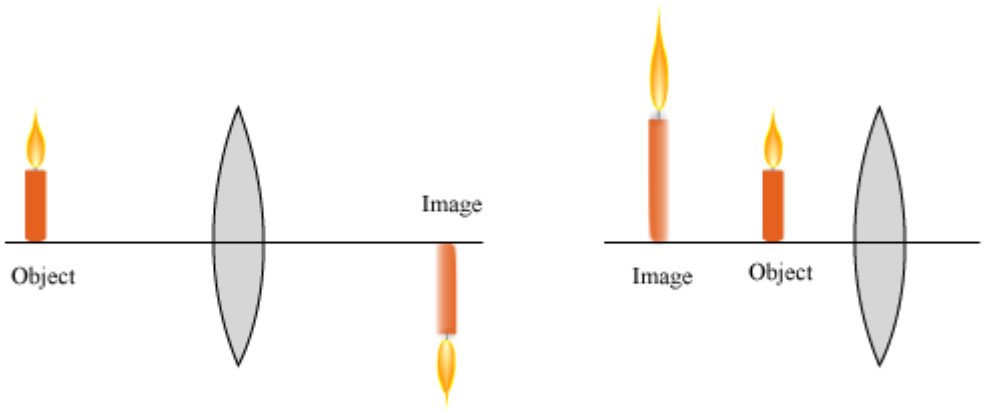
A convex lens is an optical, transparent object with a thicker middle part relative to both of its edges, as shown in the given figure.

Image formation by a convex lens

When a beam of light rays falls on the surface of a convex lens, the lens tends to bend the rays inward. All the rays meet or converge at a single point. Hence, a convex lens is also called a **converging lens**.



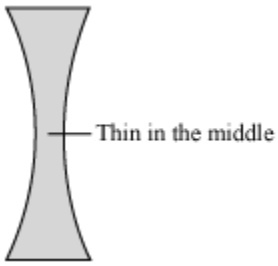
- Convex lens forms both virtual and real images. Real images are formed only behind the lens, whereas virtual images are formed in front of the lens. The size of a virtual image is larger than the size of the object, whereas the size of a real image may be the same, smaller, or larger than that of the object, depending on the distance of the object from the lens.



Finding the focus distance of a convex lens

Let us see how to find the focus distance of a convex lens.

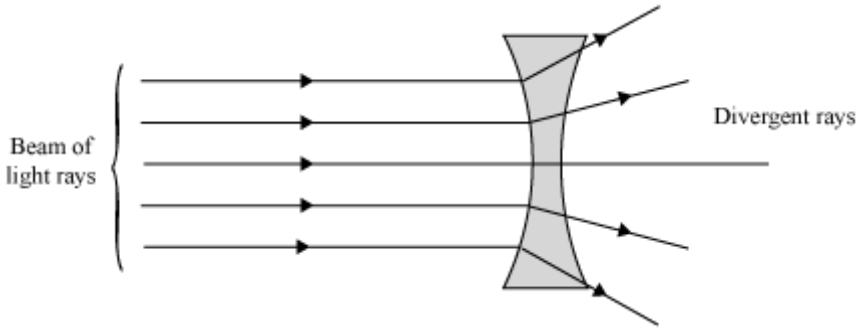
Concave lens



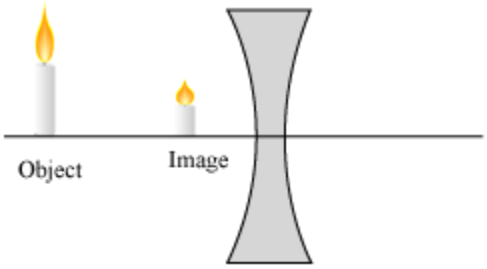
A concave lens is an optical transparent object with a thinner middle part relative to both its edges, as shown in the given figure.

Image formation by a concave lens

When a beam of light rays falls on the surface of a concave lens, the concave lens tends to bend the rays outward. Hence, all the rays diverge away from the lens. Therefore, a concave lens is also called a **diverging lens**.



- A concave lens forms virtual images of a smaller size. The images are erect and are formed in front of the lens.



Take a convex lens and place it between a burning candle and a large sheet of paper. Try to obtain the smallest image of the candle flame by moving the candle. Now, move the candle towards the lens and notice the size and the nature of the image. Repeat the same steps by further reducing the distance of the candle from the lens. **What will happen when the candle is close to the surface of the lens? Will the image disappear from the paper sheet?** Discuss the result with your teacher.

Now, replace the convex lens by a concave lens and perform the same activity. **Are you able to obtain the image in this case on the paper sheet?**

Lenses are used to form specific images in spectacles, telescopic microscopes, magnifying glasses, binoculars, etc.

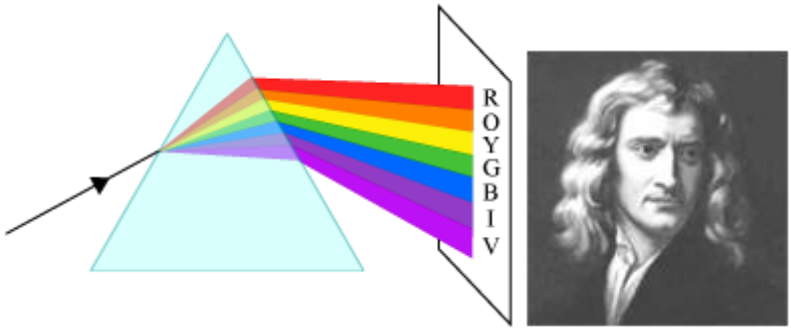
Composition of White Light

Chandu was surprised when he came to know that white light is actually a combination of lights of different colours.

On rainy days, you see a rainbow in the sky. You must have seen colours reflecting on the surface of a compact disc (CD) in the presence of sunlight. You might have wondered where these colours come from.

Newton and his Prism

Isaac Newton (1642 – 1726) was one of the greatest physicists and mathematicians that the world has ever seen. He was the first scientist to resolve white sunlight into its component colours. He used a transparent optical object called prism, which is made of glass, to separate the seven colours of white light. He allowed sunlight to enter a dark room through a hole. He then placed a prism to obstruct sunlight inside the room. He saw a band of seven colours on the dark wall. He published a paper depicting his findings about the constituent colours of white light.



The common point among the above examples is the presence of sunlight. To understand these phenomena, it is necessary to learn about the composition of sunlight.

Composition of sunlight

Let us first go through an activity.

The seven coloured disc that you have seen in the activity is known as **Newton Disc.**

So, you have learned that light emitted by the sun is composed of **seven** different colours. These colours are red, orange, yellow, green, blue, indigo and violet.

You can remember the seven colours of sunlight by the mnemonic **VIBGYOR**. Each letter represents the initial letters of the colours.

Try to obtain and observe the seven colours using a prism. Now, place a red transparent plastic sheet in front of sunlight. Are you able to see the seven colours? Perform similar experiments using other coloured transparent sheets. **What do your findings suggest?** Discuss the result with your friends.

On placing a red transparent sheet in front of sunlight, you observe that the spectrum of colours vanishes and only red-coloured light is obtained on the screen. Similarly, you will obtain only blue-coloured light on the screen for a blue transparent sheet and so on.

Try to observe the seven colours of sunlight on the surface of a soap bubble.

Take a wide tub filled with water and place it in sunlight. Observe the surface of water carefully. Is any colour of sunlight visible? Now, pour five to ten drops of petrol in water. Petrol will spread over the entire surface of water. Observe the water surface carefully. You will observe that the colours of a rainbow are present in the tub. **Is it correct to infer that petrol can act as a prism?** Discuss and confirm this with your teacher.

A rainbow appears in the sky only when it rains. Which substance or object acts as a prism to separate the various components of sunlight to form a rainbow?