# To determine angle Of minimum Deviation For a Given Prism By Plotting a Graph Between Angle Of Incidence & the Angle Of Deviation

## Aim

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

## Apparatus

Drawing board, a white sheet of paper, prism, drawing pins, pencil, half-metre scale, office pins, graph paper and a protractor.

## Theory

The refractive index in) of the material of the prism is given by

$$n = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where, $D_m$ angle of minimum deviation and A angle of the prism.

## Diagram

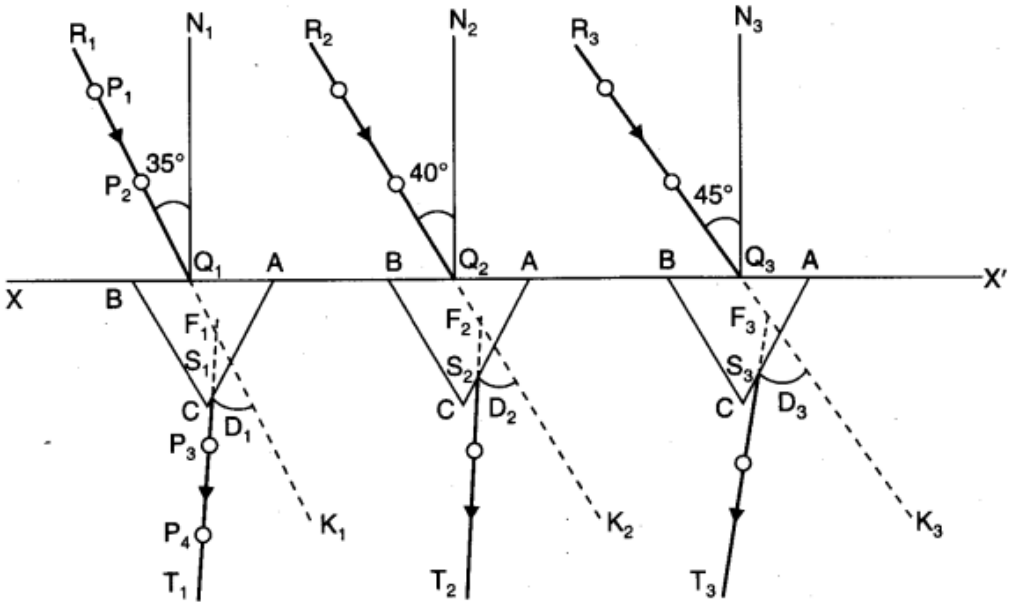


**Fig.** Refraction through prism at different angles.

## Procedure

1. Fix a white sheet of paper on the drawing board with the help of drawing pins or tape.
2. Draw a straight line XX' parallel to the length of the paper nearly in the middle of the paper.
3. Mark points $Q_1$, $Q_2$, $Q_3$,… on the straight line XX' at suitable distances of about 5 cm.
4. Draw normals $N_1Q_1$, $N_2Q_2$, $N_3Q_3$,… on points $Q_1$, $Q_2$, $Q_3$,… as shown in diagram.
5. Draw straight lines $R_1Q_1$, $R_2Q_2$, $R_3Q_3$,… making angles of 35°, 40°, … 60° (write value of the angles on the paper) respectively with the normal.
6. Mark one comer of the prism as A and take it as the edge of the prism for all the observations.
7. Put it prism with its refracting face AB in the line XX' and point $Q_1$ in the middle of AB.
8. Mark the boundary of the prism.
9. Fix two or more office pin $P_1$ and $P_2$ vertically on the line $R_1Q_1$. The distance between the pins should be 10 mm or more.
10. Look the images of point $P_1$ and $P_2$ through face AC.
11. Close your left eye and bring open right eye in line with the two images.
12. Fix two office pins $P_3$ and $P_4$ vertically, and 10 cm apart such that the open right eye sees pins $P_4$ and $P_3$ and images of $P_2$ and $P_1$ in one straight line.
13. Remove pins $P_3$ and $P_4$ and encircle their pricks on the paper.
14. Repeat steps 7 to 13 with points $Q_2$, $Q_3$,… for i = 40°,…, 60°.

    **To measure D in different cases**
15. Draw straight lines through points $P_4$ and $P_3$ (pin pricks) to obtain emergent rays $S_1T_1$,$S_2T_2$,$S_3T_3$,……
16. Produce $T_1S_1$, $T_2S_2$, $T_3S_3$, … inward in the boundary of the prism to meet produced incident rays $R_1Q_1$, $R_2Q_2$, $R_3Q_3$,… at points $F_1$, $F_2$, $F_3$,…
17. Measure angles $K_1F_1S_1$,$K_2F_2S_2$,$K_3F_3S_3$,…….. These give angle of deviation $D_1$,$D_2$,$D_3$,….
18. Write values of these angles on the paper.

    **To measure A**
19. Measure angle BAC in the boundary of the prism. This gives angle A.
20. Record your observations.

## Observations

Angle of prism 'A' =……

| *Serial No. of Obs.* | *Angle of incidence ∠i* | *Angle of deviation ∠D* |
|---|---|---|
| 1. | 35° | |
| 2. | 40° | |
| 3. | 45° | |
| 4. | 50° | |
| 5. | 55° | |
| 6. | 60° | |

## Calculations

Plot a graph between angle of incidence ∠i and angle of deviation ∠D by taking ∠i along X-axis and ∠D along Y-axis. From this graph, find the value of single of minimum deviation $D_m$ corresponding to the lowest point of the graph.

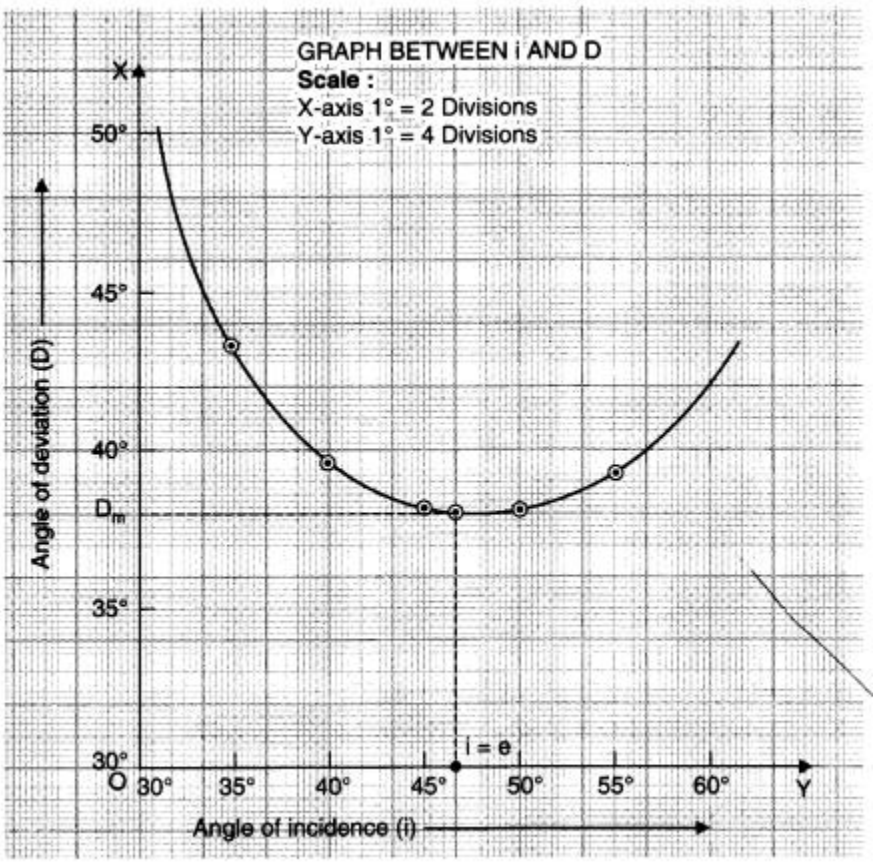


**Fig.** Graph between angle of incidence and angle of deviation.

**Let the value of angle of minimum deviation, $D_m$ = .....**

**Then,**

$$n = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

## Result

1. i-D graph indicates that as the angle of incidence (i) increases, the angle of deviation (D) first decreases, attains a minimum value ($D_m$ ) and then starts increasing for further increase in angle of incidence.
2. Angle of minimum deviation, $D_m$ = ……..

3. Refractive index of the material of the prism, n = …….

## Precautions

1. The angle of incidence should lie between 35°-60°.
2. The pins should be fixed vertical.
3. The distance between the two pins should not be less than 10 mm
4. Arrow heads should be marked to represent the incident and emergent rays.
5. The same angle of prism should be used for all the observations.

## Sources of error

1. Pin pricks may be thick.
2. Measurement of angles may be wrong.

# VIVA VOCE

**Question. 1. Define a prism.**
**Answer.** Read Art. 9.04.

**Question. 2.Define edge of the prism.**
**Answer.** Read Art. 9.04.

**Question. 3. Define angle of prism.**
**Answer.** Read Art. 9.04.

**Question. 4. Define angle of deviation.**
**Answer.** The angle through which a ray of light turns away from its original path on passing through a prism, is called angle of deviation.

**Question. 5.On what factors does the angle of deviation depend?**
**Answer.** The angle of deviation depends upon the following factors :

1. The angle of incidence.
2. The refracting angle of the prism.
3. The material of the prism. (Refractive Index)
4. The colour of the light used i.e., wavelength of light.

**Question. 6. What is the relation between different angles involved in refraction through a prism?**
**Answer.** Read Art. 9.05.

**Question. 7. Define angle of minimum deviation.**
**Answer.** The least value of the angle of deviation is known as the angle of minimum deviation. [Art. 9.06 (a)]

**Question. 8.How is angle of minimum deviation related with refractive index of prism material?**
**Answer.** Read Art. 9.06 (b).

**Question. 9. What is the specialty about minimum deviation?**
**Answer.** Under minimum deviation condition, light ray travels inside prism parallel to the base of the prism and the angle of incidence = angle of emergence.

**Question. 10. Does the angle of minimum deviation depend upon the colour of light used?**
**Answer.** Yes, it is different for different colours or wavelengths.

**Question. 11. What word helps in remembering the name of seven colours into which white light is splitted?**
**Answer.** The word is VIBGYOR.

**Question. 12. What name is given to the phenomenon of splitting white light into seven colours?**
**Answer.** The phenomenon is called dispersion of light.

**Question. 13. What does the graph between i and D indicate?**
**Answer.** There is only one unique value of angle of incidence for which the deviation is minimum.

**Question. 14. Why there are two values of angle of incidence for one value of angle of deviation?**
**Answer.** If the emergent ray be reversed, then angle e becomes i and angle i becomes e. The reversed ray will have same deviation as before.

**Question. 15. Hence, i and e are two different values for same angle of deviation. Which colour will travel (i) fastest (ii) slowest in prism?**
**Answer.**(i) Red colour (ii) Violet.

**Question. 16. Does a beam of white light give a spectrum on passing a hollow prism?**
**Answer.** No. Because dispersion does not occurs in air.

**Question. 17.Which colour deviate (i) Most (ii) Least.**
**Answer.** (i) Violet (ii) Red.

**Question. 18.Will all colour of light travel with same speed inside a prism?**
**Answer.**No. Red colour travel fastest and violet colour travel smallest.

**Question. 19.Which colours have hightest and smallest refractive index? Why?**
**Answer.**Refractive index is smallest for red colour and that is highest for violet colour

$$\text{Refractive Index} \propto \frac{1}{\text{wavelength}}.$$

**Question. 20.What is Cauchy relation?**
**Answer.**It is the relation between refractive index of a transparent medium and colour of light.

$$n = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \ldots$$

**Question. 21.Can X-rays be dispersed?**
**Answer.**Yes.

**Question. 22.What is angular deviation?**
**Answer.**The angle between the emergent rays of any two colours is called angular dispersion of those colours.

**Question. 23.On what factors angular deviation depends?**
**Answer.**(i) Angle of prism (ii) refractive index.

**Question. 24.What is dispersive power of prism?**
**Answer.**It is define as the ratio of the angular dispersion for these two colours to the mean deviation produced by the prism.

**Question. 25.What is factor on which dispersive power depends?**
**Answer.**It depends upon refractive index of the material of prism.

## Slab

A slab is a piece of transparent material with rectangular faces. All faces are transparent and opposite faces are parallel.
The dimension (side) along which the light travels inside the slab is called its thickness.

## Refraction of light through a glass slab (lateral deciation through a glass slab)

**(a) Introduction:** Diagram shows a section ABCD of a glass slab taken by a horizontal plane. The slab has thickness t.

**(b) Description:**

PQ is the incident ray

QR is the refracted ray

RS is the emergent ray.

$\angle PQN_1 = i$ = angle of incidence

$\angle RQN_2 = r$ = angle of refraction

$\angle SRN_4 = e = i$ = angle of emergence

$\angle TQR = i - r$ – angle of deviation.

Emergent ray goes parallel to the incident ray.

TU = RV = d = lateral displacement suffered by the emergent ray.

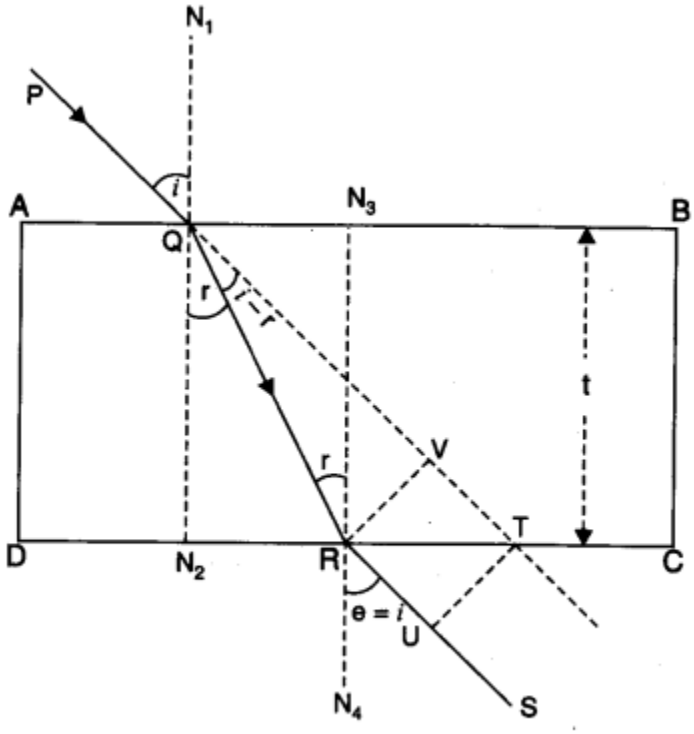


**Fig. 9.05. Refraction through a glass slab.**

**(a) Definition:** The perpendicular distance between the parallel emergent ray and the incident ray, is called lateral displacement suffered by the incident ray.

It is represented by the symbol d. It is measured in m or cm.

**(b) Calculation:** In $\Delta RQN_2$,

$$\cos r = \frac{QN_2}{QR}$$

$$QR = \frac{QN_2}{\cos r} = \frac{t}{\cos r} = t \sec r$$

In $\Delta RQV$, $\sin (i - r) = \frac{RV}{QR}$

$$RV = QR \sin (i - r)$$

$$\boxed{d = t \sec r \,.\, \sin (i - r)}$$

**This is the required expression.**

## Real and apparent thickness of a glass slab

(a) Introduction. Diagram shows a section ABCD of a glass slab taken by a horizontal plane. The slab has thickness t.

(b) Description. P is a point mark (object) at the bottom of the slab. A ray of light PQ from P is incident at the top at the point Q at an angle of incidence i and refracts along QR at an angle r. It appears to come from $P_1$.$P_1$ is the virtual image of real object P formed on normal PSN.

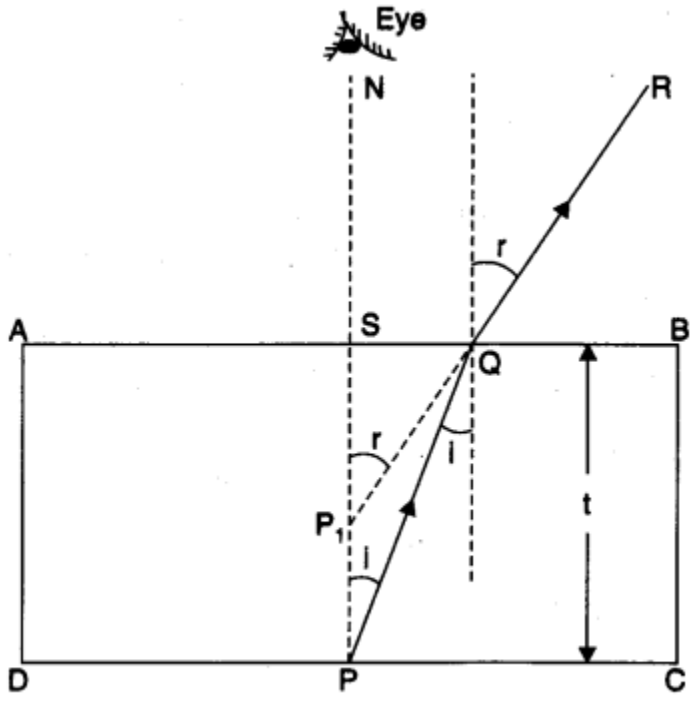


**Fig. 9.06.** Real and apparent thickness of a glass slab.

**(c)Calculation**

PS is the real thickness of the slab.

$P_1S$ is the apparent thickness of the slab.

(c) ***Calculation***

In $\Delta SPQ$, $\angle SPQ = i$ (being alternate angle of $i$)

$$\sin i = \frac{SQ}{PQ}$$

In $\Delta SP_1Q$, $\angle SP_1Q = r$ (being corresponding angle of $r$)

$$\sin r = \frac{SQ}{P_1Q}$$

From Snell's law,

For light going from glass to air

$$_gn_a = \frac{\sin i}{\sin r} = \frac{SQ/PQ}{SQ/P_1Q} = \frac{P_1Q}{PQ}$$

or

$$_an_g = \frac{1}{_g\mu_a} = \frac{PQ}{P_1Q}$$

For a ray received normally along PSN, Q is very close to S.

Then $PQ = PS$ and $P_1Q = P_1S$

and

$$_an_g = \frac{PS}{P_1S} = \frac{\text{Real thickness}}{\text{Apparent thickness}}$$

$$\boxed{_an_g = \frac{\text{Real thickness of slab}}{\text{Apparent thickness of slab}}}$$

This is an important relation. It is used for determination of refractive index of the material of the transparent glass slab.