ACTIVITY

AIM

To observe refraction and lateral deviation of a beam of light incident obliquely on a glass slab.

MATERIAL REQUIRED

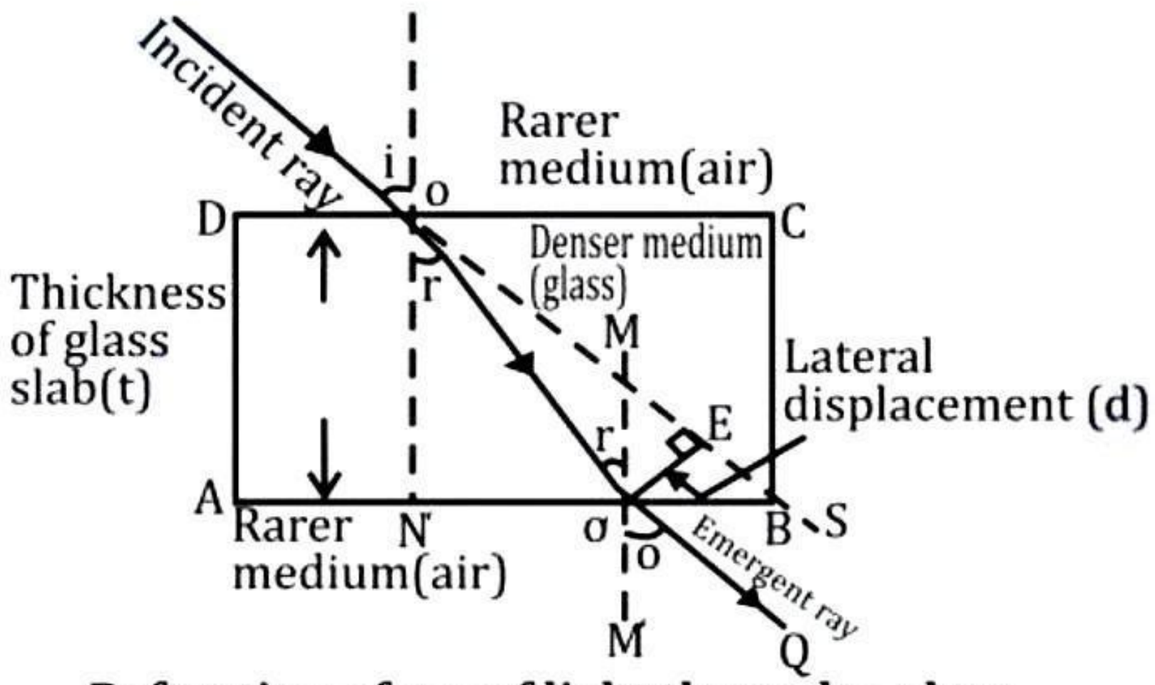
A rectangular glass slab, a white sheet of paper, a drawing board, a half-meter scale, drawing pins, a protractor, fixing pins and a pencil.

THEORY

The phenomenon of the bending of a ray of light from its straight-line path on the separation of two optical media is called the refraction of light. When a ray travels from an optically rarer medium to an optically denser medium, it bends towards the normal as shown in Fig. On the other hand, when a ray of light travels from an optically denser medium to an optically rarer medium, it bends away from the normal.

When a ray of light PO (called incident ray) falls on a glass slab obliquely, it bends towards the normal at O while entering from air to glass and it proceeds along the direction OO′ (then, the ray of light OO′ called refracted ray) inside the glass.

At O′ the ray of light emerges out of the glass and in passing from glass to air bends away from the normal along O′Q. This O′Q ray is called the emergent ray which is parallel to the direction of incident ray PO which would have proceeded in the direction of PS in the absence of the glass slab ABCD.



Refraction of ray of light through a glass

The perpendicular shift in the path of the incident ray, when it emerges from the denser medium is known as lateral displacement, lateral shift or lateral deviation.

In ΔOO′E,

$$\angle O'OE = i - r$$

$$\sin(i-r) = \frac{O'E}{OO'} = \frac{d}{OO'} \text{ or } d = OO' \sin(i-r) \text{ where d is lateral deviation}$$

In ΔONO′,

$$\cos r = \frac{ON'}{OO'} \text{ or } OO' = \frac{ON'}{\cos r}$$

Therefore, $OO' = ON' \sec r = t \sec r$ where t is the thickness of the glass slab. On substituting the values of OO',

$$d = t \sec r \sin(i - r)$$

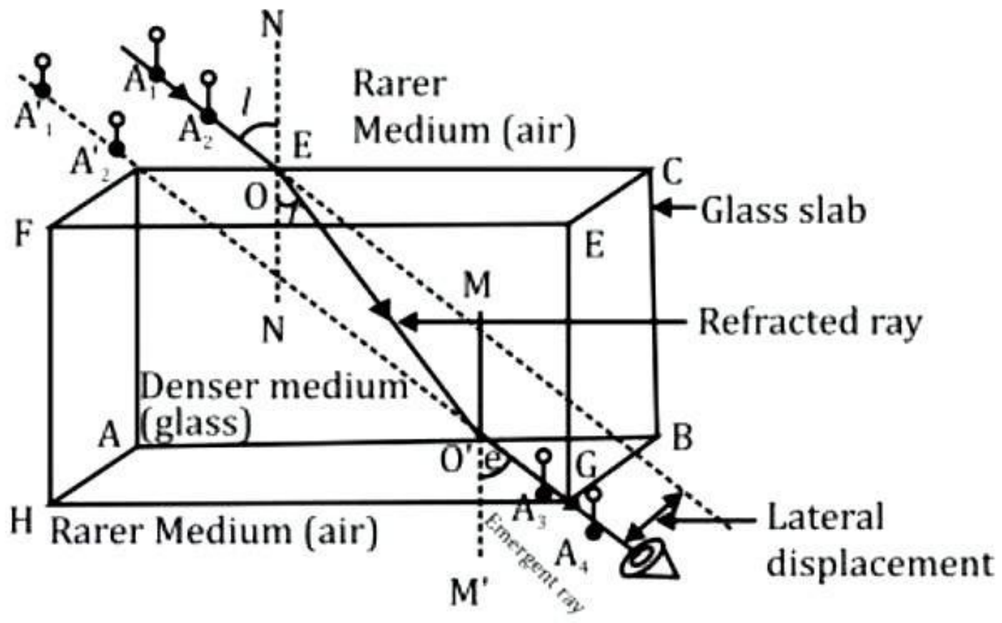
Thus, the lateral deviation for a given angle of incidence is directly proportional to the thickness of the glass slab.

You will observe from the above activity when the refraction takes place through a rectangular glass slab then,

1. The angle of incidence = Angle of emergence
2. The emergent ray is parallel to the incident ray.
3. With the increase in the angle of incidence, the angle of refraction increases.

PROCEDURE

1. Place a drawing board horizontally on a table and fix a white drawing sheet on it with the help of drawing pins.
2. Place the glass slab in the middle of the drawing sheet.
3. Draw the boundary line ABCD at the base of the rectangular glass slab with a sharp pencil as shown in Fig. Remove the glass slab.
4. Mark a point O on one side (CD) of the boundary of the glass slab. Draw a normal at point O and denote it as NN'.
5. `Draw a line A_1O which makes an angle of 35° with the normal NN'. You can make this angle with the help of a protractor. This angle is called the angle of incidence.
6. Fix the alpine A_1 and A_2 on the line A_1O at the points A_1 and A_2 in an upright position keeping a mimum distance of 8 cm between them.
7. Place the glass slab in position.
8. Look at the pins through the other side AB of the glass slab. You will see the image A_1' and A_2' of the alpins A_1 and A_2 respectively due to refraction.
9. Bring your eye down in the horizontal plane slightly above the drawing sheet to look through the glass slab. Place your eye in line with the images A_1' and A_2' of the alpins A_1 and A_2 and fix an Alpin A_3 on the drawing sheet in an upright position. So that A_3 is also in line with the images A_1' and A_2' of alpine A_1 and A_2.
10. It must be noted that the vertical side of all three pins overlaps each other, and the lower ends are exactly in the same straight line.
11. Now fix another Alpin A_4 also in the line with Alpin A_3 and the images A_1' and A_2' as above.
12. Remove the glass slab from the drawing sheet and remove the alpine A_1, A_2, A_3 and A_4 one by one and draw small circles around the alpin points.
13. Join the pricks made by alpine A_3 and A_4 by a straight line and extend it to meet the boundary AB at some point O' as shown in Fig.
14. Draw a normal at the point O' on the straight line AB and denote it as MO'M'.
15. Join the O and O' by a straight line. This OO' the line gives the direction of the refracted ray into the glass slab for the incident ray A_1O.
16. Measure and record the angle of refraction $\angle O'ON'$ and the angle of emergence $\angle M'O'A_4$ in the observation table.
17. Repeat the above procedure for angles of incidence 45°, 55° and 65° also and record the measurement of the angle of refraction and angle of emergence respectively in the observation table.



Experimental arrangement for refraction of

OBSERVATIONS

1. Least count of the protractor =_____ degree

2. Least count of the meter scale =_____cm

TABLE FOR MEASUREMENT OF ANGLES

S. No. of observations	The angle of incidence ∠i (degree)	The angle of refraction ∠r (degree)	The angle of emergence ∠e (degree)	Lateral deviation (d)
1.	35°			
2.	45°			
3.	55°			
4.	65°			

RESULT

Attach drawing sheets of the traced path of a ray of light passing through a given rectangular glass slab showing that:

1. Within the experimental error, the angle of incidence ∠i = the angle of emergence ∠e in each case.
2. The incident ray is parallel to the emergent ray.
3. With the increase in the angle of incidence, the angle of refraction increases as given in the above table.
4. The lateral deviation (displacement) of the incident ray varies with the angle of incidence.

PRECAUTIONS

1. The drawing board should be made of some softwood.
2. Alpins should be fixed vertically.
3. Take a glass slab of uniform thickness.
4. The feet of the alpine (not their heads) should be in the same straight line.
5. The distance between the pins should be about 8 cm.
6. The angle of incidence taken should lie between 30° to 65°.
7. While fixing pins, the eye should be at a distance of 25 cm from the nearest pins.
8. Use a very sharp pencil for geometrical work.

SOURCES OF ERROR

1. If the feet of the pins are not in the same straight line on the drawing board, an error takes place in the path of the incident ray and emergent ray.
2. Personal error in measurement of angles.

VIVA- VOCE

Q 1. What do you mean by denser and rarer media?

Ans. In a pair of media, the medium having a large refractive index, or a lower velocity of light is known as a denser medium and the other one as a rarer medium. Denser and rarer media are relative terms.

Q 2. What happens when a ray of light passes from a denser medium to a rarer medium?

Ans. When a ray of light passes from a denser medium to a rarer medium, it bends away from the normal at the point of incidence.

Q 3. What do you mean by the refraction of light?

Ans. Refraction is the phenomenon of the bending of light from its straight-line path on the surface of the separation of two optical media.

Q 4. A ray of light travels from air to glass and strikes at a point on the separation of two media. In which direction, the ray of light is likely to bend in glass?

Ans. It bends towards the normal at the point of incidence.

Q 5. State laws of refraction.

Ans. The laws of refraction are:

(i) The incident ray, the refracted ray, and the normal at the point of incidence all lie in the same plane.

(ii) The ratio of the sine of the angle of incidence to the sine of the angle of refraction for any two given media and for the light of a given wavelength is a constant quantity.

Q 6. State Snell's law of refraction of light.

Ans. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant which is the refractive index of medium 2 to medium 1, i.e., $\frac{\sin i}{\sin r} = n_{21}$.

Q 7. How can you define the refractive index of a medium in terms of the velocity of light?

Ans. The refractive index (n) of a given medium is defined as the ratio of the velocity of light in air to the velocity of light in that given medium.

$$\text{i.e., } n = \frac{c_a}{c_m}$$

where c_a and c_m are the velocities of light in air and medium, respectively.

Q 8. What do you mean by lateral displacement?

Ans. The perpendicular shift in the path of the incident ray, when it emerges from the denser medium, is known as lateral displacement.

Q 9. How is the angle of emergence related to the angle of incidence?

Ans. The angle of emergence is always equal to the angle of incidence for a rectangular glass slab.

Q 10. On what factors does the refractive index of a medium depend?

Ans. It depends upon:

(i) The colour or wavelength of light used. It is minimum for red colour and maximum for violet colour.

(ii) Nature of the medium.