

Chapter 04

Refraction of Light at Plane Surfaces

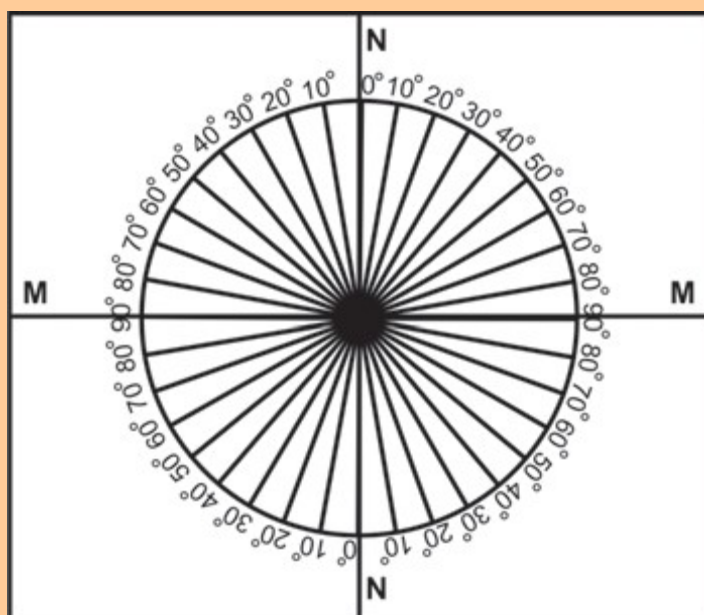
Activity

Obtaining a relation between angle of incidence and angle of refraction.

Materials required:

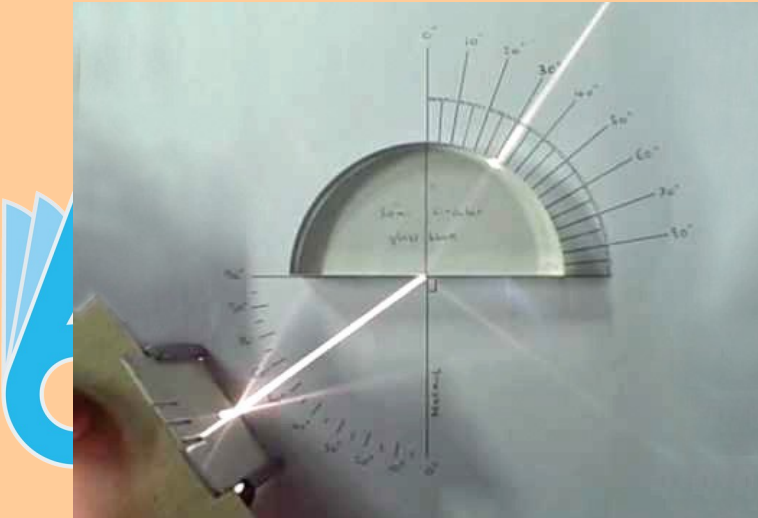
A plank, white chart, protractor, scale, small black painted plank, a semi-circular glass disc of thickness nearly 2cm, pencil and laser light.

Take a wooden plank, which is covered with white chart. Draw two perpendicular lines, passing through the middle of the paper as shown in the fig. Let the point of intersection be 'O'. Mark one line as NN which is normal to the another line marked as MM. Here MM represents the line drawn along the interface of two media and NN represents the normal drawn to this line at 'O'.



Take a protractor and place it along NN in such way that its centre coincides with O as shown in fig. Then mark the angles from 0° to 90° on both sides of the line NN as shown in fig. Repeat the same on the other side of the line NN. The angles should be indicated on the curved line.

Now place a semi-circular glass disc so that its diameter coincides with the interface line (MM) and its center coincides with the point O. Point a laser light along NN in such a way that the light propagates from air to glass through the interface at point O and observe the path of laser light coming from other side of disc as shown in the following fig. (If you cannot observe the path of laser light put a black coloured plank against the curved line and observe the light point and imagine the light path).



- Is there any deviation?

Send Laser light along a line which makes 15° (angle of incidence) with NN and see that it passes through point O. Measure its corresponding angle of refraction, by observing laser light coming from the other side (Circular side) of the glass slab. Do the same for the angles of incidence such as 20° , 30° , 40° , 50° and 60° and note the corresponding angles of refraction.

Find $\sin i$, $\sin r$ for every 'i' and 'r' and evaluate $\frac{\sin i}{\sin r}$ for every incident angle 'i'.

Note:

Take the help of your teacher to find the values of $\sin i$ and $\sin r$ for

each case.

$$\frac{\sin i}{\sin r}$$

Finally, we will get the ratio $\frac{\sin i}{\sin r}$ as a constant.

- Is this ratio equal to refractive index of glass? Why?

This ratio gives the value of refractive index of glass. In the above experiment you might have noticed that 'r' is less than 'i' in all cases and the refracted ray bends towards normal in each case.

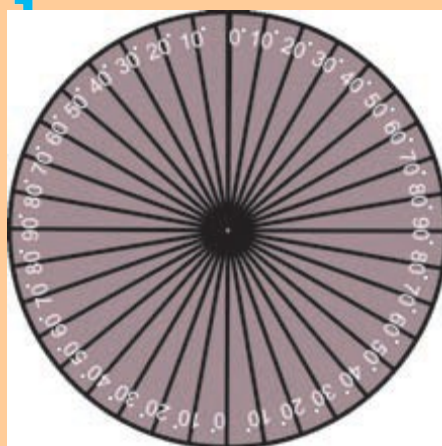
- What do you conclude from these observations?

From the above experiment we can conclude that when light ray travels from a rarer medium (air) to a denser medium (glass) the value of r is less than the value of 'i' and the refracted ray bends towards the normal.

- Can you guess what happen when light ray travels from a denser medium to a rarer medium?

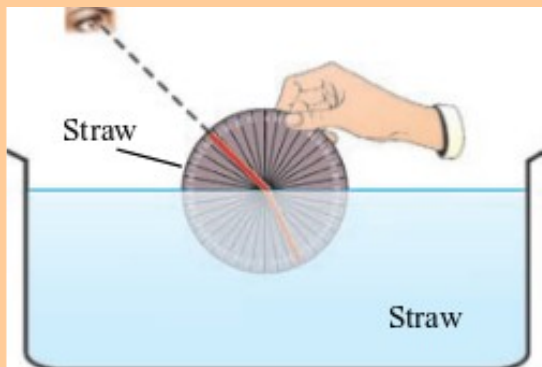
Activity

Take a metal disk. Use a protractor and mark angles along its edge as shown in the fig.



Arrange two straws at the centre of the disk in such a way that they can be rotated freely about the centre of the disc.

Adjust one of the straws to make an angle 10° . Immerse half of the disc vertically into the water, filled in a transparent vessel. While dipping, verify that the straw at 10° is inside the water. From the top of the vessel try to view the straw which is inside the water as shown in fig.



Then adjust the other straw, which is outside the water until both straws appear to be in a single straight line.

Then take the disc out of the water and observe the two straws on it. You will find that they are not in a single straight line.

- Why do the straws appear to be in a straight line when we view them from the top?

Measure the angle between the normal and second straw. Draw table again in your notebook and note the value. Do the same for various angles.

Brainbox

i	r	$\sin i$	$\sin r$	$\sin i / \sin r$

Find the corresponding angles of refraction and note them in the table drawn. Use the data in the table and find refractive index of water. Do not take up this activity for angles of incidence greater than 48 degrees. You will learn the reasons for this in the following sections.

You will observe that in the above activity, ' r ' is greater than ' i ' in all cases that means when light travels from water (denser) to air (rarer). It behaves in an opposite way to that we observed in lab activity 1.

From this activity we can generalize that when the light ray travels f

from denser to rarer, it bends away from the normal and $r > i$.

- Is there any relation between the angle of incidence and the angles of refraction?

The relation between angle of incidence and angle of refraction can be

given by $n_1 \sin i = n_2 \sin r$.

This is called **Snell's law**.

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

We know $\frac{n_2}{n_1} = \frac{v_1}{v_2}$

$$\Rightarrow \frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

When light travels from one medium to another the ratio of speeds is $\frac{v_1}{v_2}$ and the ratio of refractive indices is $\frac{n_2}{n_1}$. Hence angle of incident and angle of refraction will follow $\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$.