EXPERIMENT

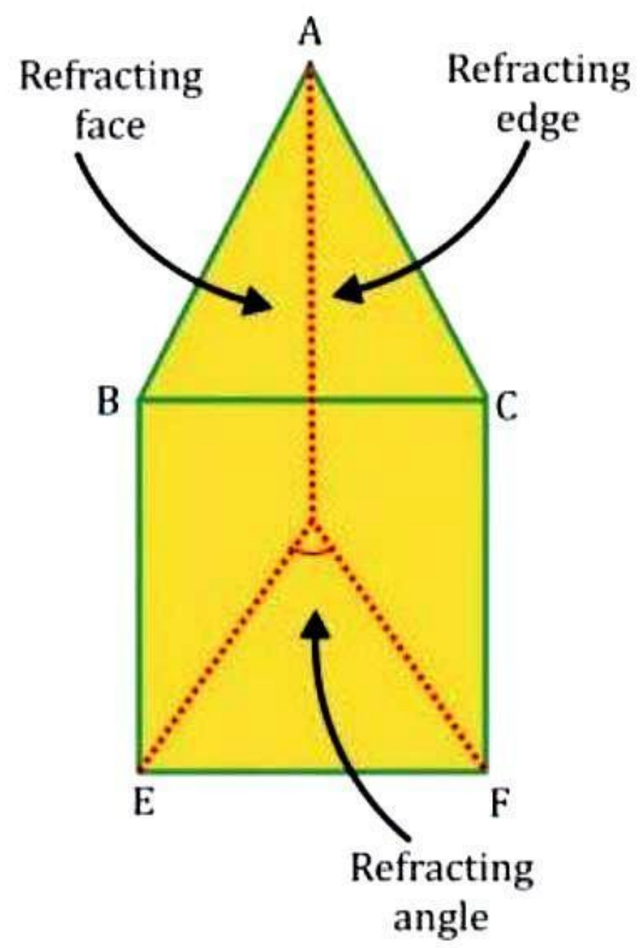
AIM

To determine the angle of minimum deviation for a given prism by plotting a graph between the angle of incidence and angle of deviation.

MATERIALS REQUIRED

Glass prism, drawing board, pins, white paper sheets, sharp pencil, metre scale, eraser, sharpener and protractor.

DIAGRAM



Glass Prism

THEORY

A prism is a transparent piece of material with three rectangular surfaces that form a triangle. The base is an opaque surface, while the other two surfaces are transparent and referred to as refracting surfaces. The line where the refracting surfaces meet is known as the prism's edge, and the angle between these surfaces is called the angle of the prism.

Consider a ray of light PQ incident on face AB of a glass prism ABC at an angle of incidence i. As the ray enters the denser glass medium at Q, it bends towards the normal N, resulting in the refracted ray QR. Upon reaching the air medium at R, which is less dense, the ray bends away from the normal N' during emergence, forming the emergent ray RS. The angle of emergence, denoted as e, is the angle between RS and the normal. If RS is extended backward and PQ forward, they intersect at M, forming an angle & mdash, the angle of deviation. This angle represents the deviation of the light ray from its original path.

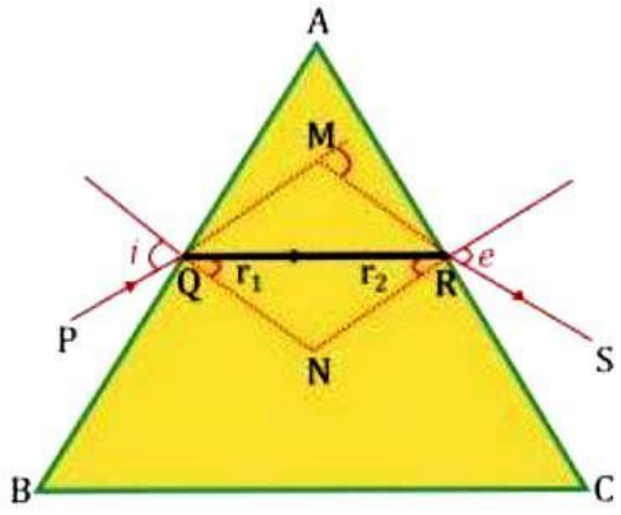


Fig. Refraction of light through glass prism

For a prism with a large angle, the angle of deviation is not independent of the angle of incidence. As the angle of incidence increases, the angle of deviation initially decreases, reaches a minimum value, and then begins to increase again. In the position of minimum deviation, the angles of incidence and emergence are equal, and the light ray passes symmetrically through the prism.

PROCEDURE

1. Secure a white sheet of paper onto the drawing board using fixing pins.
2. Create a straight line XX′ parallel to the paper's length, positioning it close to the paper's midpoint.
3. Identify points K_1, K, K_1 on the straight line XX ' at appropriate intervals of approximately 5cm.
4. Draw normals N_1K_1, N_2K_2, N_3K_3 at points K_1, K_2, K_3,
5. Sketch lines $I_1K_1, I_2K_2, I_3K_3, \ldots \ldots$ at angles $30°, 35°, 40°, \ldots \ldots 60°$ respectively, with respect to the normals $N_1K_1, N_2N_2, \ldots \ldots$
6. Designate one corner of the prism as (A) and consider it as the prism's edge. Position the prism with its refracting face (AB) on the line XX′, aligning points K_1, K_2, K_3, K_4 at the midpoint of (AB). Outline the boundary of the prism using a pencil.
7. Secure two pins P_1 and P_2 vertically on the line R_1K_1, ensuring a minimum distance of 10cm between them.
8. Observe the images of P_3 and P_4 through the face (AC) by closing your left eye. Position pins P_3 and P_4 so that pins P_3, P_4 and the images of pins P_1 and P_2 all lie in a straight line.
9. Remove pins P_3 and P_4 and encircle their pricks on the paper. Connect the positions of pins P_3 and P_4 with a pencil to form the emergent ray S_1T_1.
10. Repeat steps 6 to 9 with points $K_2, K_3, \ldots$ for $i = 35°, 40°, \ldots 60°$ to obtain the emergent rays $S_2T_2, S_3T_3, \ldots \ldots$
11. Extend $T_1S_1, T_2S_2, T_3S_3 \ldots$ inward within the boundary of the prism through the face AC to intersect the extended incident rays $I_1K_1, I_2K_2, I_3K_3, \ldots$ at points $F_1, F_2, F_3, \ldots \ldots$
12. Measure the angle of deviation (δ) i.e., $\angle E_1F_1T_1, \angle E_2F_2T_2, \angle E_3F_3T_3, \ldots \ldots$ corresponding to this angle of incidence.

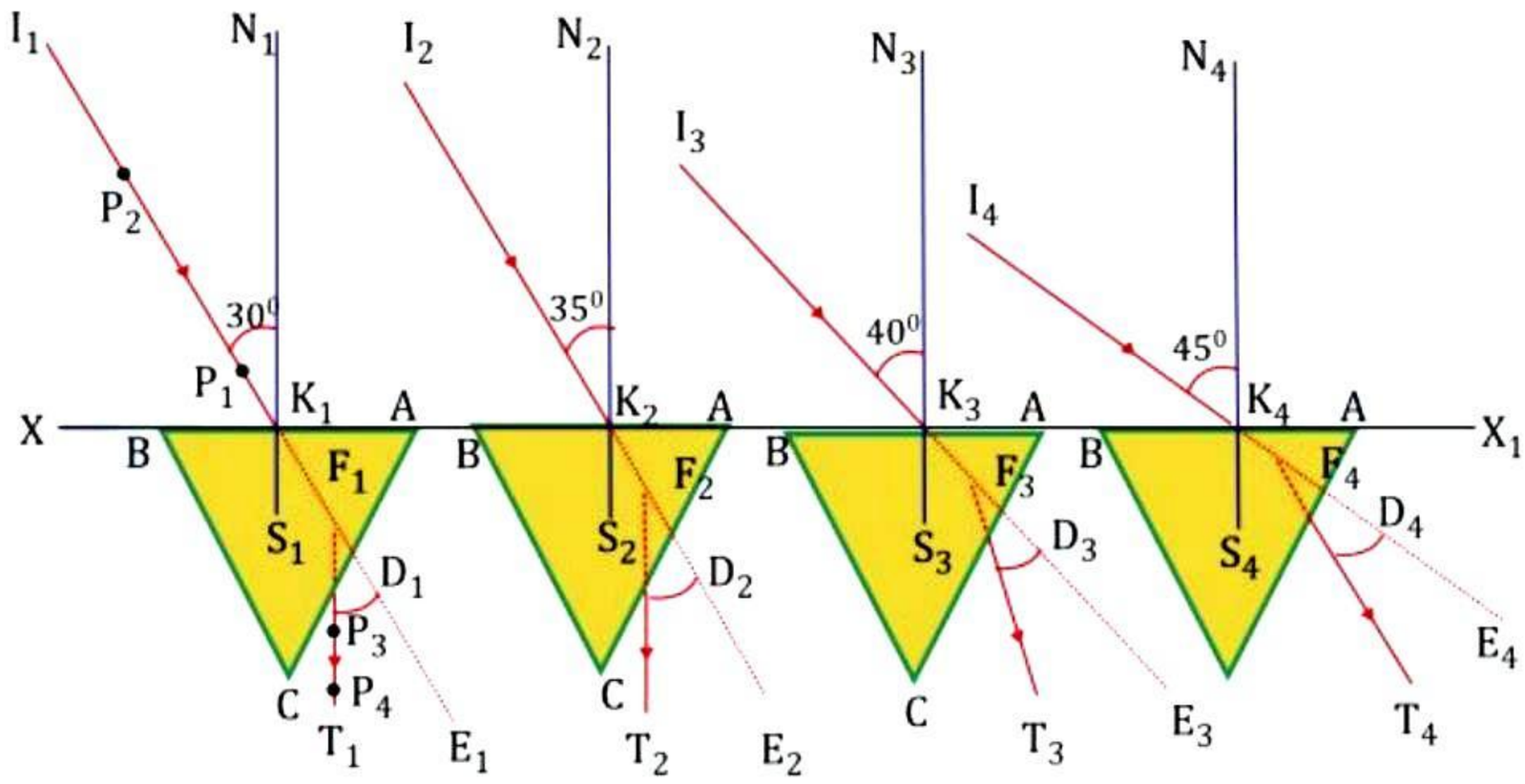


Fig. Refraction through prism at different angle of incidence and studying angle of deviation

OBSERVATIONS

1. Prism type employed: glass prism with an equilateral configuration.
2. Prism angle = 60°.

3. Record the angle of incidence i and the corresponding angle of deviation δ values in the table provided below.

Variation of angle of deviation δ with angle of incidence i.

S. No.	Angle of incidence, i (degree)	Angle of deviation, δ (degree)
1.		
2.		
3.		
4.		

CALCULATIONS

1. Construct a graph with the angle of incidence i plotted against the angle of deviation δ along the X-axis, using the data obtained from the table. This will result in a i ~ δ curve depicting the behavior of the prism.
2. Analyze and interpret the i ~ δ curve.
   At the nadir M of the i ~ δ curve, draw a tangent parallel to the X-axis, intersecting the Y-axis at point D. Determine the angle of minimum deviation δ_m corresponding to the lowest point M on the graph.

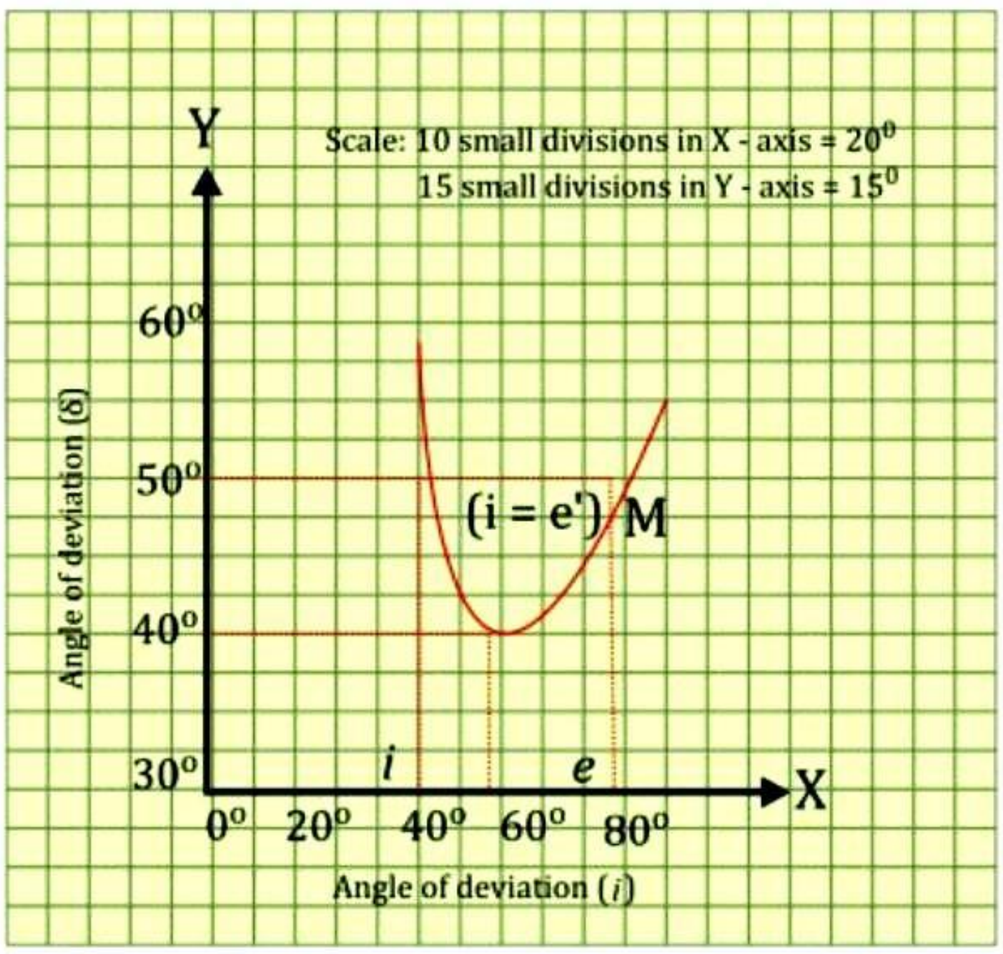


Fig. Plot of angle of deviation (δ) versus angle of incidence (i) for a equilateral glass prism

RESULT

The angle of minimum deviation, $\delta_m = \cdots$ degree.

PRECAUTIONS

1. Avoid altering the placement of the prism on the white paper sheet.
2. Ensure there is no parallax between the image pins P_3, P_4 and object pins P_1, P_2.
3. Maintain a minimum distance of 10cm between two pins.
4. Position the first pin P_1 in close proximity to the prism.
5. Secure all pins perpendicular to the white paper sheet.

SOURCES OF ERROR

1. There exists a singular angle of incidence i that corresponds to the minimum angle of deviation δ.

2. Reversing the emergent ray results in the angle e becoming i, and vice versa. The reversed ray maintains the same deviation as before.
3. If you obtain the following measurements for a given prism, with a:
   Refracting angle $A = 60°$
   Minimum deviation, $\delta_m = 48°30'$

$$\frac{A + \delta_m}{2} = 54°15'$$

   Along with $\frac{A}{2} = 30°$.
   Referring to the table of natural sines gives $\sin 54°15' = 0.8116$ and $\sin 30° = 0.500$. The refractive index of the prism material is then determined using the equation:

$$\mu = \frac{\sin\frac{A + \delta_m}{2}}{\sin\frac{A}{2}} = 1.623$$

VIVA- VOCE

Q 1. What is meant by a triangular prism?

Ans. A triangular prism is a prism that has a triangular base over which three lateral rectangular faces are inclined over each other.

Q 2. State two factors on which the angle of deviation depends.

Ans. The angle of deviation depends upon the angle of incidence and refractive index of the material of the prism.

Q 3. Define the angle of the prism. What is its value for (a) equilateral (b) right-angled prism?

Ans. The angle between two refracting faces of the prism is called the angle of the prism. Its values for given prisms are:
(a) 60°
(b) 90°

Q 4. How does the angle of deviation change with a change in (a) the angle of incidence and (b) the angle of the prism?

Ans. (a) When the angle of incidence becomes larger, the angle of deviation decreases until it acquires a minimum value. Thereafter, it begins to increase again.
(b) The angle of deviation increases with the angle of the prism. [$D_m = 2i - A$]

Q 5. Why does light disperse into a band of seven colours on passing through a prism?

Ans. Light disperses into seven colours on passing through a prism because light consists of seven colours and every colour has a different velocity.

Q 6. When does refract ray travel parallel to the base of the prism?

Ans. When the angle of deviation is minimum.

Q 7. State the relation between the refractive index of the prism and the angle of minimum deviation.

Ans. Refractive index, $\mu = \frac{\sin\frac{(A+D_m)}{2}}{\sin\left(\frac{A}{2}\right)}$.

Q 8. For which colour of light is the angle of deviation (a) least, (b) maximum?

Ans. (a) Red light

(b) Violet light

Q 9. Why does dispersion of light not occur in a glass slab?

Ans. Dispersion of light does not occur in a glass slab because it may be regarded as consisting of two triangular prisms placed opposite to each other. So dispersed beam of light recombines to form white light again.

Q 10. Why do we use flint glass to make prisms crown glass is preferred to make lenses.

Ans. Crown glass has lesser dispersive power than flint glass. So, crown glass is used to make lenses while flint glass is used to make prisms.