

Chapter 04

Refraction of Light at Plane Surfaces

Mirages:

Mirage is an optical illusion where it appears that water has collected on the road at a distant place but when we get there, we don't find any water.



- Do you know the reason why it appears so?

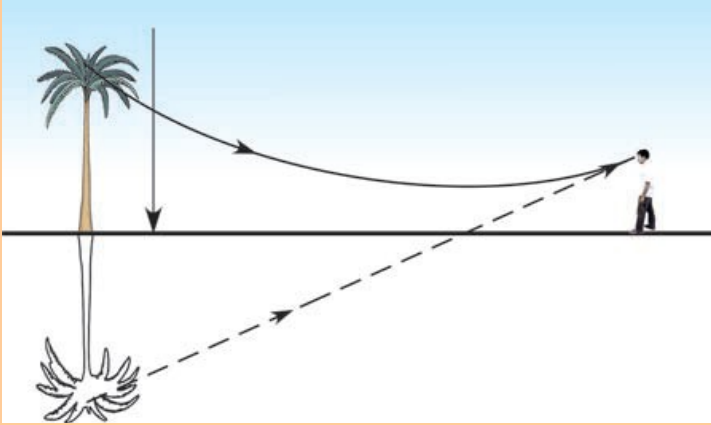
The formation of a mirage is the best example where refractive index of a medium varies throughout the medium.

During a hot summer day, air just above the road surface is very hot and the air above is less warmer. As a result density of air increases with height above road. We know that refractive index of air increases with density. Thus the refractive index of air increases with height. So, the cooler air at the top has greater refractive index than hotter air just above the road. Light travels faster through the thinner hot air than through the denser cool air above it.

When the light from a tall object such as tree or from the sky passes through a medium just above the road, whose refractive

index decreases towards ground, it suffers, refraction and takes a curved path because of total internal reflection.

This refracted light reaches the observer in a direction shown in fig.



This appears to the observer as if the ray is reflected from the ground. Hence we feel the illusion of water being present on road(shown in fig.)



Which is the virtual image of the sky (mirage) and an inverted image of tree on the road.

Applications of total internal reflection:

Brilliance of diamonds:

Total internal reflection is the main reason for brilliance of diamonds. The critical angle of a diamond is very low (24.4°) due to higher refractive index. So if a light ray enters a diamond it is very likely to undergo multiple total internal reflection which makes the diamond shine from its multiple edges.

Optical fibres:

Total internal reflection is the basic principle behind working of optical fibre. An optical fibre is very thin fibre made of glass (or) plastic having radius about a micrometer (10^{-6} m). A bunch of such thin fibres form a light pipe.

Because of the small radius of the fibre, light going into it makes a nearly glancing incidence on the wall. The angle of incidence is greater than the critical angle and hence total internal reflection takes place. The light is thus transmitted along the fibre.

All organs of the human body are not accessible to the naked eye of the doctor, for example intestines. The doctor insert slight pipe into the stomach through the mouth. Light is sent down through one set of fibres in the pipe. This illuminates the inside of the stomach. The light from the inside travels back through another set of fibres in the pipe and the viewer gets the image at the outer end.

The other important application of fibre optics is to transmit communication signals through light pipes. For example, about 2000 telephone signals, appropriately modulated with light waves, may be simultaneously transmitted through a typical optical fibre. The clarity of the signals transmitted in this way is much better than other conventional methods.

