

Chapter 04

Refraction of Light at Plane Surfaces

We have learnt about the reflection of light on plane surfaces in our previous class. Light exhibits many interesting phenomena.

You might have observed that a coin kept at the bottom of a vessel filled with water appears to be raised. Similarly, a lemon kept in a glass of water appears to be bigger than its size. When a thick glass slab is placed over some printed letters, the letters appear raised when viewed through the glass slab.

Aren't these interesting and fascinating at the same time.

We will discuss many such interesting activities in this chapter.

Activity-1

Take some water in a glass tumbler. Keep a pencil in it. Look at the pencil from one side of the glass and also from the top of the glass.

- How does it look?
- Do you find any difference between the two views?

Activity-2

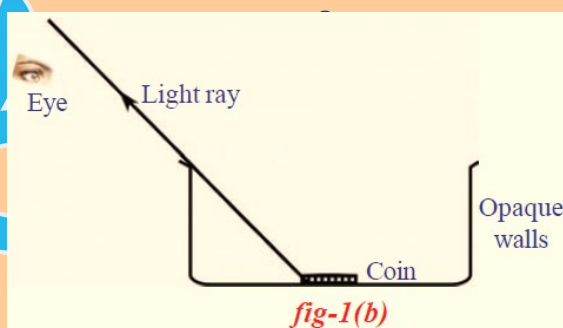
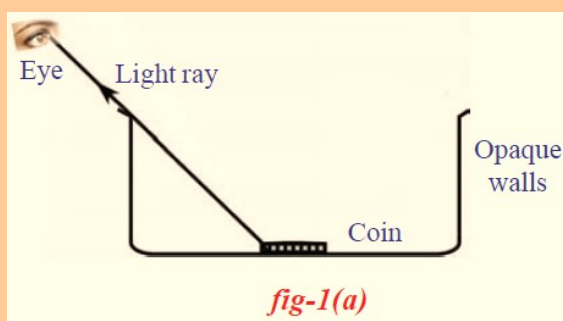
Go to a long wall (of length about 30feet) facing the Sun. Go to one end of a wall and ask your friend to bring a bright metal object near the other end of the wall. When the object is a few inches, from the wall it appears distorted and you will see a reflected image in the wall as though the wall were a mirror.

- Why is there an image of the object on the wall?

To answer the above questions and to give reasons for the situations mentioned we need to understand the phenomenon of refraction of light.

Refraction:

Take a shallow vessel with opaque walls such as a mug. (A tin or a pan is suitable). Place a coin at the bottom of the vessel. Move away from the vessel until you cannot see the coin.



Stand there. Ask your friend to fill the vessel with water. When the vessel is filled with water the coin comes back into view.

- Why are you able to see the coin when the vessel is filled with water.

You know that the ray of light originating from the coin, doesn't reach your eye when the vessel is empty (see fig.-1b). Hence you couldn't see the coin. But the coin becomes visible to you after the vessel is filled with water.

- How is it possible?
- Do you think that the ray reaches your eye when the vessel is filled with water?

If yes, draw a ray diagram from the coin to the eye. Keep in mind that the light ray travelling in a medium takes a straight-line path.

- What happens to the light ray at the interface between water and air?
- What could be the reason for this bending of the light ray in the second instance?

The above questions can be answered by Fermat's principle.

- What exactly is Fermat's principle?

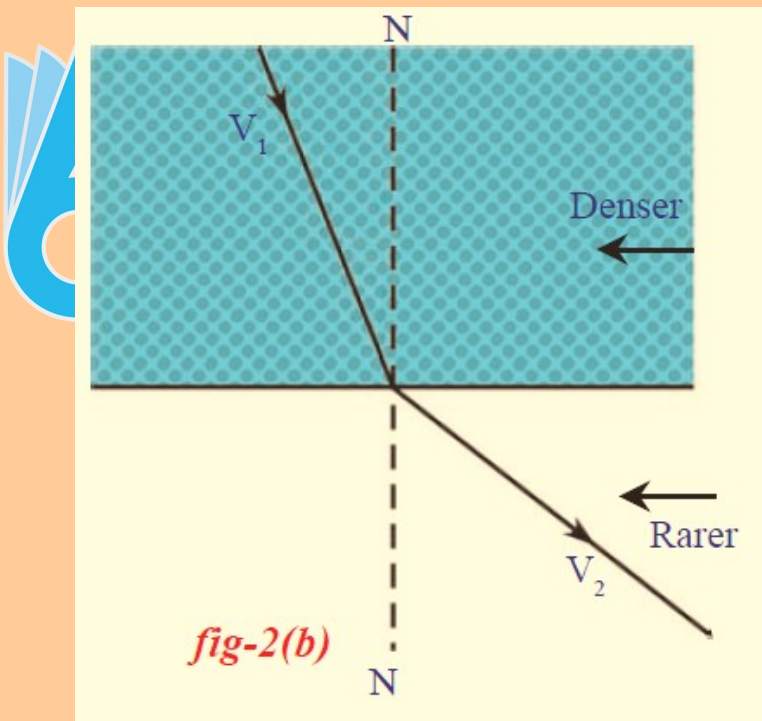
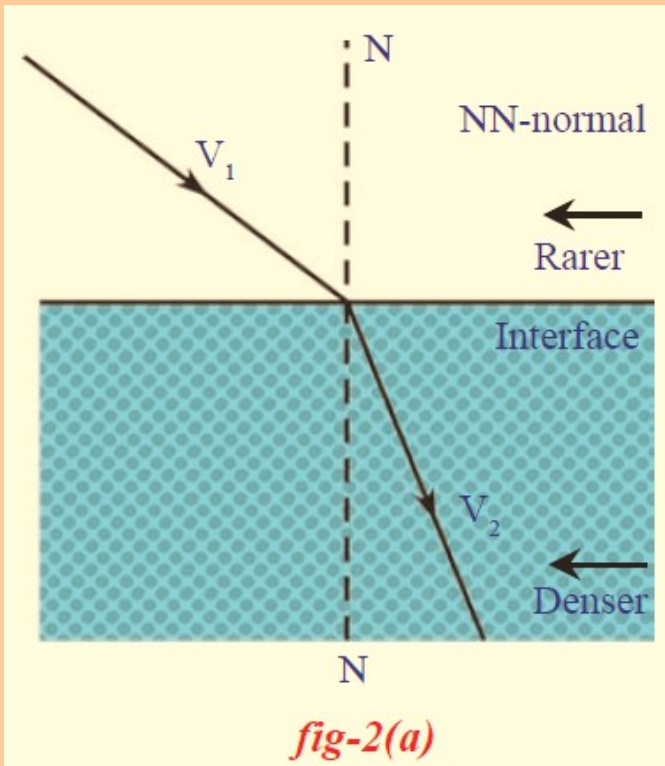
Fermat's principle states that the light ray always travels between two points in a path, which needs the shortest possible time to cover.

By observing the path of the ray, it is clear that the light ray changes its direction at the interface separating the two media i.e., water and air. This path is chosen by the light ray so as to minimize time of travel between coin and eye. This is possible only if the speed of the light changes at interface of two media. Thus we can conclude that the speed of the light changes when light propagates from one medium to another medium.

From this we now define what is Refraction?

The process of changing speed at an interface when light travels from one medium to another resulting in a change in direction is refraction of light. The process of refraction involves bending of light ray except when it is incident normally.

Consider that light travels from medium 1 with speed v_1 to medium 2 with speed v_2 as shown in figures-2(a) and (b).



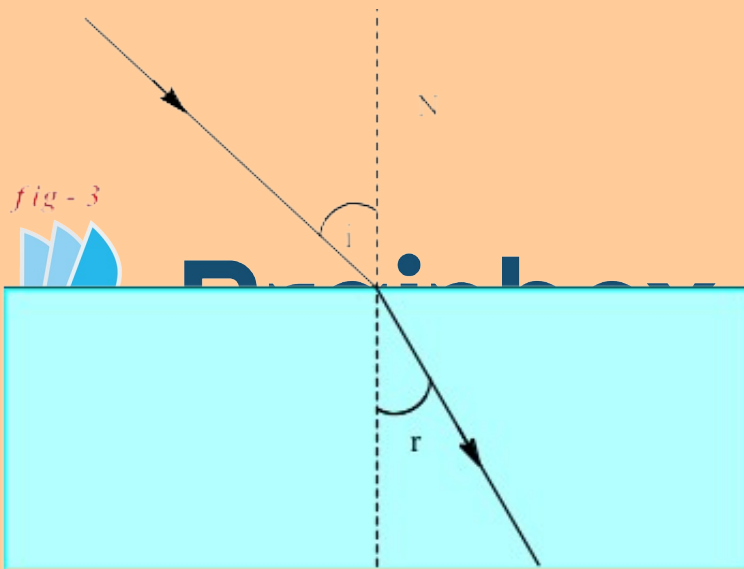
- What difference do you notice in fig 2(a) and Fig 2(b) with the respect to refracted rays?
- Is there any relation between behaviour of refracted rays and speeds of the light?

Change in the direction of light is due to change in the speed of the light in the medium

If v_2 is less than v_1 then medium 2 is said to be denser with respect to medium 1.

If v_2 is greater than v_1 then medium 2 is said to be rarer with respect to medium 1.

If light ray enters from rarer medium to denser medium then refracted ray moves towards the normal drawn at the interface of separation of two media. When it travels from denser medium to rarer medium it bends away from normal. We have seen that the ray of light deviates from its path at the interface. Draw a normal at the point of incidence as shown in fig-3.



Let 'i' be the angle made by incident ray with normal and 'r' be the angle made by refracted ray with the normal. These angles are called the angle of incidence and angle of refraction respectively.

To explain the process of refraction we need to know about a constant called refractive index, which is the property of a transparent media.