EXPERIMENT 15

DEVIATION BY A GLASS PRISM

AIM: To determine the refractive index and angle of minimum deviation for a triangular glass prism.

APPARATUS: Light source, Acrylic, white paper, Equilateral triangular glass prism, drawing pins, 30 cm rule, protractor, drawing board, white sheet paper

THEORY:

The deviation produced by the a prism depends on the angle at which the light is incident on the prism. The deviation is minimum when the light passes symmetrically through the prism.

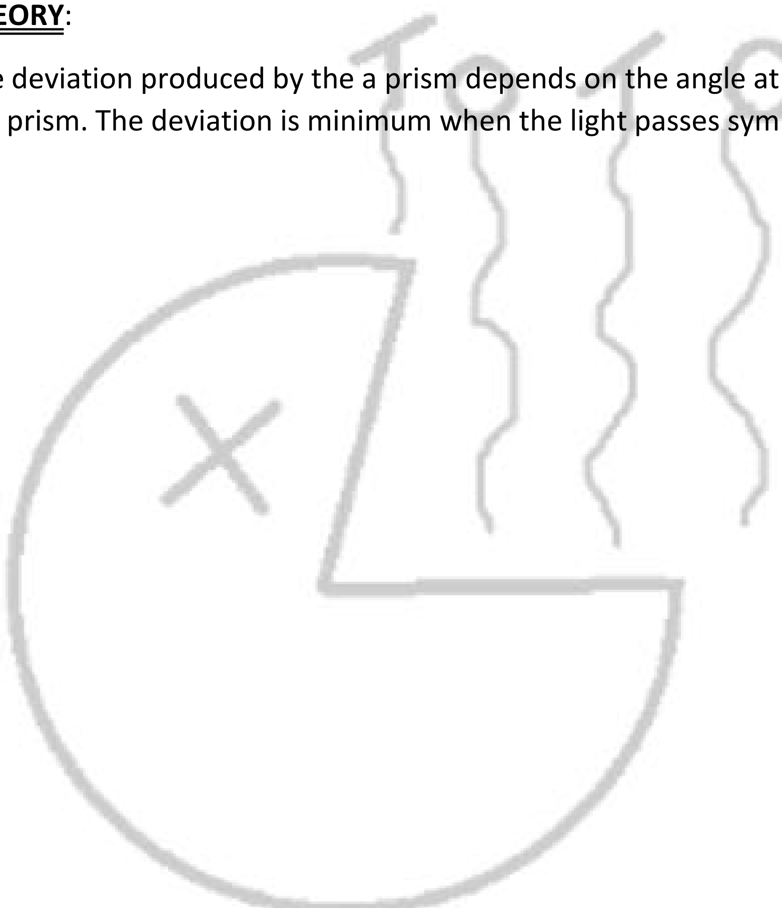

Figure 1. Light incident on glass prism

In the figure above the angles have the following relations:

$$D_m = 2i - 2r \qquad (9.1)$$

$$A = 2r \qquad (9.2)$$

$$i = \frac{A + D_m}{2} \qquad (9.3)$$

According to Snell's law,

$$n_1 \sin i = n_2 \sin r \qquad (9.4)$$

If light is incident from air, $n_1 = 1$, the refractive index of the material into which light impinges is given by

$$n_2 = \frac{\sin(\,A + D_m)}{\sin\left(\frac{A}{2}\right)} \qquad (9.5)$$

PROCEDURE PART A

1. The outline of the prism was drawn on a white paper fixed on a drawing board and the edges were labelled ABC.
2. A normal was drawn to the side AB.
3. A line incident to the prism which made an angle of 30° below the normal was drawn and two pins P and Q fixed along this line.
4. Then the image of the pins was looked at through the other face of the prism AC.
5. Two other pins R and S where placed such that the images of P and Q appeared to be in the same line.
6. The prism was removed from the paper and lines PQ and RS where extended until they intersected at a point O. The line PQ was extended further and a point T on this line away from point O was marked.
7. The angle <TOR was measured, this was the angle deviation.
8. The experiment was repeated by increasing the angle of incidence in steps of 5° upto 60°
9. The steps from 1-8 was repeated on new sheets of paper for different angles of incident.
10. A graph of the angle of incidence against angle of deviation was plotted.

PROCEDURE PART B

1. The outline of the trapezoid was draw on a white paper fixed on a drawing board and the edges were labelled as in figure 4.2
2. A normal was draw to AB
3. A line incident to the trapezoid and below the normal that makes an angle of 10° below the normal was draw.
4. The wheel was turned to select a single ray on the light source in the ray-box mode and it was placed on the paper such that the single was in line with the incident ray.
5. Three dots were traced on side DC to outline the refracted ray. The trapezoid was removed from the paper and a line was drawn through the three dots. The incoming and out going rays were indicated with arrows in the appropriate directions. The points were the rays entered and left the trapezoid were marked.
6. A line was drawn on the paper connecting the points where the rays entered and left the trapezoid This line represented the ray inside the trapezoid.
7. The angle of incidence (θ_i) and the angle of refraction θ_r were measured using a protractor. Both angles were measured from the normal.
8. The steps 1-7 were repeated on new sheets of paper for different angles of incidence.

DATA ANALYSIS

Table 1. Angles of incidence and corresponding Angles of Deviation

Trial Number	Angle of incidence i	Angle of Deviation D
1	30°	34°
2	35°	26°
3	40°	10°
4	45°	12°
5	50°	75°
6	55°	87°
7	60°	91°

From the graph the Minimum Angle of Deviation is 34° which is occurring at an angle of incidence 30°.

From equation 9.3 $i = \frac{A+D_m}{2}$,which gives us: $A = 2i - D_m$

$$A = 2(30°) - 34°$$

$$A = 60° - 34°$$

$$\boldsymbol{A = 26°}$$

Refractive index, $n_2 = \frac{\sin(\frac{A+D}{2})}{\sin(\frac{A}{2})}$ 5

$$n_2 = \frac{\sin(\frac{26+34}{2})}{\sin(\frac{26}{2})}$$

$$n_2 = \frac{\sin(\frac{60}{2})}{\sin(13)}$$

$$n_2 = \frac{\sin(30)}{0.225}$$

$$n_2 = \frac{0.5}{0.225}$$

$$n_2 = 2.222$$

$$\mathbf{n_2 \approx 2.2}$$

Thus, the refractive index of the prism $\approx$ 2.2

Table 9.1 Relation between angle of incidence and angle of refraction

Trial No.	Angle of incidence (θ_i)	Angle of refraction (θ_r)	$\sin\theta_i$	$\sin\theta_r$	Refractive index of acrylic ($n_{acrylic} = \frac{sin\theta_i}{sin\theta_r}$)
1	10°	8°	0.174	0.139	1.25
2	20°	18°	0.342	0.309	1.11
3	30°	20°	0.5	0.342	1.46
4	40°	30°	0.642	0.5	1.28
5	50°	50°	0.776	0.776	1.0

From the graph the refractive index of the acrylic is:

$$n_{acrylic} = \frac{sin\theta_i}{sin\theta_r}$$

$$n_{acrylic} = \frac{0.4 - 0.2}{0.31 - 0.16}$$

$$n_{acrylic} = \frac{0.2}{0.15}$$

$$\mathbf{n_{acrylic} = 1.3}$$

$$\sum r = (1.25 + 1.11 + 1.46 + 1.28 + 1.0)$$

$$\boldsymbol{\sum r = 6.1}$$

$$\text{mean r} = \bar{\text{r}} = \frac{1}{\text{N}}\sum_{\text{i}=1}^{\text{N}} \text{r}_\text{i}$$

$$\text{where N} = 5,\ \sum_{\text{i}=1}^{\text{N}} \text{r}_\text{i} = \text{r}_1 + r_2 + \ldots\ldots\ldots + \text{r}_5 = \sum \text{r} = 6.1$$

$$\therefore\ \bar{r} = \frac{1}{5}(6.1)$$

$$= \mathbf{1.2}$$

Percentage Error

$$\%\ \text{error} = \frac{\bar{\alpha} - \alpha}{\alpha} \times 100$$

$$= \frac{1.3 - 1.2}{1.3} \times 100$$

$$\underline{\mathbf{\%\ Error = 7.7\%}}$$

The refractive index from the graph is close to the mean refractive index with the difference of 0.1, giving a percentage error of 7.7%.

DISCUSSION

When the angle of incidence is plotted against the angle of deviation. A smooth curve is produced. The curve has a minimum value which represents the minimum angle of deviation. In this case it was found to be 34° occurring at an angle of incident of 30°.

The ratio of the sine of the angle of incident to the sine of the angle of refraction is constant for a particular material, it is called the refractive index. In this experiment it was found to be close to 1.2,after averaging. This value is very close to the slope of the graph- 1.3.The difference in the values of the refractive index is due to experimental errors. We encountered a couple of experimental errors. Parallax errors were the most common of all during the location of the image formed by the pins. These can be avoided by closing one eye. To further reduce on the errors the experiments was done several times to obtain the main value.

CONCLUSION

The minimum angle of deviation was found from the graph and the refractive index was found using the formula $n_2 = \frac{\sin(\frac{A+D}{2})}{\sin(\frac{A}{2})}$. This was approximately 2.2. Overall, the experiment was a success. The refractive index was found from the slope of the graph and from the formula $n_{acrylic} = \frac{sin\theta_i}{sin\theta_r}$.

REFERENCE

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