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Advanced LASER Approach of Sugar Content in a Liquid

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***Abstract*: Consider it takes costly, complicated tools to determine the rapidity of light? Think again! Setup manually with an easy handheld laser pointer, a protractor, and gelatin and you're ready to get started. As awareness that can be stature away how a large amount of sugar is in a liquid not including ever taste it? In this paper leaning of measure the concentration of sugar dissolved in a liquid by using a laser pointer, a hollow prism, and some physics. Here we will find out how refraction, or the bending of light, is the solution to measure the sugar substance of a liquid with a laser pointer.**

***Keywords*: Bending, laser. Prism, reflection**

1. Introduction

An odd "bending" result while we place a straw (or pencil) in a tumbler of water: the straw appears to bend at the border between the air and the water. Compare the two images in Fig. 1, and observe if you notice anything unlike between them.

Fig. 1. These two figures demonstrate refraction by liquids. One tumbler contains plain water, and the other contains sugar-water. Which glass has which liquid? (Wood, 2003) (Images © Robin Wood, 2003, used with permission.)

The straws in Fig. 1, on top of, appear to bend for the reason so as to occurrence called refraction, the bending of a wave as it passes commencing one substance into a different. Waves travel at dissimilar speeds from beginning to end dissimilar mediums (such as air and water), and this speed dissimilarity prepare the wave refract when it passes from one material into another. As light waves pass through from the water into the air, the wave refracts, which makes the straws in Fig. 1, above, look bent or broken. The difference has been observed due to one tumbler is filled with a denser solution than the other. The denser the medium, the slower the wave movements through the medium. The speed at which a light wave movements through a medium is quantified in the directory of refraction i.e. n, of that medium. It indicates the proportion between the speed of light in a vacuum and the speed of light in the medium of interest. Let us consider, the index of refraction of air is 1.00028, so light travels 1.00028 times earlier in the vacuum than it does in air.

2. Terms and concept

In this paper, the wide scope of research is available for the following concepts

- Refraction
- Index of refraction
- Snell's Law
- Angle of incidence
- Angle of refraction
- Density
- Prism
- Angle of minimum deviation

A. Refraction

In physics refraction is the change in direction of a wave passing from one medium to another or from a gradual change in the medium [1]. Refraction of light is the mainly usually practical occurrence, but further waves such as sound waves and water waves also experience refraction. How much a wave is refracted is resolute by modify in wave speed and the early trend of wave propagation relative to the direction of vary in speed.

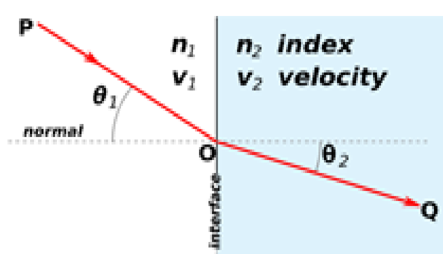

Fig. 2. Refraction

B. Index of refraction

In optics, the refractive index or index of refraction of a substance is a dimensionless quantity that describe how light propagate through that medium. [2] It is defined as n=c/υ

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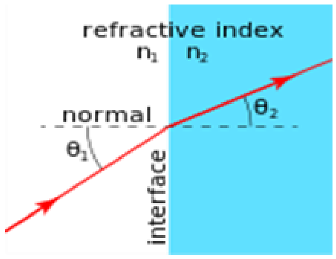

Fig. 3. Index of refraction

C. Snell's Law

This form of Snell's law was actually published by Descartes as the law of Sines. Snell did discover the relationship but articulated it in a different way. It is the form used by Descartes that is called Snell's law [3]. The law is defined as: $n_1\sin\theta_1=n_2\sin\theta_2$

Where n is the refractive index and θ the corresponding angles as shown. The refractive index is the ratio of the speed of light in a vacuum to the speed of light in a given medium. So, if the top part of the diagram is air, n_1 is the speed of light in air and if the bottom part is glass, n_2 is the speed of light in glass, both relative to the speed of light in a vacuum. Snell and Descartes realized that when light went from one medium to another, the angles & refractive indexes of the media determined the path that light took. The relationship is a function of the sine of the angles.

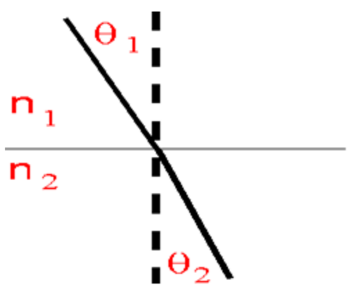

Fig. 4. Snell's Law

n_1 = index of refraction of material 1 (no units, since it is a ratio)
θ_1 = angle of incidence (degrees or radians)
n_2 = index of refraction of material 2 (no units, since it is a ratio)
θ_2 = angle of refraction (degrees or radians)

D. Angle of incidence

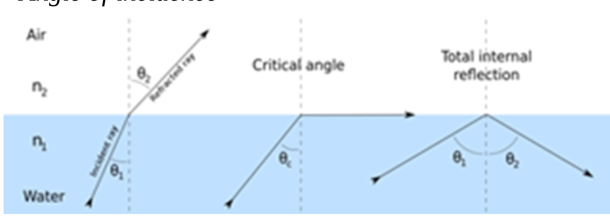

Fig. 5. Angle of incidence

In geometric optics, the angle of incidence is the angle between a ray incident on a surface and the line perpendicular to the surface at the point of incidence, called the normal. The ray can be formed by any wave: optical, acoustic, X-ray, microwave and so on. In the figure below, the line representing a ray makes an angle θ with the normal (dotted line). The angle of incidence at which light is first totally internally reflected is known as the critical angle. The angle of reflection and angle of refraction are other angles related to beams [4].

E. Angle of refraction

As soon as light movements from a intermediate with a advanced refractive index to lone with a lesser refractive index, Snell's law seems to have need of some cases that the sine of the angle of refraction be superior than individual. This of course is impractical, and the light in such cases is absolutely reflect by the margin, a phenomenon known as total internal reflection. The largest possible angle of incidence which still results in a refracted ray is called the critical angle; in this case the refracted ray schedule along the margin among the two media. [5]

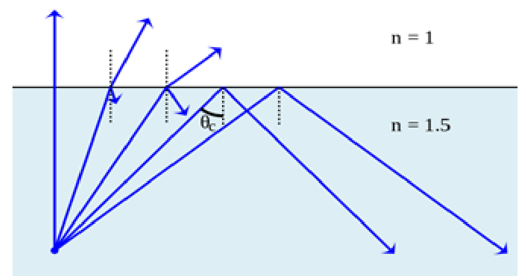

Fig. 6. Angle of refraction

F. Angle of minimum deviation

A beam of light enters the apparent substance, the ray's direction is deflected, based on the access angle, the material's refractive index, and according to Snell's Law. A ray passing through an object like a prism or water drop is deflecting two times: once incoming, and another time when exit. The sum of these two deflections is called the deviation angle [6].

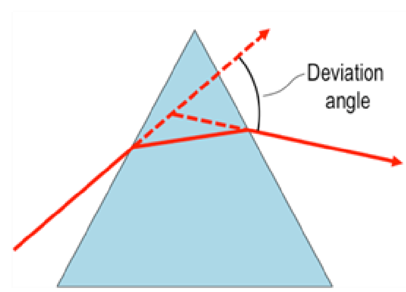

Fig. 7. Angle of refraction

3. Experimental setup

A. Measuring the Index of Refraction of a Liquid

Note: Do this project in an area where you can put a table close to a flat wall or window, and where taping paper to the wall or window is allowed.

1. In Fig. 7, the arrangement will be used for measuring the index of refraction of a liquid. The setup would appear whether top view is observed.

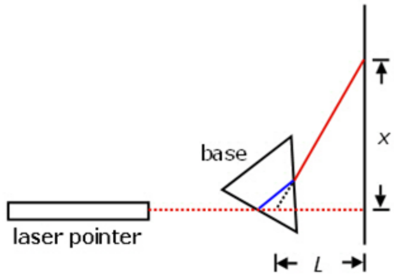

Fig. 8. Diagram of setup for measuring the index of refraction of a liquid using a laser pointer and a hollow triangular prism (not to scale; based on the diagram in Nierer, 2002).

2. Leave the laser stick on a desk. The beam must be concentrated of the laser pointer so its beam (dotted red line in Fig. 7) is perpendicular to the wall.
3. In front of the Laser pointer is laid on a piece of paper. Tie it strongly to the desk. The paper will be used to spot everywhere the laser beam enters and exits the prism.
4. Situate the prism on the apex of the paper, a small number of centimeters in frontage of the laser pointer. One of the prism's triangular faces must be latent on the paper. Using a pencil, trace around the prism's base. Whether movement of the prism has been done, always return it to previous location earlier than revolving it, if needed, as explained in step 12.
5. Alter the pinnacle of the laser pointer with pieces of cardboard until the laser's beam hits concerning middle up the side of the prism.

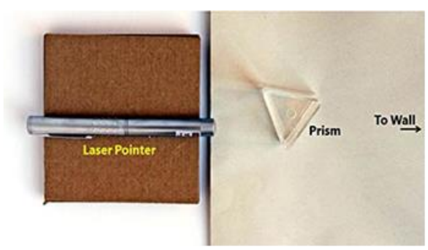

Fig. 9. Diagram of setup for measuring the index of refraction of a liquid using a laser pointer and a hollow triangular prism (not to scale; based on the diagram in Nierer, 2002)

Fig. 10. Adjust the height of the laser pointer with pieces of cardboard. The beam of the laser should hit the prism about halfway up the prism's side

6. Tie the cardboard to the desk and after that tie the laser pointer to the cardboard. Make sure that neither the laser pointer nor the cardboard can move. Whether, the laser pointer's position changes, measurements will be inaccurate.

Precaution Note: If you have two or greater than two sheets of cardboard stacked in concert, you may need to tie the pieces of cardboard in concert so that they do not slide.

7. Tie a large portion of the paper to the wall in front of the laser pointer. Paper will be used to spot everywhere the laser ray hits the wall.
8. To calculate the angle of minimum deviation, θmd, which to calculate the index of refraction of the liquids that you test, mark several points and determine the distances flanked by some of these points. Figure 10, is an additional complete sight of the prism and wall. It shows every point need to be marked in order to calculate the angle of minimum deviation, θ_{md}. The process underneath explains how to mark these points and determine the angle of minimum deviation, θ_{md}.

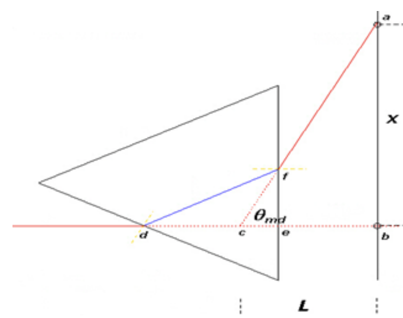

Fig. 11. Detail diagram showing how to measure the angle of minimum deviation (not to scale; based on the diagram in Nierer, 2002)

9. Fig. 11. Empty prism (filled only with air), insertion of it in the laser's path should not deflect the beam. Turn the laser on, and blotch the spot everywhere the beam hits the paper taped to the wall. Name it as ‘b’ (point b in Fig. 10).

Precaution Note: Previous to trying a new solution, turn on the laser and excel it all the way through an empty prism to create sure that the laser beam unmoving point b. If the laser beam no longer hits point b, the calculation will be inaccurate. Regulate the laser's position, if required, until the attentive beam hits point b.

10. By way of the prism unfilled, mark everywhere the beam enters the prism on the paper the prism is sitting on (point d in Fig. 10). Label it point d.
11. By way of the prism unfilled, mark everywhere the laser beam exits the prism on the paper the prism is sitting on (point e in Fig. 10). Label it point e.
12. Switch off the laser. Fill up the prism with natural water. If the position of the prism to fill it with water is changed, go again it to the sketch out as per outline the piece of paper. Switch the laser back on.
13. Turn approximately the prism so that the conduit of the refracted beam contained by the prism (solid blue

line from d to f in Fig. 10) is parallel with the foot of the prism, the plane of the prism that has no laser beam striking it.

Precaution Note: A pinch of non-dairy creamer in the liquid can assist to observe the beam within the prism, and should not have a considerable outcome on the index of refraction of the liquid.

14. As soon as the prism is rotated in the approved manner (as described in step 13), mark the spot where the rising beam hits the paper taped to the wall (point a in Fig. 10). Label it point a.
15. On top of the paper on the desk, mark the point where the beam emerges from the prism (point f in Fig. 10). Name it point f.
16. The Prism can be removed. Depart the papers taped in place.
17. With a help of scale connect a line from point d to point e. This marks the conduit of the undirected beam.
18. After that, enlarge a line from point a (on the wall) from beginning to end point f (on the table). Enlarge a string from point a so that it passes over point f. Mark the position where the string crosses the line between d and e. This is point c.
19. Calculate the distance between points a and b, It is distance x (see Fig. 10).
20. Calculate the distance between point's b and c. It is distance L (see Fig. 10).
21. The distances calculated define the angle of minimum deviation, θ_{md}. x/L which is given ratio is the tangent of the angle of minimum deviation, θ_{md}. With the help calculator angle can be determined. i.e. arctangent of x/L. ("the angle whose tangent is equal to x/L." is given by the arctangent of x/L
22. Substitute in equation, the angle of minimum deviation, and hence calculate the index of refraction, n, of the liquid in the prism.

Equation:

$$n = 2.00056 \times \sin[(\theta_{md} + 60°)/2]$$

n = index of refraction of solution (unit less, since it is a ratio)
θ_{md} = angle of minimum deviation (degrees)

23. By calculating the index of refraction of plain water using steps 9 during 22 of this practice. An index of refraction of about 1.334 is obtained.

4. Experimental setup

1. Water solutions using three different levels of concentration as shown in Table 1. Employ the gram scale to evaluate the suitable quantity of sugar.

Precaution Note: By using warm water the sugar melt more rapidly.

Table 1
Amounts of sugar and water for standard sugar solutions

Desired concentration (% mass/volume)	Sugar Amount (g)	Water Amount (ml)
10	10	90
20	20	80
30	30	70
40	40	60

2. Blend each of the solutions in Table 1 in a graduated container or liquid measuring beaker with metric units, by means of a moving rod to melt the sugar. Once the solutions are finished and the sugar is totally melted, set aside the 20%, 30% and 40 % solution and fills the prism with as a great deal of the 10% sugar solution as potential.
3. Find the index of refraction of the 10% sugar solution. Do again your calculations four additional periods for the 10% sugar solution, intended for a total of five replicates. Middling the results using average calculations.
4. Vacant the prism and soak it with plain water. After that do again step three using 20%, 30% and then 40% sugar solutions. Now evaluate the index of refraction of a solution with unidentified sugar concentration (e.g., a clear soft drink or fruit juice). Whether measure a carbonated beverage, compose that there are no bubbles in the path of the laser.
5. Taking reference of index of refraction of the unidentified solution, combined with the data you have from your recognized sugar solutions, you should be able to approximation the sugar concentration of the unidentified solution

5. Conclusion

The laser operated unidentified sugar solution can be recognized with the help of reference for the index. It can be used for diabetic persons for keeping health conscious.

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