BIRZEIT UNIVERSITY
Physics Department

Physics 111

**Experiment No. 6**

# Index of Refraction

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– **Abstract:**


**1)The aim of the experiment:**

is to measure the index of refraction of transport for a kind material ( Glass or Plastic ) , and to use least square fit method .

**2) The method used:**

is by measuring the angles of the reflection of the light when it falls throw a medium like glass by placing a block of glass on a piece of white paper .

**3) The main results are:**

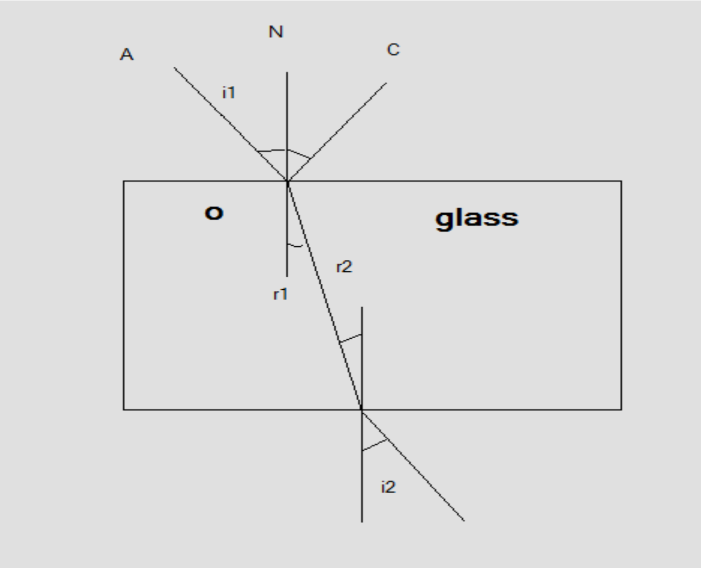
$$\mu = 1.46 \pm 0.03$$


– **Theory:**

When light passes from one medium to another, the path of the light bends, Examples of media are glass , plastic, water and air different colors bend by different amounts at the boundary between the two media that bending is called " refraction " and each medium has it's own refraction index N due that not all media bend a given light by the same amount ( index of refraction = speed of light in vacuum / speed of light in the medium )

$$n = \frac{c}{v}$$

The refraction index is a measure of how much bending will occur for the light when it falls on a medium in the figure below:




When light falls on a block of glass from air AO represent a rag of light traveling in air incident on the surface of the block , OC represent the reflected ray, OB represents the refracted ray while ON represent the normal to the block surface "I" is the angle of incidence while "r" is the angle of refraction applying Snell’s law which is :

$$\mu_a \sin(i) = \mu_g \sin(r)$$

$\mu_a$ is the index of refraction of air which is near that of the vacuum ( $\mu_a \approx 1$). $\mu_g$ is the index of refraction of the glass.

Then:

$$\sin(i) = \mu_g \sin(r) = \mu \sin(r)$$

$$\sin(i) = \mu \sin(r)$$

Then we can find $\mu$ from the plot of sin(i) vs. sin(r). The error in $\mu$ is founded by:

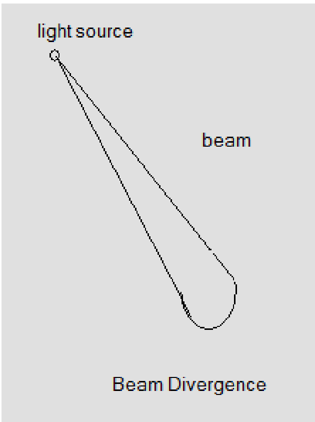
$$\mu = \frac{\sin(i)}{\sin(r)}$$

$$\Delta\mu = \left|\frac{\cos(i)\Delta i}{\sin(r)}\right| + \left|\frac{-\sin(r)\cos(i)\Delta r}{\sin^2(r)}\right|$$

$$\Rightarrow \frac{\Delta\mu}{\mu} = \frac{\cos(\mathrm{i})}{\sin(\mathrm{i})}\Delta i + \frac{\cos(\mathrm{r})}{\sin(\mathrm{r})}\Delta r$$

**Procedure:**

The block was placed on a piece of white paper the borders of block were drown in the paper . The angle of incidence were marked as shown on the figure on the previous page the first angle was choosed near 10 , the second angle near 20 , and so a narrow bean of light was shone exactly on path 1, then the path was marked and labeled this procedure was repeated for five more times for other angle from 20 to 60 , the block was removed and for eash outgoing bean , a perpendicular line was drown to the block boundary at each exit point, the exist point and the incident point were connected for each incident and out going $i_1 = i_2)$ ,$(\mathrm{r}_1 = r_2)$ for each incident and outgoing beam were measured and written down in the table below after all $\Delta r$ & $\Delta \mathrm{i}$ were estimated in radians .



– **Data:**

| NO. | Angle ( i) degree | | i average | Sin ( $\bar{i}$ ) | Angle (r) degree | | r average | Sin ( $\bar{r}$ ) |
|---|---|---|---|---|---|---|---|---|
| | $i_1$ | $i_2$ | | | $r_1$ | $r_2$ | | |
| 1 | 10 | 9 | 9.5 | 0.17 | 7 | 6 | 6.5 | 0.11 |
| 2 | 20 | 20 | 20 | 0.34 | 13 | 12 | 12.5 | 0.22 |
| 3 | 30 | 27 | 28.5 | 0.48 | 20 | 18 | 19 | 0.33 |
| 4 | 40 | 36 | 38 | 0.62 | 26 | 25 | 25.5 | 0.43 |
| 5 | 50 | 48 | 49 | 0.76 | 32 | 31 | 31.5 | 0.52 |
| 6 | 60 | 60 | 60 | 0.87 | 36 | 35 | 35.5 | 0.58 |

– **Calculations: (Using Least Square Fit method** )

Let x= Sin ( $\bar{r}$ ), y= Sin ( $\bar{i}$ )

| $x_i$ | $y_i$ | $x_i y_i$ | $x_i^2$ | $y_i - mx_i - b$ | $(y_i - mx_i - b)^2$ |
|---|---|---|---|---|---|
| 0.11 | 0.17 | 0.019 | 0.0121 | 0.075 | 5.625*10 |
| 0.22 | 0.34 | 0.075 | 0.0484 | 0.079 | 6.241*10 |
| 0.33 | 0.48 | 0.16 | 0.1089 | 0.053 | 2.81*10 |
| 0.43 | 0.62 | 0.27 | 0.1849 | 0.042 | 1.764*10 |
| 0.52 | 0.76 | 0.4 | 0.2704 | 0.046 | 2.116*10 |
| 0.58 | 0.87 | 0.5 | 0.3364 | 0.066 | 4.356*10 |
| $\sum x_i=$ 2.19 | $\sum y_i=$ 3.24 | $\sum x_i y_i=$ 1.424 | $\sum x_i^2=$ 0.96 | | $\sum( y_i - mx_i - b)^2=$ 0.022912 = 0.023 |

$$D = N\sum x_i^{\ 2} - (\sum x_i)^2$$ = 0.96

$$m = (N\sum x_i y_i - \sum x_i \sum y_i)/D$$ = 1.46

$$b = (\sum x_i^2 \sum y_i - \sum x_i \sum x_i y_i)/D =$$ = 0.008127

**Calculation of errors:**

$$\sigma_y^{\ 2} = \frac{1}{N-2}\sum(y_i - mx_i - b)^2 =$$ = 1.44*10

$$\Delta\mu = \sigma_m = \sqrt{\frac{N\sigma_y^{\ 2}}{D}} =$$ = 0.033843 = 0.034=0.03

$$\Delta b = \sigma_b = \sigma_y\sqrt{\frac{\sum x_i^{\ 2}}{D}} =$$ = 0.013611 = 0.014=0.01

– **Results and conclusion:**

$\mu$ = 1.46 ± 0.03

According to the range test , our range in this experiment is 1.43< $\mu$ <1.49 and the theoretical value of M of glass is 1.52 , so our experimental value is not included in the range , so the range test failed … so our experiment failed systematic errors exist due to use a glass block which have not equally borders and they were inaccurate , and there were systematic errors due to, that we had estimated the middle of the light bean each time so in conclusion we were able to find the index of refraction of glass and learn how to use the least square fit method ,