

REFLECTION OF LIGHT

LAWS OF REFLECTION AND FORMATION OF IMAGE BY PLANE MIRRORS

1.1 REFLECTION OF LIGHT

When you smile into a mirror, you see your own face smiling back at you. This is caused by the reflection of light rays on the mirror. Reflection occurs when a light ray bounces off an illuminates them. When the reflected light reaches our eyes, we can see the objects.

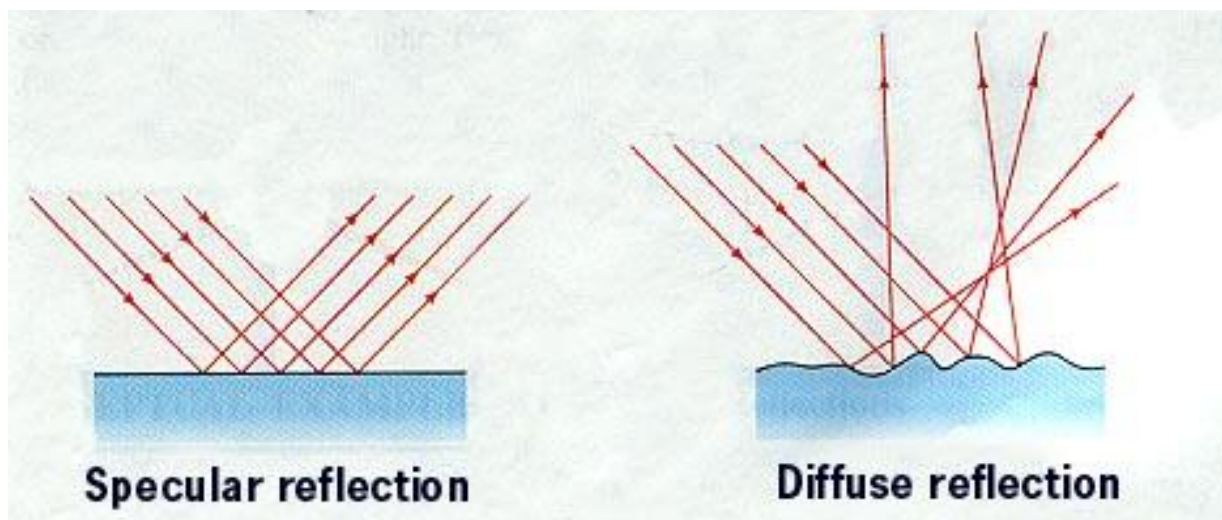
Reflection can be defined as the bouncing back of light into the same medium after striking a surface.

Different surfaces reflect light to different extents. A highly polished and smooth surface, such as a plane mirror, reflects almost the entire light falling on it.

A plane mirror is made from a thick glass plate. One surface of the glass is polished to a high degree of smoothness which forms the reflecting surface of the mirror and the other surface is silvered using silver or mercury. The silvered surface is coated with red lead oxide so as to protect the silvering on the surface. Light enters from the polished surface and is reflected from the silvered surface. The coating serves as the opaque surface and it does not reflect light.

1.2 Types of Reflection

The Law of Reflection is true for any surface. Does this mean that when parallel rays approach a surface, the reflected rays will also be parallel? This depends on the texture of the reflecting surface.



Specular (Regular) Reflection

Parallel incident light rays hit the smooth surface and parallel reflected light rays leave the surface. This type of reflection is called specular or regular reflection. Specular reflection occurs when rays are reflected from a smooth, shiny surface. The normal to the surface is the same at every point on the surface. Parallel incident rays become parallel reflected rays. When you look in a mirror, the image you see is formed by specular reflection.

Diffuse (Irregular) Reflection

When multiple rays hit an uneven surface, diffuse reflection occurs. The incident rays are parallel but the reflected rays are not. Each point on the surface has a different normal. This means the angle of incidence is different at each point. Then according to the Law of Reflection, each angle of reflection is different. Diffuse reflection occurs when light rays are reflected from bumpy surfaces. You can still see a reflection as long as the surface is not too bumpy. Diffuse reflection enables us to see all objects that are not sources of light.

1.3 Terms related to reflection

1. **Incident ray:** The light ray striking the reflecting surface is called the incident ray.

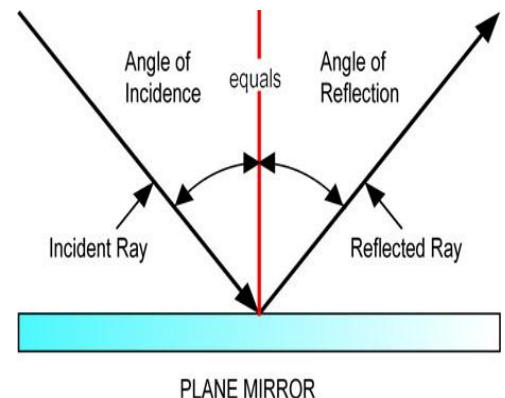
2. **Point of incidence:** The point at which the incident ray strikes the reflecting surface is called the point of incidence.

3. **Reflected ray:** The ray that returns back to the medium after reflection is called the reflected ray

4. **Normal:** The perpendicular drawn to the surface at the point of incidence is called the normal.

5. **Angle of incidence:** The angle which the incident ray makes with the normal is called the angle of incidence.

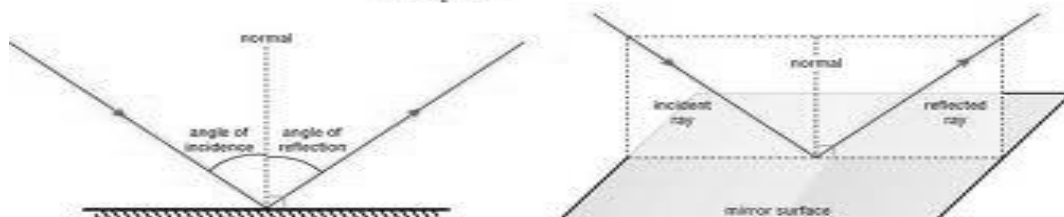
6. **Angle of reflection:** The angle which the reflected ray makes with the normal is called the reflected ray.



1.4 Laws of Reflection

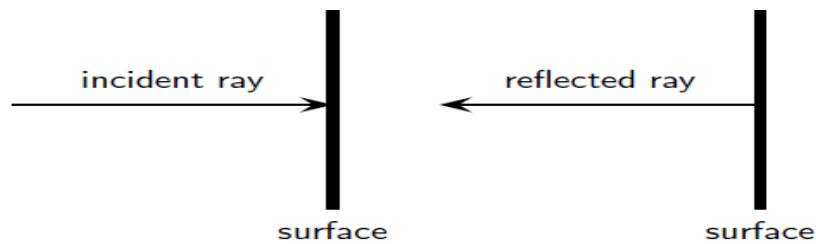
The reflection at a surface obeys the following two laws which are called the laws of reflection.

1. The angle of incidence equals the angle of reflection.
2. The incident ray, the reflected ray, and the normal all lie in the same plane.

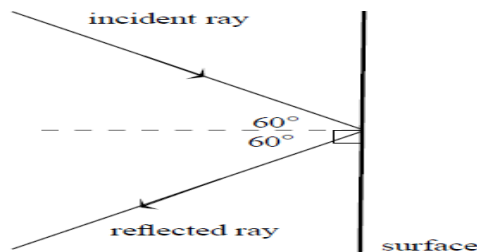


1. The angle of incidence is equal to the angle of reflection

The simplest example of the law of incidence is if the angle of incidence is 0° . In this case, the angle of reflection is also 0° . You see this when you look straight into a mirror.



When a wave strikes a surface at right angles to the surface, then the wave is reflected directly back. If the angle of incidence is not 0° , then the angle of reflection is also not 0° . For example, if light strikes a surface at 60° to the surface normal, and then the angle that the reflected ray makes with the surface normal is also 60° .



2. The incident ray, reflected ray and the normal at the point of incidence, lie in the same plane

1.5 Experimental verification of the laws of reflection

The laws of reflection can be verified by the following experiment:

Apparatus required: a drawing board, a white sheet of paper, a few common pins and a plane mirror.

Procedure: Pin the white sheet of paper firmly on the drawing board. Place the plane mirror on it and trace its outline on the paper. Then remove the mirror and draw the 'normal.' The normal is the 90° vertical line drawn to the outline of the mirror.

Now place the mirror again on the outline. The normal will be reflected clearly on the mirror.

Next place two pins in a straight line on one side of the normal on the white sheet of paper.

Next place two pins on the other side of the normal in such a way, that these two pins are in a straight line with the reflection of the two pins on the other side of the normal.

Now remove the mirror and the pins and join the pin marks to the normal.

It will be seen that the angles which the lines make on both sides of the normal will be equal. So, if one line represents the incident ray - the ray which is travelling from the source of light - and the other line represents the reflected ray - the ray of light which has been reflected - it is proved that the angle which the incident ray makes to the normal is always equal to the angle which the reflected ray makes to the normal.

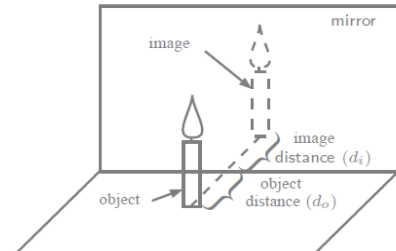
Since the lines representing the normal and the incident and reflected rays are all represented on the sheet of plain paper, the second law that the incident ray, the reflected ray and the normal are coplanar.

1.6 Formation of image by reflection

Definition: Image

An image is a representation of an object formed by a mirror or lens. Light from the image is seen.

If you place a candle in front of a mirror, you now see two candles. The actual, physical candle is called the object and the picture you see in the mirror is called the image. The object is the source of the incident rays. The image is the picture that is formed by the reflected rays.



The image formed in the mirror is virtual and upright

The object could be an actual source that emits light, such as a light bulb or a candle. More commonly, the object reflects light from another source. When you look at your face in the mirror, your face does not emit light. Instead, light from a light bulb or from the sun reflects off your face and then hits the mirror. However, in working with light rays, it is easiest to pretend the light is coming from the object.

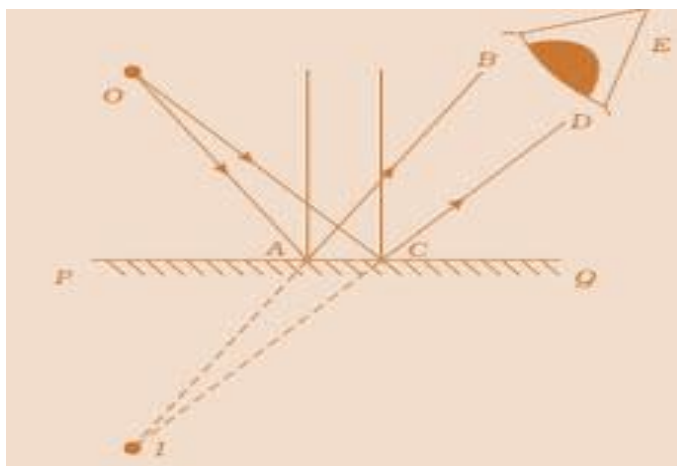
An image formed by reflection may be real or virtual. A real image occurs when light rays actually intersect at the image. A real image is inverted, or upside down. A virtual image occurs when light rays do not actually meet at the image. Instead, you "see" the image because your eye projects light rays backward. You are fooled into seeing an image! A virtual image is erect or right side up (upright).

You can tell the two types apart by putting a screen at the location of the image. A real image can be formed on the screen because the light rays actually meet there. A virtual image cannot be seen on a screen, since it is not really there.

To describe objects and images, we need to know their locations and their sizes. The distance from the mirror to the object is the object distance, d_o . The distance from the mirror to the image is the image distance, d_i .

1.7 Image of a point object formed by a plane mirror

Let PQ be a plane mirror in front of which a point object O is placed. From the object O, rays of light travel in all directions. To show the formation of image by a plane mirror, we need at least two rays from the point object O which fall on the mirror PQ. Let OA and OC be the two rays incident on the mirror from the point object O. The rays OA and OC obeying the laws of reflection get reflected from the mirror PQ in directions AB and CD respectively.



When seen from the position between B and D, the rays appear to come from some point I behind the mirror. The point I is the virtual image of the object O. The image is virtual because the reflected rays AB and CD do not actually meet at I, but to our eye they appear to come from I. To locate the point I, the rays AB and CD are produced backwards.

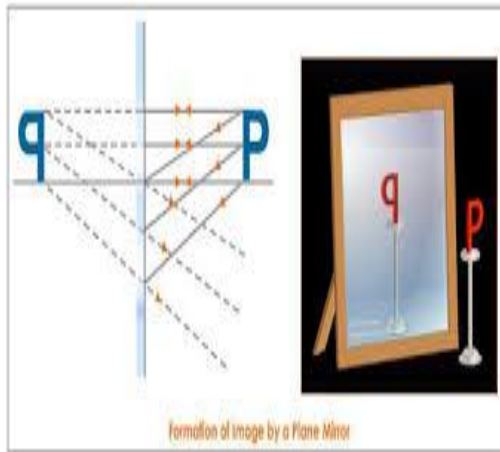
Position of image: The image I is as far behind the mirror as the object O in front of it. i.e., the perpendicular distance of image from the mirror is equal to the perpendicular distance of object from the mirror.

1.8 Lateral Inversion

When you look in a mirror, your left hand appears to be a right hand. If you hold a textbook up to a mirror, you will notice that the text appears to be reversed. This interchange of the left and right sides is called the lateral inversion.

The phenomenon in which left appears as right or vice versa in the image formed by a plane mirror is called lateral inversion.

The figure below shows the image formation of a letter P in a plane mirror. Note that lateral inversion of letters such as A, H, I, M, O, T, U, V, W, X and Y is not noticeable since their image remains unchanged



It is due to lateral inversion of the image formed in a plane mirror that it becomes difficult to read the text of a page from its image formed by reflection from a plane mirror. Sometimes, emergency vehicles are labelled in reverse printing so that their signs can be read in car's rear view mirror

1.9 Characteristics of the image formed by a plane mirror

The image formed by a plane mirror is

1. Upright (or erect)
2. Virtual
3. Of same size as the object
4. Laterally inverted
5. The image is as far behind the mirror as the object is in front of it.

1.10 Uses of Plane mirrors

Plane mirrors have a number of applications in our daily life. Some of the applications are given below

1. As a looking glass
2. In a barbers shop for seeing the hair at the back of the head.
3. In the opticians room to increase the effective length of the room by keeping a plane mirror on the front wall and the sign board on the opposite wall behind the patient.
4. In a periscope
5. In a kaleidoscope.
6. In solar heating devices such as a solar cooker.

1.11 Simple Periscope

Periscope, an optical device used for viewing objects that are out of the line of sight. Periscopes are used in tanks and submarines where it is necessary to see from a protected position. They have also been used for viewing the interiors of nuclear reactors. Simple periscopes are sometimes used by onlookers at parades, for seeing over the heads of the crowd.

Principle: It is based on the principle of reflection at the two parallel plane mirrors facing each other and each kept inclined at an angle of 45° with the vertical.

Construction:

A simple periscope is just a long tube with a mirror at each end. The mirrors are fitted into each end of the tube at an angle of exactly 45 degrees (45°) so that they face each other.

In the periscope, light hits the top mirror at 45° and reflects away at the same angle. The light then bounces down to the bottom mirror. When that reflected light hits the second mirror it is reflected again at 45° , right into your eye. Light is always reflected away from a mirror at the same angle that it hits the mirror.

Working: The rays of light entering the tube from the object strike the first mirror at an angle of incidence nearly equal to 45° . These rays are reflected along the axis of the tube obeying the laws of reflection. The rays reflected from the first mirror strike the second mirror at an angle of incidence nearly equal to 45° . The rays are finally reflected by the second mirror parallel to their original path reaching the eye. Thus the objects which could not be seen due to obstruction can now be seen.

