

Chapter 04

Refraction of Light at Plane Surfaces

Total Internal Reflection:

Activity

Place the semicircular glass disc in such a way that its diameter coincides with interface line MM and its centre coincides with point 'O' as we have done in lab activity. Now send light from the curved side of the semi-circular glass disc. This means that we are making the light travel from denser medium to rarer medium. Start with angle of incidence (i) Equal to 0° i.e., along the normal and look for the refracted ray on the other side of the disc.

- Where do you find the refracted ray?
- Does it deviate from its path when it enters the rarer medium?

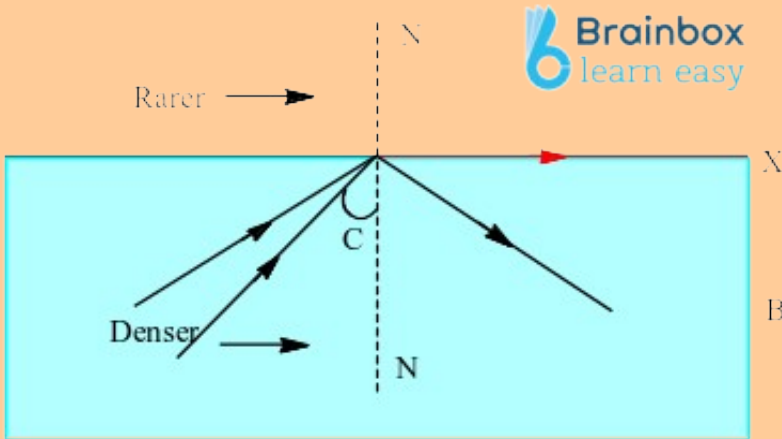
You might have noticed that it doesn't deviate.

Send laser light along angles of incidence 5° , 10° , 15° etc..and measure the angle of refraction.

- At what angle of incidence do you notice that the refracted ray grazes the interface separating the two media (air and glass)?

You will observe that at a certain angle of incidence the refracted ray does not come out but grazes the interface separating air and glass. Measure the angle of incidence for to this situation. This angle of incidence is known as critical angle.

Let us consider the light ray that travels from medium 1 with refractive index n_1 to medium 2 with refractive index n_2 .



It is already found that the angle of refraction is more than angle of incidence when a light ray travels from denser (n_1) to rarer medium (n_2).

For the angle of incidence i , let r be the angle of refraction.

From Snell's law,

$$n_1 \sin i = n_2 \sin r$$

$$\frac{n_1}{n_2} = \frac{\sin r}{\sin i}$$

We know that, $\frac{n_1}{n_2}$ is greater than 1, so that $\frac{\sin i}{\sin r}$ is greater than 1. So we conclude that the angle of refraction is greater than the angle of incidence i.e. r is greater than i .

The angle of incidence at which the light ray, travelling from denser to rarer medium, grazes the interface is called critical angle for denser medium.

Let C be the critical angle. Then r becomes 90° .

$$\frac{n_1}{n_2} = \frac{\sin 90^\circ}{\sin c}$$

$$\Rightarrow \frac{n_1}{n_2} = \frac{1}{\sin c}$$

We get $\sin c = \frac{1}{n_2/n_1}$. We know that $\frac{n_1}{n_2}$ i.e., n_{12} is called refractive index of denser medium with respect to rarer medium.

$$\sin c = \frac{1}{n_{12}}$$

When the angle of the incidence is greater than critical angle, the light ray gets reflected into the denser medium at the interface i.e., light never enters the rarer medium. This phenomenon is called total internal reflection.

We will understand total internal reflection using some activities.

Activity

Take a transparent glass tumbler and coin. Place the coin on a table and place glass tumbler on the coin. Observe the coin from the side of the glass.

- Can you see the coin?

Now fill the glass tumbler with water and observe the coin from the side of the glass tumbler.

- Can you see the coin?
- Explain why the coin disappears from view.

