

Unit 9

Refraction of Light

Many times we see the things which is differ from the original things. Such as the star present in the sky is steady still they look like twinkling. Moreover on road, when we look at farther distance it feels like there is water on the road, but when we go near we see that there is nothing expect the road.

You may have seen such things. Note them down.



What is required ?

Glass, water and 1 rupee coin, pencil.



What to do ?

- ☞ Place the 1 rupee coin on the table.
- ☞ Place the empty glass on the coin as shown in figure.
- ☞ Observe the coin.
- ☞ Look at the coin continuously and pour water in glass.
- ☞ Can you see the coin in the glass ?



Where is the coin ?

Now, look in the glass from the top. What can you see ?

Where can you see the coin ? Inside the glass or outside the glass ?



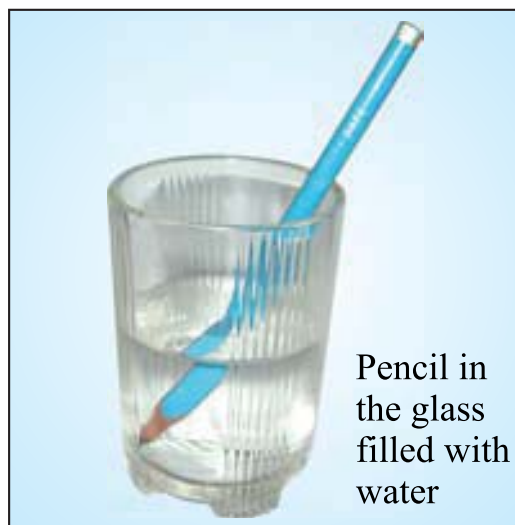
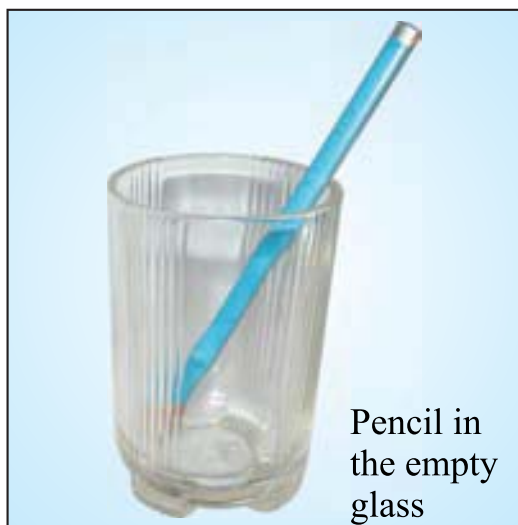
Why does it happen ?

Now, as above experiment put the coin in glass filled with water and observe. Where do you see the coin in glass ?



Why does it happen ?

Now, keep the pencil in the glass filled with water and observe.



How does the pencil appear, when it is kept in glass full of water ?



Why does it happen ?

Appearance of the coin inside the glass-when it is kept outside, appearance of the coin slight up side then it is present in the glass, appearance of pencil as if broken or bend in the glass filled with water, for this various phenomena, refraction is responsible.



Activity

What is required ? Rectangular glass slab and drawing-paper, pencil, pin, laser torch, thermocol sheet, scale for measurement.

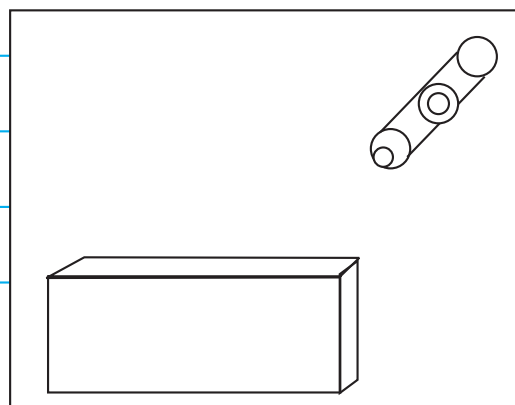
What to do ?

- Adjust the drawing-paper on the thermocol sheet.
- Then after adjust the rectangular glass slab on it.

- Now, as shown in the figure, project the beam of laser light on the glass slab such that it touches the surface of the drawing-paper.
- What happens when light passes through the rectangular glass slab ?

- Repeat this experiment two to three times and note down the changes, which you observe and draw path of beam in the figure.

Show the path of light rays.



- ☞ Does the light ray pass straight ? Yes / No

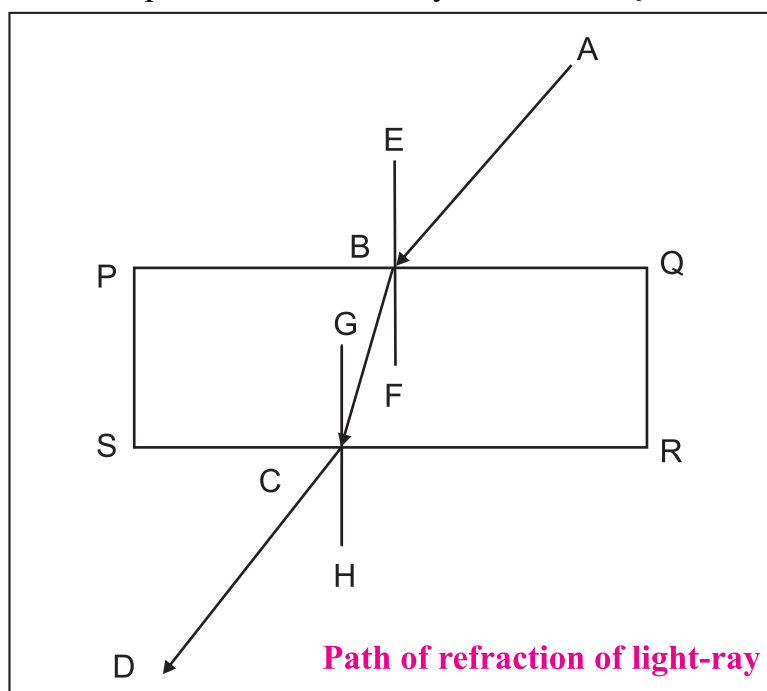
- ☞ Through which medium the light ray passes ?

Here the bent ray of light passes from rarer medium like air to denser medium like glass meanwhile it slightly bends at the surface separating two mediums.

When light ray passes from rarer medium to denser medium it changes its direction at the surface separating mediums, this phenomenon is called refraction.

Now, in above activity, mark the position of the rectangular surface with pencil. Mention the points of the rectangle P, Q, R, S. Now, as shown in the figure, project the beam of light from laser in such a way that it projects slantly on the rectangular surface PQ. Mark this ray as A. And the point where the ray touches PQ surface, mark it as B.

Now observe the slightly bent ray passing through the rectangular slab. This ray comes out from the other surface RS of the rectangle. The point through which this ray comes out is marked as C. Now, the ray coming out is marked as D. Now, remove the rectangular slab. Now, connect the points A, B, C, D. You will observe the figure as shown below. This figure represents the path of refraction of light. Now, draw line EF at point B on the PQ surface of the rectangle as



shown in the figure. Similarly draw line GH at point C on the surface RS of the rectangle as shown in the figure.

Ray AB is called Ray of Incidence and the angle produced between the ray and line EF is called angle of incidence.

- Which angle in the figure is the incident angle
- What is the value of incident angle ?
- **Ray of refraction :** The ray propagating through rectangular slab is called ray of refraction.
- **Angle of refraction :** The angle between the refracted ray and normal is called angle of refraction.

Which angle in figure is angle of refraction ?

- What is the value of angle of refraction ?

We have studied that the light ray travels from rarer medium like air and enters the denser medium like glass.

During this process, the light rays are slightly bent from the path.

In the previous activity, the path of motion of light ray is given by ABCD.

The refracted ray for surface RS becomes its incidence ray and the emergent ray becomes its refracted ray.

Where for both sides of the rectangle incident ray and emergent ray are same and $\angle DCH$ is called Emergent angle.



What is the angle of incidence for side RS ?

What will be the angle of refraction ?

Now let us change the value of incidence angle and repeat the experiment, note down your readings in the below table.

Sr No.	Medium of incidence ray	Medium of refracted ray	For PQ side of the rectangle		For RS side of the rectangle	
			Angle of incidence	Angle of refraction	Angle of incidence	Angle of refraction
1						
2						
3						

From the above activity, we can say that for side PQ the angle of incidence is greater than angle of refraction.

Where for side RS, the angle of incidence is less than angle of refraction. Moreover it obeys following laws of refraction.

Laws of refraction :

- (1) Incidence ray and refracted ray are on opposite sides of normal and are in different mediums.
- (2) Whenever light ray enters from rarer to denser medium, it slightly bends towards the normal and when it enters from denser to rarer medium it bends away from the normal.
- (3) The ray incident normal to the plane is not refracted.
- (4) Incident ray, critical ray and normal to the plane are in same plane.



When does the refraction of light takes place ?

- (A) When there is obstacle in the path of light.
- (B) When the medium of path of light changes.
- (C) When the light increases or decreases.

We know that in different mediums light has different velocities. In some mediums the velocity of light is as given in the below table :

No.	Medium	Velocity of light
1	Vacuum / air	3,00,000 km / second
2	Glass (simple transparent glass)	1,80,000 km / second
3	Water	2,25,000 km / second

In vacuum the velocity of light is maximum. Where as in other mediums it is less. Thus, the velocity of light in different transparent mediums is different so when the light ray travels from one medium to other medium its velocity changes. Therefore the refraction of light occurs.

The refraction of light measured with the help of Refractive Index of light.

The ratio of velocity of light in vacuum to the velocity of light in medium is called the Absolute Refractive Index of that transparent medium.

It means that Absolute Refractive index of medium = velocity of light in vacuum / velocity of light in medium.

Its symbol is μ .

When the light ray enters from one medium to other medium instead of absolute refractive index we consider its relative refractive index. For example, in order to calculate the refractive index using formula for the ray of light entering from air medium to glass medium, then its relative index can be obtained as follows :

$$\text{Refractive index of glass with respect to water} = \frac{\text{velocity of light in air (3,00,000 km/second)}}{\text{velocity of light in glass (1,80,000 km/second)}}$$

$$\text{Where, air } (\mu) \text{ glass} = \frac{(3,00,000 \text{ km/second})}{(1,80,000 \text{ km / second})}$$

$$\text{So, air } (\mu) \text{ glass} = 1.66$$

Where, air (μ) glass is called refractive index of glass with respect to the air.

With the same method find the refractive index of water with respect to air.

Refractive index of water with respect to air =

Where, air (μ) water =

So, air (μ) glass =

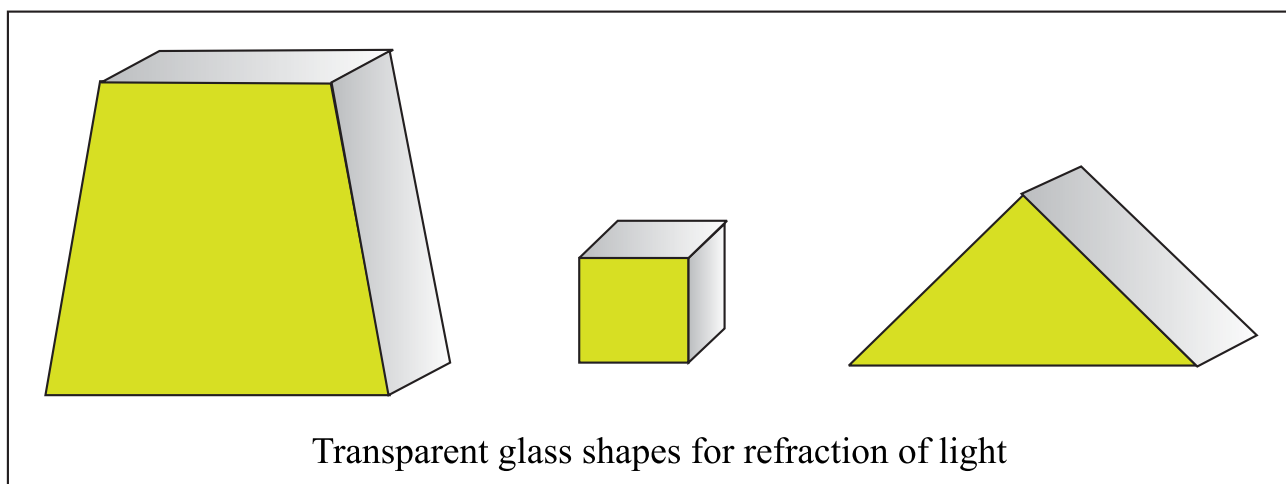
Where. Air (μ) water is called refractive index of water with respect to the air.

As refractive index of medium is more the refraction of light in that medium is more.



Let us observe the refraction of light with the help of different transparent glass shapes.

What is required ? Drawing-paper, laser torch and glass cube of different shape.

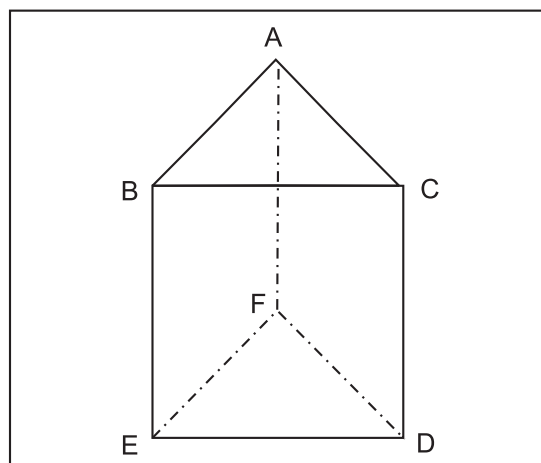


What to do ?

- Place the slab of glass of different shapes on drawing-paper.
- Now mark the surface surrounding and give name to corners of the glass slab as A, B, C, D.
- Now, incident the ray of laser light with the help of torch on any one of its surface.
- Note down your observation.
- From the above figure, do you observe the difference in the path of refraction of light in different slabs ? Yes / No.
- **What difference is observed ?**

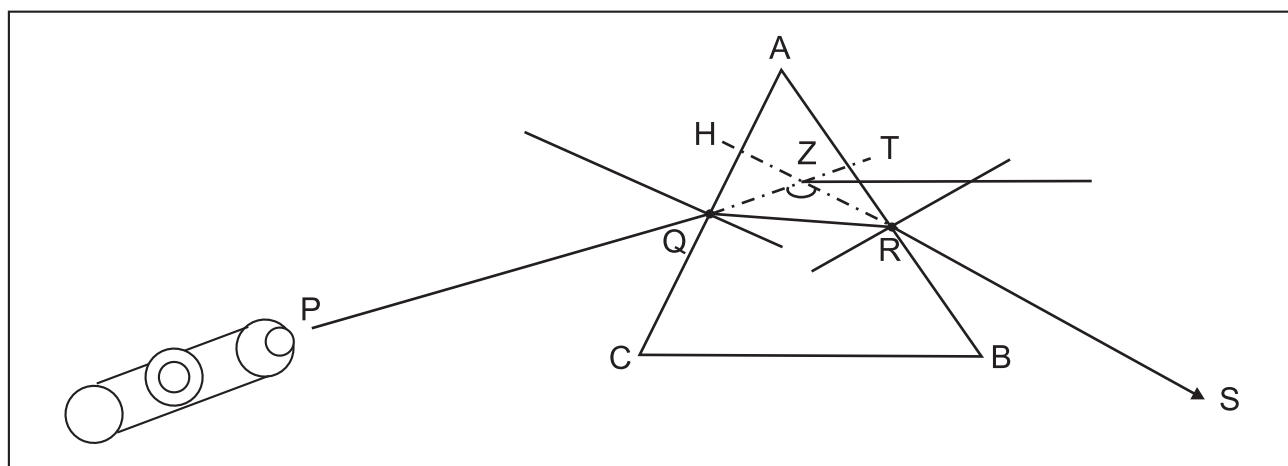
Observe the ABCDEF figure. This figure looks like a triangle. Actually it is not a triangle but a special construction of transparent glass. This is called prism. Its mutually opposite sides are in the shape of triangle. Other than these, three mutually opposite sides are in the shape of rectangle.

Find out a prism and observe it.



Now, let us observe the refraction of light with the help of prism.

What is required ? Prism, laser torch, drawing paper, pencil and scale.



What to do ?

- As shown in the figure, arrange the drawing-paper on the surface.
- Now, place a prism in such a way that its triangular surface touches the drawing-paper.
- Now, mark the surface of prism with the help of pencil as ABC.
- As shown in the figure incident the ray PQ from laser light on the plane AB of prism.
- Similarly mark the emergent ray. Now, remove the prism. Join two points Q and R.

Observe the path of refraction of light ray with the help of prism and complete the following information :

- Mention the incident ray
- Mention the ray of refraction

Which is the emergent ray ?

Which is the angle of incidence for AC surface ?

Which is the angle of refraction for AC surface ?

What is the value of angle of incidence on the surface AC ?

What is the value of angle of refraction on the surface AC ?

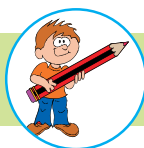
• In which direction the emergent ray bent ? Upward / downward towards base.

In the above figure extend the incident ray PQ towards T by dotted line. Now, extend emergent ray RS towards point H in backward direction by dotted line. Both the rays meet each other at point Z. There the angle RZQ is formed. This angle is called angle of deviation.

The angle between incident ray and the emergent ray is called angle of deviation. It's symbol is (δ) delta.

Repeat this activity two-three times and observe the deviation of emergent ray and note down. Upward / downward towards base.

The light ray incident on any surface of the prism when emerge from the opposite side it deviate towards the base of the prism.



Q.1 Do the experiments of refraction, which you know, with your friends. Discuss it and note down.

Q.2 For the given figure decide the light ray and different angles.

