Light

Laws of Reflection and Image Formation by Plane Mirror

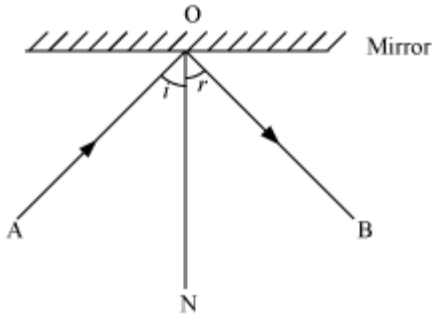
We are able to see things because of our sense of sight. It enables us to see beautiful landscapes, buildings, stars, moon, and everything else around us. **Have you ever wondered how we are able to see these objects?**

We are able to see different objects when light from these objects enters our eyes. This light may have been emitted by the object or reflected by it. We cannot see in dark. **Can you explain why?**

Laws of reflection

Consider a ray of light falling on a plane mirror. When the ray of light hits the mirror, it gets reflected in a certain direction. The ray of light which was incident on the mirror is known as the **incident ray,** whereas the ray of light reflected by the mirror is known as the **reflected ray**.

A straight line drawn perpendicular to the surface of the mirror at the point of incidence is known as **normal (N)** to the surface. The angle made by the incident ray with the normal is known as the **angle of incidence** (i). The angle made by the reflected ray with the normal is known as the **angle of reflection(r).**



Reflection from a plane mirror

Remember that in the activity, you have to take incident ray, reflected ray and normal on the same piece of paper. This shows that **incident ray, reflected ray and normal lie in the same plane**. This is the **second law of reflection**.

Reflection of light ray incident normally on a plane mirror

When a light ray is incident normally on a plane mirror, then the angle between the normal and the incident ray will be 0^o i.e. $\angle i = 0o \angle i = 0o$. Thus, following the law of reflection of

light, angle of reflection will also be 0^o i.e. $\angle r = 0o \angle r = 0o$. This shows that the light rays retraces its path after reflection if it is incident normally on a plane mirror or any reflecting surfaces.

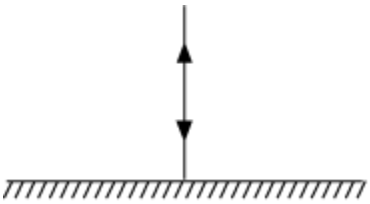


Image formation of a point object by a plane mirror:

Consider a plane mirror MM_1 and a point object O is placed in front of it. Rays from the point object travel in all directions but for its image formation (I) only two rays would be sufficient to consider.

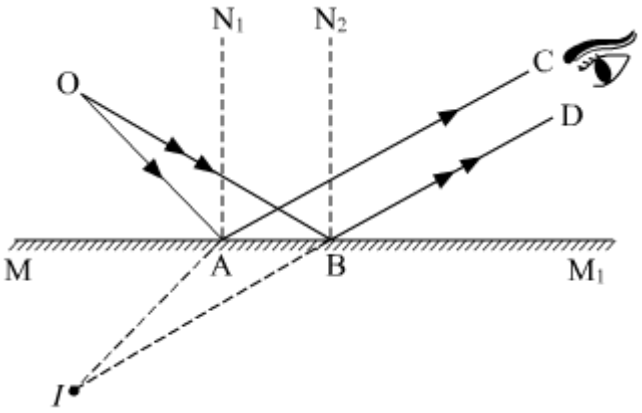
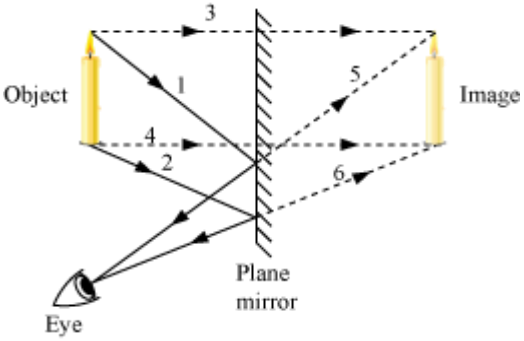


Image formation of an extended object by a plane mirror:

Take a candle and place it in front of a plane mirror. Mark the two rays coming from it as **1** and **2**.After reflecting from the mirror, these rays reach your eye.



However, these rays appear to be coming from somewhere inside the mirror. Also, the left part of the candle appears on the right and its right part appears on the left. This is known as **lateral inversion.**

Characteristics of image formed by plane mirror

- virtual and erect
- same size as of object
- laterally inverted
- image distance and object distance are same and perpendicular from mirror

Virtual images are those images which cannot be obtained on screen. But there are some images which can be obtained on screen. Such images are called real image.

Uses of plane mirror

- It is used as a looking glass.
- It is used to increase the effective length of an optician's room.
- In periscope, two parallel plane mirrors are inclined at 45 degrees with vertical walls such that they are facing each other.
- In kaleidoscope, three plane mirrors are inclined with each other at 60 degrees.
- It is used in solar heaters and cookers to heat substances by reflecting the sunlight towards the substances.

Differences between an image and a shadow

Image	**Shadow**
An image is formed by the reflection of light from a surface.	A shadow is formed when the path of light is blocked by an opaque object.
An image shows the details of an object.	A shadow does not show the details of the object.
An image has same colour as the object.	A shadow is always black.

Regular and Diffused Reflection

You have already learned about formation of image on plane and spherical mirrors. Now let us see how reflection of light rays takes place from different types of surfaces.

Therefore, we can define regular and irregular reflections as

When all the reflected rays from a given smooth surface are parallel for parallel incident rays, the reflection is known as regular reflection.

And

When for a given set of incident parallel rays, the reflected rays do not remain parallel to each other, the reflection is known as diffused or irregular reflection.

The laws of reflection are valid in regular as well as irregular or diffused reflections.

Objects that give their own light are known as **luminous objects**. The sun, candle, and bulb are a few examples of luminous objects.

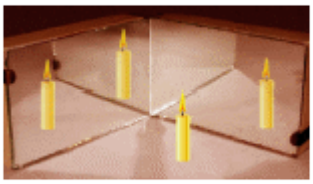
However, most objects that we see around us are visible because of the light reflected from them. For example, moon does not have its own light. It reflects the light of the sun, which incidents on it. Objects that are visible because of reflected light are known as **illuminated objects**.

Multiple Reflection

Have you ever visited a magical mirror-house where a large number of mirrors are fixed on the wall? There, you can see a large number of your own images in a single mirror.

How is this possible?

To find out, let us perform an activity. Take two plane mirrors and place them at right angles to each other. Now, place a candle between the mirrors.



How many images can you see in the mirrors? In this arrangement, three different images of the candle can be seen. When you decrease the angle between the two mirrors to 60°, then more than three images are visible. If you place two mirrors parallel to each other, then you can see infinite number of images! **How is this possible?**

This is due to multiple reflections. Let us explore.

Multiple reflections from two mirrors

A ray of light from an object gets incident on mirror **1**. Mirror **1** reflects this ray towards mirror **2**. This reflected ray from the first mirror acts as an incident ray for the second mirror. In the same way, the reflected ray from mirror **2** acts as an incident ray for the third mirror. Hence, multiple reflections take place .You can see as many images as reflected rays. If infinite reflections take place, then they produce infinite images.

How can we calculate the number images formed by multiple reflection between two mirrors?

Well it can be calculated very easily using

Number of images formed between two mirrors= $\frac{360^{o}}{angle\ between\ two\ plane\ mirros} - 1$

Periscope

Periscope is an optical device used to see objects that are not along the line of sight. Let us see the working principle of a simple periscope.

Periscopes are used in submarines. Crew members can see the ships above water, while they remain underwater.

Kaleidoscope

It is a tube which consists of mirrors fixed inside a cylindrical box. This tube also contains loose colour beads or pebbles. It functions on the principle of multiple reflections of light.

When light enters the tube, it undergoes multiple reflections. Hence, it forms a large number of images of the coloured beads. When rotated, a beautiful symmetric coloured image is formed.

In a kaleidoscope, you cannot get the same pattern of the coloured image again. This is because each time you rotate the tube, relative positions of the loose colour beads change.

Dispersion of light

So, you have seen that when light coming from the sun is allowed to pass through a prism, it breaks down into different colours. This splitting of light into different colours is known as **dispersion**.

Let us perform another activity to understand this better.

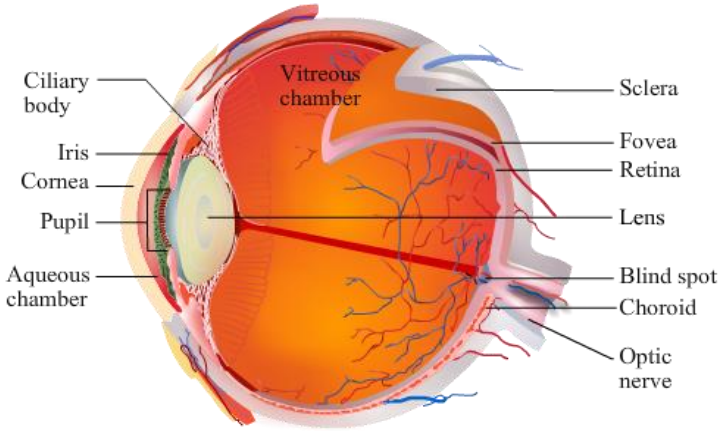
Take a cardboard sheet and make a small hole in it. Now, place a small mirror in a bowl filled with water. Make sure that the mirror faces the sun. Now, hold the cardboard between the mirror and a paper sheet and obtain the reflected sunlight from the mirror on the white paper sheet. When the sheet of paper is adjusted properly, you will see that the reflected light has different colours.

Human Eye

We are able to see things with the help of our eyes. The Eye is one of the most important sense organs. Let us see the structure of our eye.

The Shape of the eye is roughly spherical with an average diameter of around 2.3 cm. The outer part of the eye is quite tough and white in colour. This white part of the eye is known as **sclera.** The transparent, front outer covering of the eye is known as the **cornea**. Behind the cornea, there is a colored membrane known as the **iris**. It regulates the amount of light entering the eye. It also gives colour to the eye. In the iris, there is a variable sized, black circular opening known as the **pupil**. Its size is controlled by the iris. It appears to be black in colour because most of the light entering it is absorbed by the tissues, which are present in the pupil.

The size of the pupil depends on the brightness of light. It opens and closes in order to regulate and control the amount of light entering the eye. When we enter a dimly lit room, it takes the iris some time to expand the pupil to allow more light to enter the eye. For this reason, it takes us a few seconds to clearly see objects in a dimly lit room



Behind the pupil there is a lens which is thicker at the centre. It is made up of **living cells**. Two **Ciliary muscles** hold the lens within the eye-ball. The eye lens being convex in nature converges the light rays' incident on it. Hence, it focuses the light falling on it on a thin layer of nerve cells called the **retina**. The retina is made up of a large number of nerve cells. Light falling on these nerve cells stimulate two kinds of sensitive cells known as **cones** and **rods**. Rods are sensitive to low light levels. Cones are sensitive to bright light, but they sense colours. Sensation felt by them is transmitted to the brain in the form of electrical signals through the optic nerve. This allows us to see.

The point where the retina and the optical nerve meet each other is devoid of any sensory cells. Hence, vision is not possible from this point. This point is known as the blind spot.

Take a white sheet of paper and write the alphabets **'A'** and **'Z'** on it (as shown in the give figure). Make sure that both alphabets are separated by atleast 8 cm. Now, close your right eye and look continuously at **'Z'**. Simultaneously, move the paper sheet slowly towards your eye. You will observe that the letter **'A'** disappears at some point. **What does this indicate?**

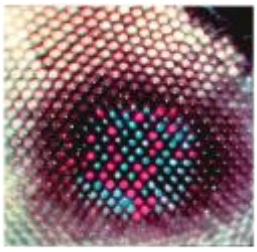
It indicates that there exists a spot on the retina where no images are formed. Perform the same activity by closing your left eye and looking at letter **'A'**. This time the alphabet **'Z'** would disappear. This implies that the blind spot is situated rightward in the right eye and leftward in the left eye.

The natural tendency of the iris and the pupil to contract and expand respectively, when exposed to bright light is used to check an unconscious person. Paramedics use this by shining a torch light in the eyes of an unconscious person to observe whether his/her iris or pupil is showing any change or not.

Persistence of an image

The image formed on the retina persists for about $\frac{1}{16}$th of a second. This means that if you are shown still pictures of a moving object at a rate faster than 16 pictures per second, then the object will appear to be moving. This is because, the image of a picture stays on your retina for $\frac{1}{16}$th of a second and you will not be able to recognize the time taken to change these pictures. This method is used in motion pictures where a large number of pictures are flashed at a rate of 24 images per second! Hence, they appear to be moving.

Do You Know:

Animals use their eyes in a special way. Crabs have very small eyes, which are located on the head. This helps a crab to look behind. Butterflies have a large number of eyes. An Owl's eye is composed of a large numbers of rod cells and a very few number of cones on the retina. Hence, it is not able to see in daylight.	 Butterfly eye

Do you know what happens if the image of an object does not form on the retina of an eye?

One will not be able to see clearly. The retina consists of photosensitive cells, which sends electrical pulses to the brain via the optic nerve. This enables us to see and sense objects.

Eye defects

We can see distant objects as well as the objects near us. The minimum distance up to which an eye can see clearly and distinctly without any stress is called the **least distance of distinct vision.**

The least distance of distinct vision for a normal eye is 25 cm.

The least distance of distinct vision varies as we grow older or because of some disease. This leads to many eye defects. For example, some people are able to see distant objects clearly; however they face problems in looking at objects close to them. On the other hand, some people can clearly see objects close to them, but face problems in looking at distant objects. These eye defects can be corrected by using suitable lenses (convex lens for the first defect, and concave lens for the second defect).

Sometimes with the passing of age, the eye lens can become cloudy and opaque. Due to this, the person's eyesight becomes foggy. This defect is known as **cataract**. In this defect, a white spot can be seen in the eye lens. This type of a defect is corrected by surgery, by removing the opaque lens and installing an artificial lens.

The Eye Care

The Eye is a very sensitive organ. Hence, special care must be taken to protect them.

To protect your eyes, the following points should be remembered:

- Avoid reading in dim light.
- Wash your eyes at least four times a day with clean and cold water.
- Wash your eyes quickly if dust particles or small insects enter your eye.
- Visit an eye specialist regularly. Improper vision can cause stress, eyestrain, and even headaches.
- While reading, maintain a distance of atleast 25 cm between your eyes and the book.
- Do not rub your eyes. If redness in the eye persists, then consult an eye specialist immediately.
- Avoid direct exposure to sunlight. Exposure to a large amount of light can harm your retina.

A balanced diet is essential for maintaining good eyesight. Deficiency of some minerals can also lead to various eye defects. For example,deficiency of vitamin A can lead to night blindness. Therefore, it is essential to include vitamin A in our diet. Vitamin A is found in raw carrots, broccoli, and green vegetables like spinach. Cod liver oil, eggs, milk, curd, cheese, butter, and fruits such as mango and papaya are also rich in vitamin A

Visually Handicapped People

Visually handicapped people have limited vision to see objects. People can be visually handicapped since birth or because of some disease. Such people try to identify objects

with the help of other sensory organs like sense of hearing or by touching objects around them. Their capabilities can be increased with the help of additional resources. These resources are primarily classified into two categories:

I. Optical aids

Lenses, contact lenses, tinted (lightly coloured) lenses, bifocal lens, magnifying glasses, and telescopic aids are some examples of optical aids, which consist of optical glasses. Defects in vision can be minimized with the help of these aids.

II. Non optical aids

Visual aids, tactual aids, auditory aids, electronic aids etc. are some examples of non optical aids.

- **Visual aids**

  They are used to magnify words, to provide light of suitable intensity, and to maintain objects at proper distances for strain free vision.

- **Tactual aids**

  They include the Braille writer slate and stylus, which helps visually handicapped people to take notes, read, and write. These devices use the sense of touch.

- **Auditory aids**

  Include magnetic cassettes, tape recorders, talking books, and other similar devices. These devices use the sense of hearing.

- **Electronic aids**

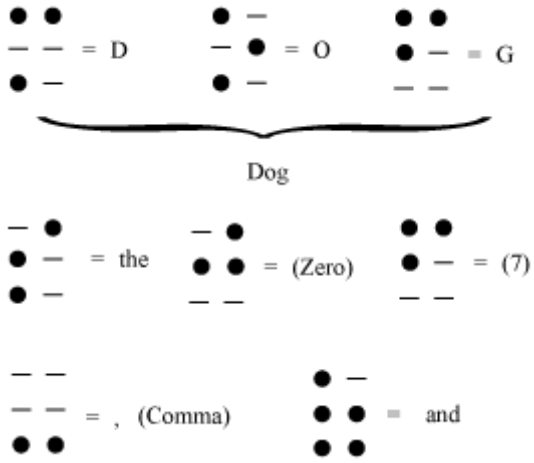
  These aids are used for computational works by visually challenged people. They include devices like the talking calculator. Closed circuit television enlarges the printed words with proper contrast and illumination. Audio CDs and voice boxes are also helpful in reading and writing.

Braille system

Visually challenged people use a tactual aid known as the **Braille system**. In this system, people use the sense of touch to read and write words. It is the most popular system devised for reading and writing for the visually handicapped. The present form was adopted in 1932. A **Braille code** is used for common languages, mathematical works, and scientific notations.

Reading by the Braille system

To read, visually challenged people have to memorize each character of the Braille code such as letters, special characters, and letter combinations by touching them. Braille codes and texts can also be produced by machines such as type writers and printing machines.

Braille code **Do you know that the founder of the Braille system was also a visually challenged person?** Louis Braille, a Frenchman, devised this system in 1821. This system has 63 dot patterns or characters. Each character stands for a letter, a combination of letters, a word, or a grammatical sign. In the Braille coding, dots are arranged in cells of three rows and two columns. These dots are raised slightly, so that it becomes easier to touch them.	

Do You Know:

Some visually challenged Indians have done wonders in many walks of life. Some of them are Diwakar (singer); Ravindra Jain (lyricist, singer, and music composer); Mr. Lal Advani (established an association for special education and rehabilitation for the disabled in India).	 Ravindra jain

Helen A Keller, a renowned American author, became visually challenged due to meningitis.	 Helen A Keller