
Livya and Maheera's
logbook

‘Shine It Out’

Why This?

- *We love interplay of light & prisms and wanted to explore more about them.*
- *Title matches with what we are attempting in our science experiment*
- *Further we got to learn a lot of new concepts like Snell’s law, Refractive index, Incident ray, Emergent ray, Refraction, Diffraction, Minimum deviation, Angle of incidence etc. It has sparked further curiosity in us to explore physics.*

Testable Question

“How does the type of a solute in a liquid affect the diffraction pattern produced, when a laser beam passes through a hollow prism filled with liquid?”

DEFINITIONS

- **Refraction:** Bending of light as it passes from one material to another
- **Diffraction:** Spreading of waves around obstacles or through small openings.
- **Angle of Incidence:** The angle between the Incoming light and the Normal (perpendicular line) at the point of contact with a surface.
- **Snell's law**: It describes the relationship between the angle of incidence and refraction and states that as the light moves from one material to another, it bends and how much light bends would depend on the relative density of the materials.
- **Refractive index** : It is the ratio of speed of light in air/vaccum to the speed in the given medium and tells you how much path of light is bent as it enters any medium
- **Angle of refraction**:Angle between the refracted ray (bent light) and the normal line (perpendicular line at the surface of contact).
- **Deviation**: Directional change from the usual or expected path, like light bending or an object changing direction!
- **Minimum deviation**: It is the smallest amount of bending light does when passing through a prism, happening when the light's path is altered the least.

Background information

How does a laser light work?

- "Laser"- Acronym for Light Amplification by Stimulated Emission of Radiation.
- LASER works by concentrating the light particles (Photons) in a single direction by exciting and vibrating particles through a glass or gas medium. So rather than spreading, the light is concentrated and thus goes much farther and in a straight direction than the ordinary light would.

Author: Live science

Source Website:

:https://www.livescience.com/physics-mathematics/how-do-lasers-work

Background information

PRISM: A 3D (three -dimensional) transparent glass object, which separates the passing light into seven different colours (ROYGBIV) with Red being at the top and violet at the Bottom (See picture)

Properties of Prisms:

1. There are two identical faces (called bases) & Several rectangular faces (lateral faces) and Edges where the faces meet. Depending upon the shape of bases, Prisms could be triangular (3 sides), rectangular (4 sides), pentagonal (5 sides) & Hexagonal (6 sides)
2. Measurement:
   a. **Volume:** Multiplying the area of the base by the height
   b. **Surface Area:** Sum of the areas of all faces
   c. **Height:** Distance between its bases.

Background Information

Interaction of Light & Prisms

When light passes through a prism, it bends and changes direction as it changes from one medium(air) to another (Glass). Snell's Law states denser the material through which light passes, higher is the bending.

Now, the ordinary white light is made up of seven different colors (ROYGBIV- red, orange, yellow, green, blue, indigo, and violet.). When these colors pass through the prism, they bend at slightly different angles because they travel at different speeds. This is why we see a band of colors, like a mini rainbow ! These colors always appear in the same order since red light bends the least as it travels fastest, while violet bends the most as it travels the slowest.

[Author: Wonders of Physics.
Source Website: https://wonders.physics.wisc.edu/prisms/ **]**

Background Information

Hollow Prism

A hollow prism is a special kind of prism that has a empty space inside. This space can be shaped like a cylinder or other geometric shapes.

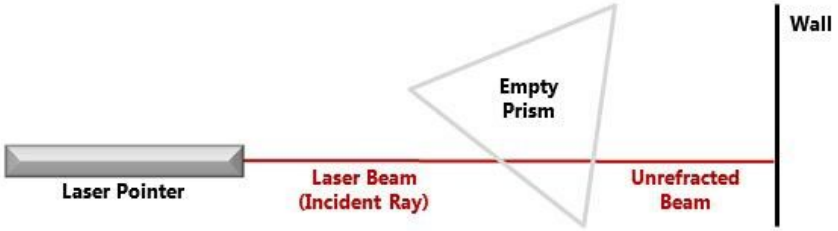
Properties of Hollow Prism:

- the hollow part can be filled with air, gas, or other fluids.
- When white light passes through a hollow prism, it doesn't break into different colors (spectrum) because the light is passing from one medium (air) to the same medium (air) inside the prism. However, when filled with any liquid, the light bends twice.

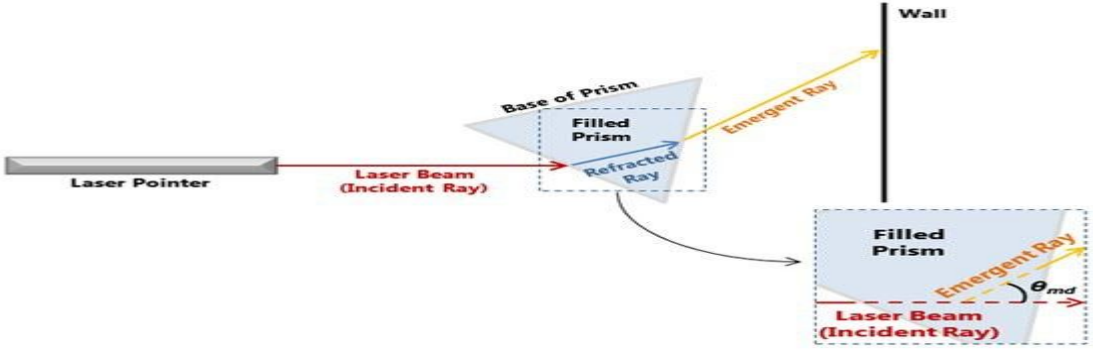
[Author: Wonders of Physics.
Source Website: https://wonders.physics.wisc.edu/prisms/]

Hollow prism and light interaction.

Hollow Prism with No Fluid (No Bending)



Hollow Prism with Fluid (Double Bending)



Background Information

How to calculate the refractive index (n) of any liquid using Snell's Law

1. Measure the ratios: **ab/bc**

2. Calculate **Angle of Minimum Deviation (dm)**: dm = tan inverse (ab/bc)

3. Apply **Snell's Law:** $n = 2.00056 \times \sin[0.5(\theta md + 60°)]$

Where: (see the diagram)

ab: distance b/w the undeviated (un-filled) & deviated (Liquid filled) light beam

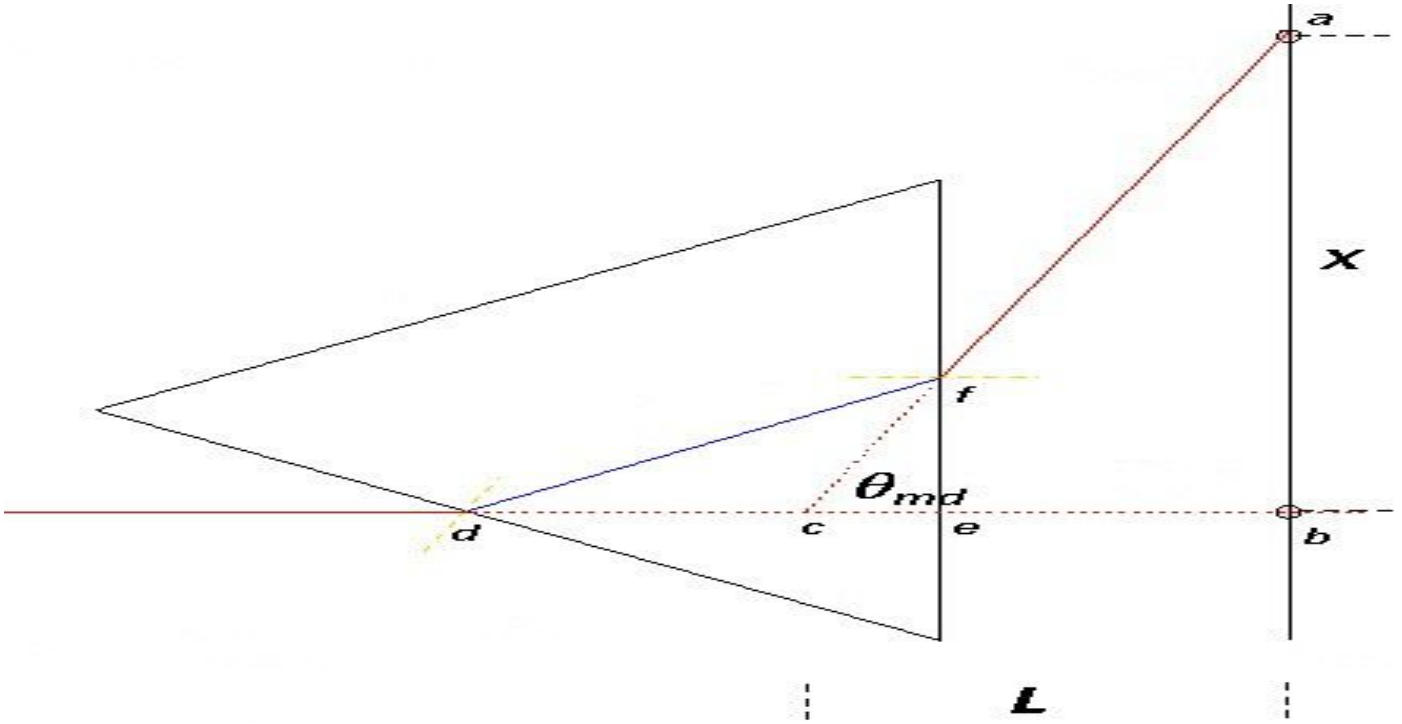
bc: distance b/w center of the prism & the deviated (refracted) light beam.

dm = Angle of Minimum Deviation

A = Angle of Incidence (60° in an triangular prism) & **n** = Refractive Index

Source:
https://www.sciencebuddies.org/science-fair-projects/project-ideas/Phys_p028/physics/measuring-sugar-content-of-a-liquid-with-a-laser-pointer

Diagram of our project



Sources of Information

Title	Author	Source website	Year
What are some prism properties?	Vedantu	https://www.vedantu.com/formula/prism-formula#	2025
how does a laser light work?	Life science	https://www.livescience.com/physics-mathematics/how-do-lasers-work	2025
how does light go through a prism?	W prisms	https://wonders.physics.wisc.edu/prisms/#:~:text=A%20prism%20works%20because%20the,out%20instead%20of%20	2025

Variables

Independent Variable	Dependent Variable
Different types of a solute (liquids with different densities) filled within hollow prism	How much does the laser beam bends when it enters & exits a hollow prism?

Variables

Controlled Variables - Ones kept as constant across the experiments:

- Temperature of a liquid (Room temperature)
- Laser light source (Laser beam)
- Prism type (Hollow Prism)
- Angle of the laser (Perpendicular)
- Distance from prism to screen (10 cm)
- Smooth surface box (Cardboard)

Hypothesis

A hypothesis is like an "educated guess" that one makes before doing an experiment, where one uses what one already knows to predict what will happen based on one’s observations. It is basically a guess one can test to see if it's right!

H1: Denser the solute filled within hollow prism, higher would be the refraction of laser beam, that is, light will bend more if it passes through a denser solution like vinegar or sugar than water.

Materials for Experiment

1. Hollow Prism
2. Laser light
3. Thin string
4. Scissors
5. Ruler
6. White paper
7. Protacter
8. 3 different types of solute(plain water, vinegar,sugar water)
9. Tape
10. Cardboard smooth surface box
11. Scientific calculator
12. Wall

Procedure

1. Prepare three types of solutions
    a. Plain Water
    b. Sugar Water
    c. Vinegar
2. Set up the Hollow Prism on a White Paper
3. Set up the Laser Light on the cardboard box & fix with tape
4. Put the three solutions in the Hollow prism One by One
5. Beam the Laser Light on the Hollow Prism perpendicularly
6. Measure the bending of light by observing the angles on White Paper
7. Repeat the experiment with different liquids
8. Note down the measurements in a table

Date: 1/26/2025

Experiment: Trial 1

Data: (Plain Water)

Trials	Refractive Index
1	1.332
2	1.332
3	1.331

Mode Value : 1.332

Observation

In this trial, we observed that when we used Plain Water,
ab = 4.5 cm
bc = 8.2 cm

Angle of Minimum deviation (dm) = tan inverse * 4.5/8.2 = 28.757
(Using Scientific calculator)

Refractive Index (n) = 2.00056 * sin ((60 + dm)/2) = 1.332

Experiment: Trial 1

Photos

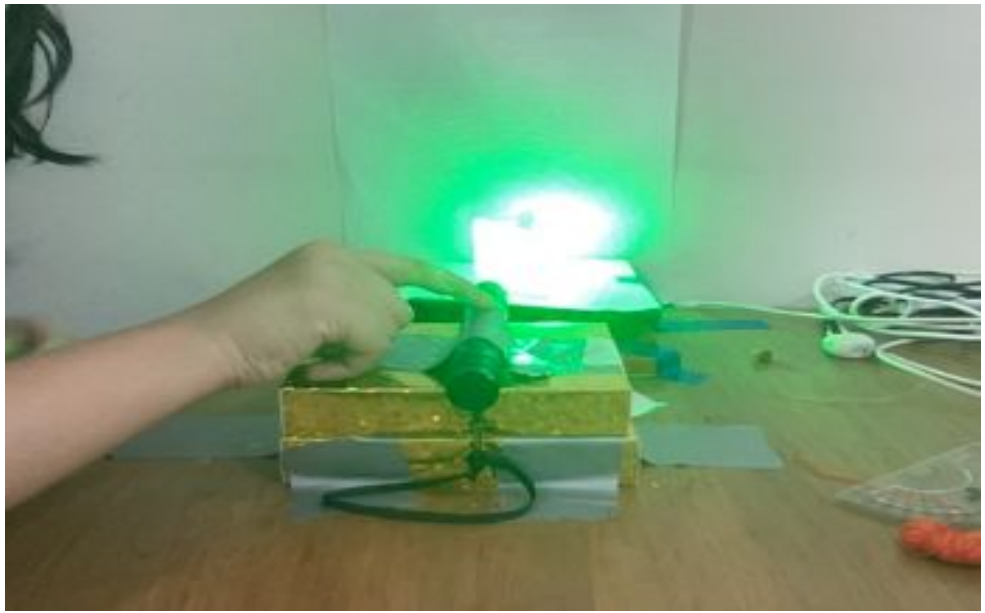
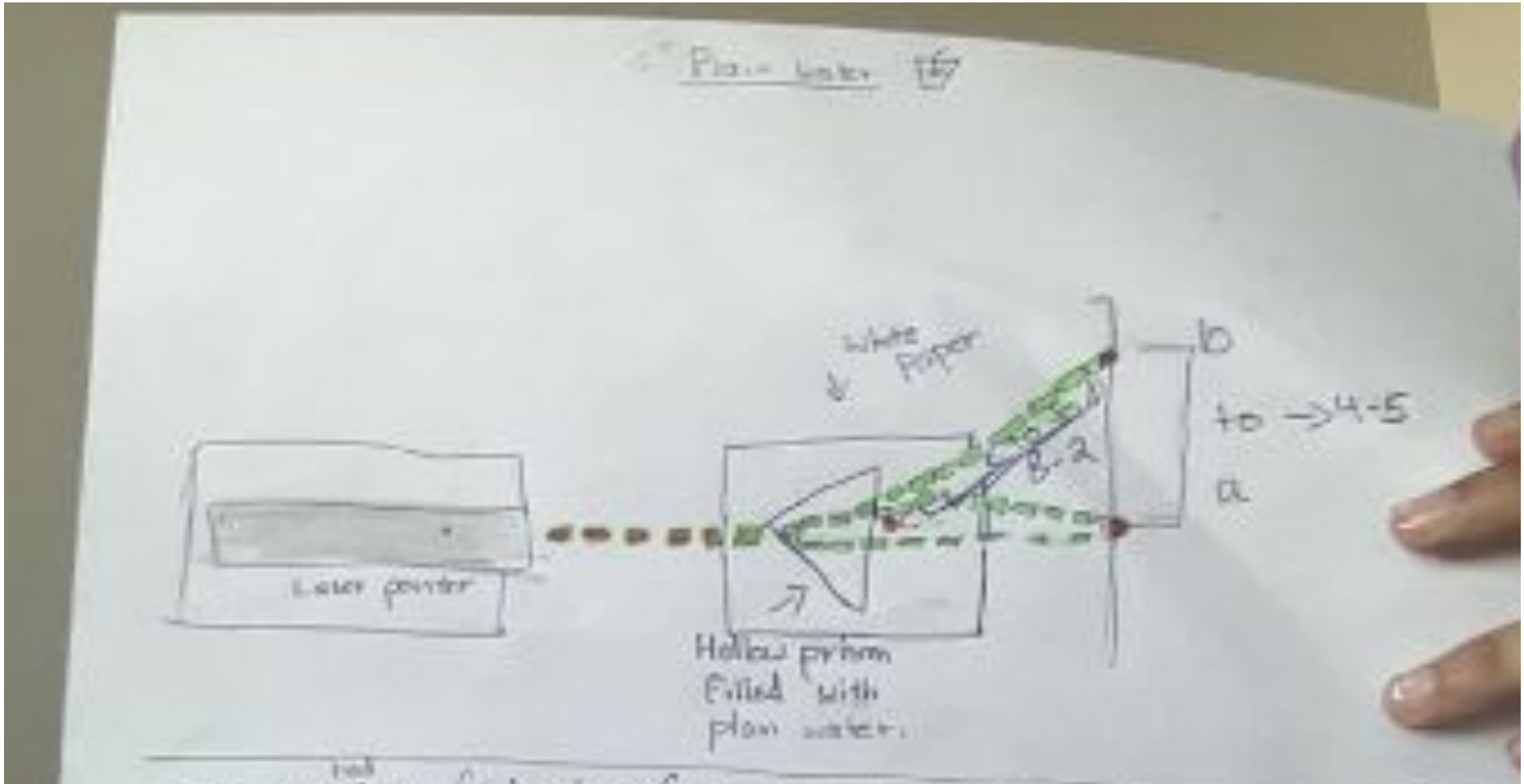


Diagram plain water



What we did (written)

First we needed to find out the dm meaning minimum deviation and the formula is tan inverse(ab/bc) and we know that a to b is 4.5 and b to c is 8.2 so the dm will be tan inverse * 4.5/8.2 and we used scientific calculator for all the calculation we did because we needed the tan inverse and the sin . so after we calculated the sum we got 28.757 now all we had to do was to find n () and we know the formula and that is n = 2.00056 * sin ((60 + dm)/2) and we know what dm is 28.757 so n = 2.00056 * sin ((60 + 28.757)/2) and by using the scientific calculator we got 1.332

Date: 1/26/2025

Experiment: Trial 2

Data: (vinegar)

Trial Attempt	Refractive Index
1	1.335
2	1.336
3	1.336

Mode Value : 1.336

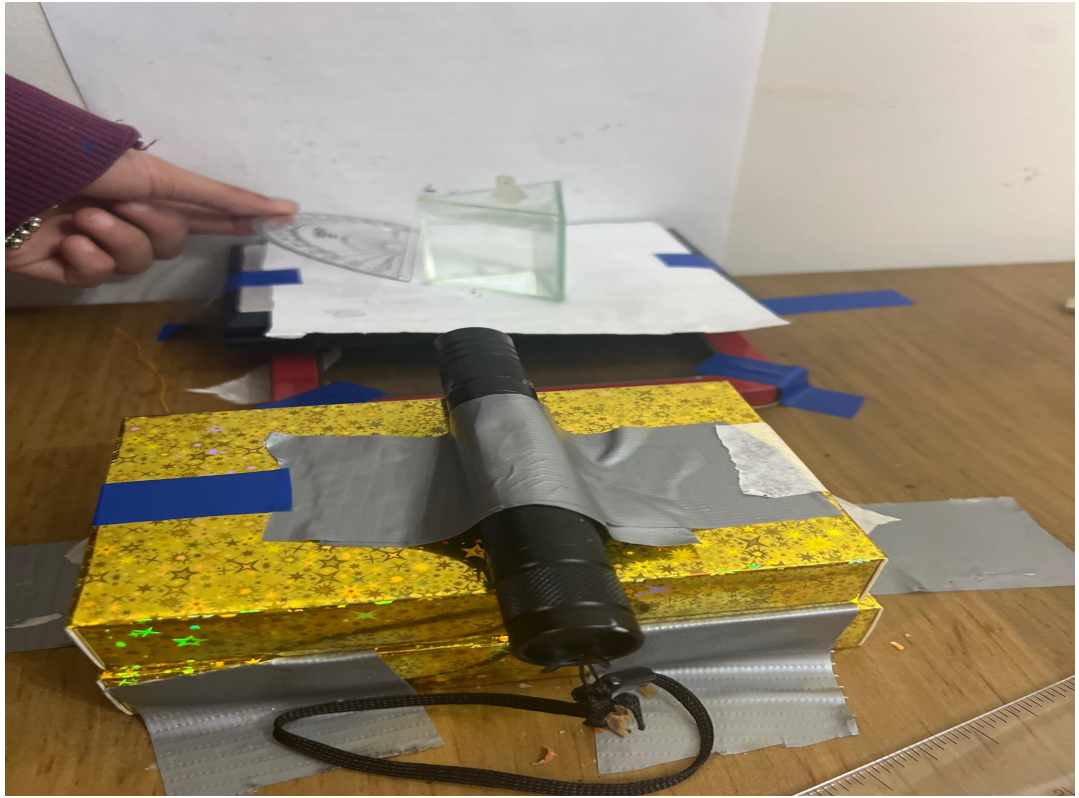
Observations/Notes:
In this trial, we observed that when we used Vinegar,
ab = 4.5 cm
bc = 7.8 cm

Angle of Minimum deviation (dm) = tan inverse * 4.5/7.8 = 29.981
(Using Scientific calculator)

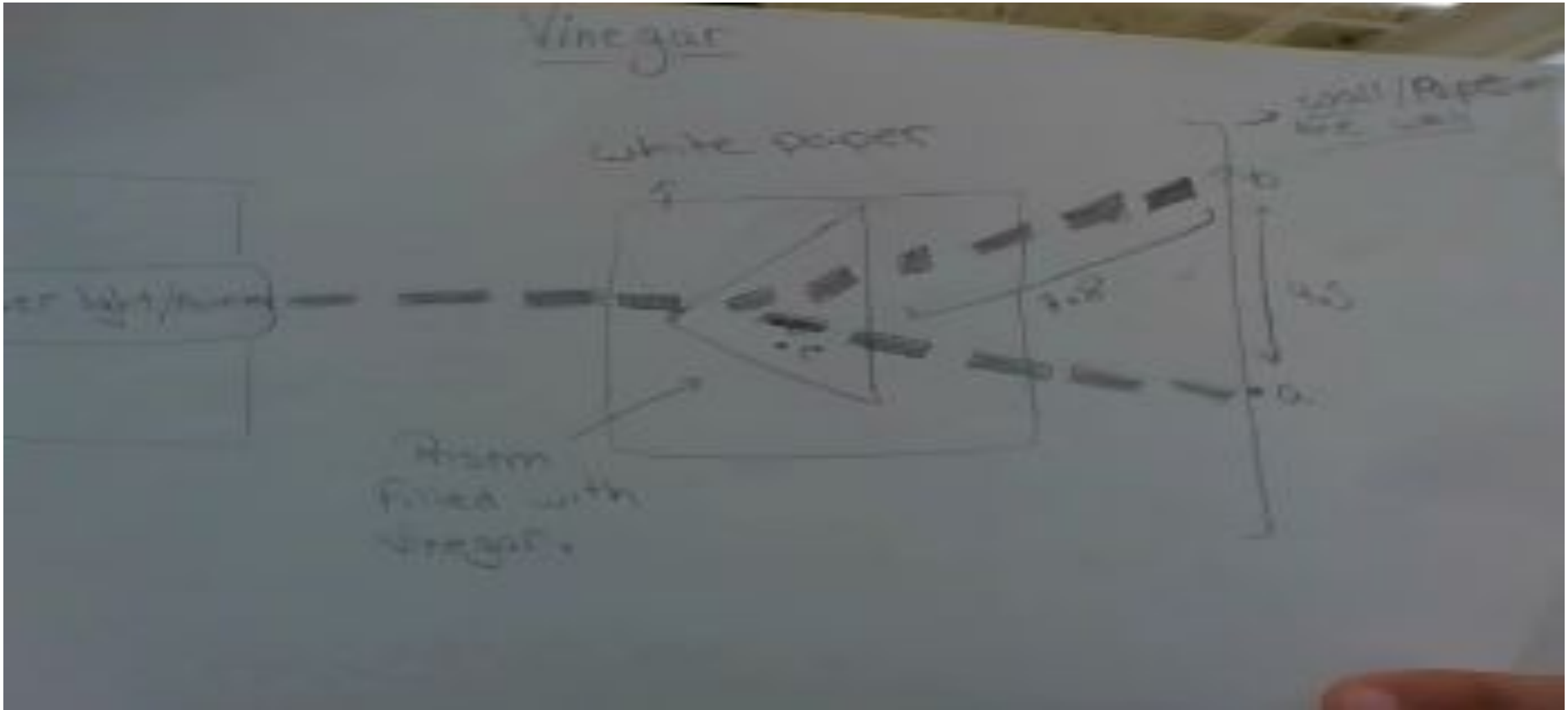
Refractive Index (n) = 2.00056 * sin ((60 + dm)/2) = **1.336**

Experiment: Trial 2

Photos:



Graph



Date: 1/26/2025

Experiment: Trial 3

Data: (sugar water)

Trial Attempt	Refractive Index
1	1.383
2	1.384
3	1.387
4	1.383

Mode Value : 1.383

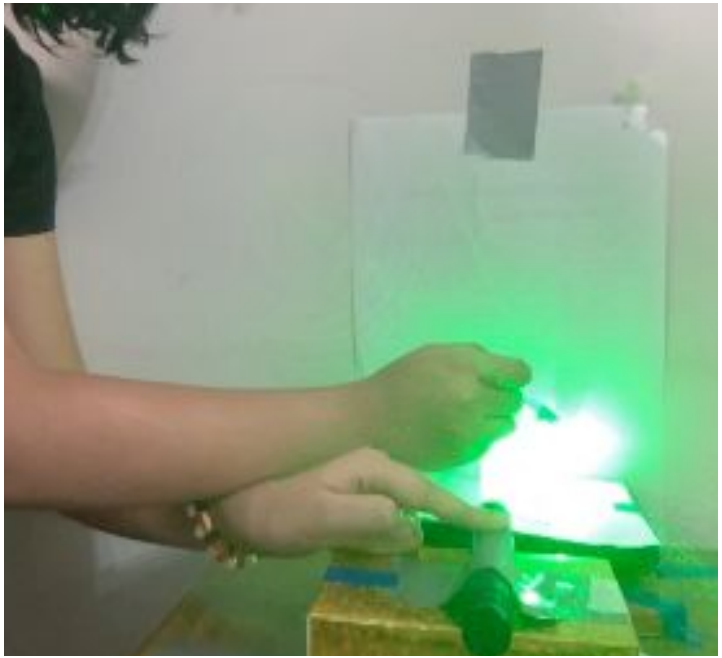
Observations/Notes:
In this trial, we observed that when we used Sugar Water,
ab = 5 cm
bc = 7.7 cm

Angle of Minimum deviation (dm) = tan inverse * 5/7.87 = **32.997**
(Using Scientific calculator)

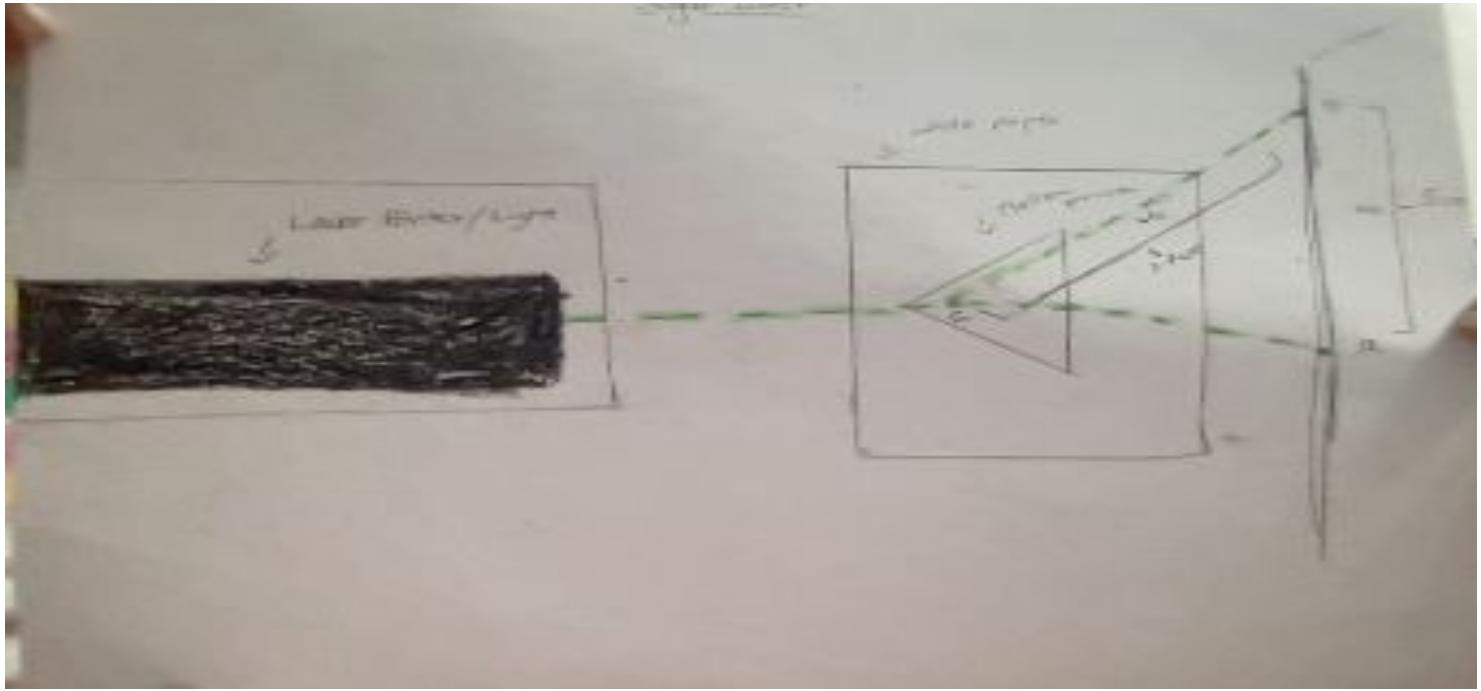
Refractive Index (n) = 2.00056 * sin ((60 + dm)/2) = **1.383**

Experiment: Trial 3

Photos:

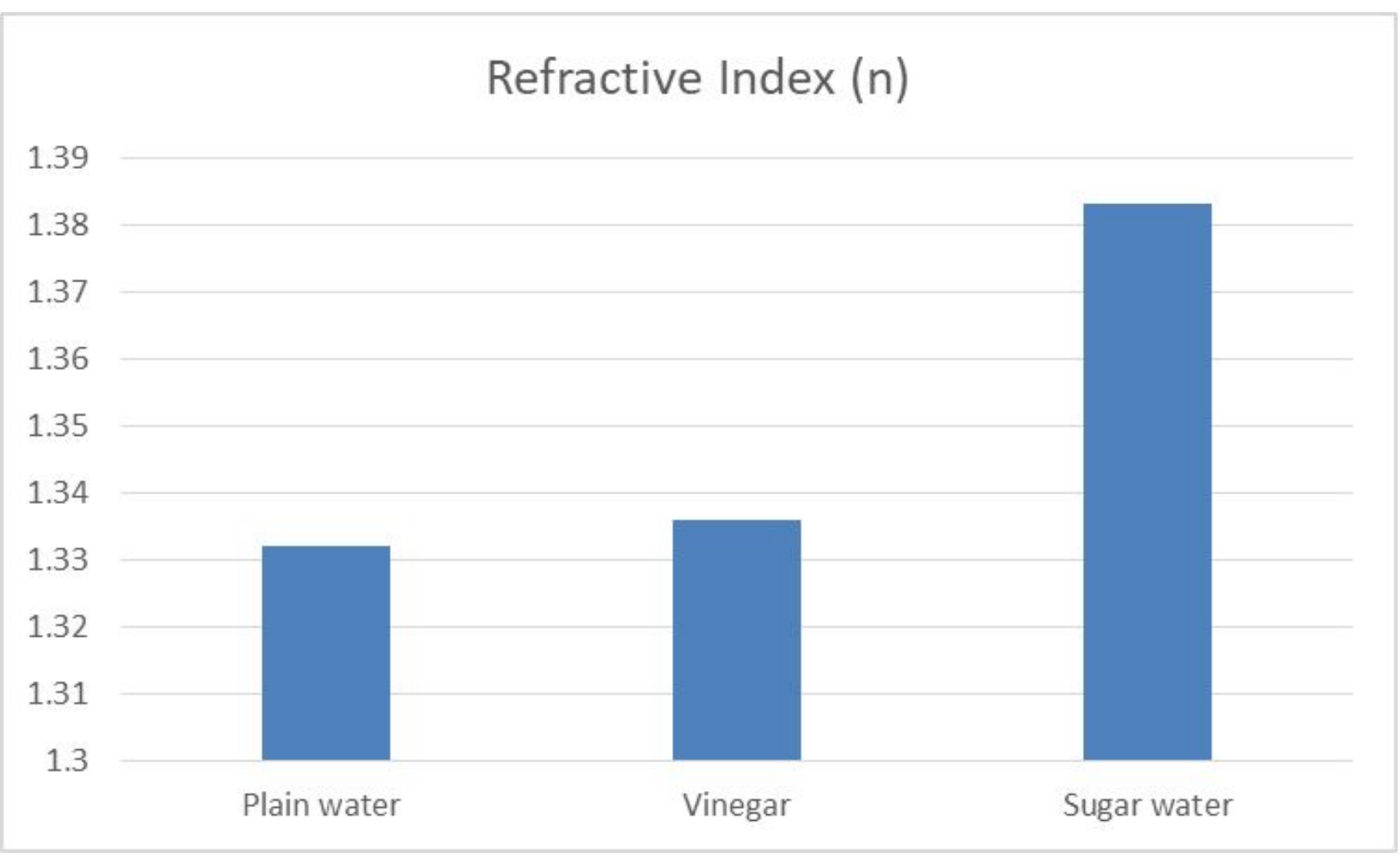


Graph



Results - Chart

Trials	**Solutions**	**Refractive Index (n)**	**Minimum deviation**
Trial 1	Plain water	1.332	lowest
Trial 2	Vinegar	1.336	middle
Trial 3	Sugar water	1.383	highest


Refractive Index (n)
1.39
1.38
1.37
1.36
1.35
1.34
1.33
1.32
1.31
1.3
Plain water
Vinegar
Sugar water

Results - Analysis

Look at your data and observations. Look for patterns and trends. Explain what happened in your experiment and what you found out:

- The trials and results depict how Snell's Law operates in real life.
- When we change the solution, filled within the hollow prism, from less dense solutions like plain water to denser solutions like vinegar and sugar water, the angle of minimum deviation as well as the bending increases.
- Thus higher the refractive index of the medium, higher is the bending.
- Results show that plain water has the lowest density, followed very closely by vinegar solution (which is water plus acetic acid only) and then Sugar water, which has the highest density.

Conclusion

Testable question: How does the type of a solute in a liquid affects the diffraction pattern produced when a laser beam passes through a hollow prism filled with the liquid?.

Answer : On increasing the density of the solution, on changing the type of solute the diffraction pattern changes. More the denser the solution more the diffraction.

H1 (Hypothesis) is accepted as rightly predicted, denser the solute, higher the bending and data proves it to be so too.

Applications

- **Refractometer**- An instrument that uses Snell's law to calculate the refractive index of liquids like we did it in our experiment.
  - Measures how much light bends as it passes through a liquid. It's used to analyze the purity, concentration, or other properties of liquids. Various Industry Applications are as following:
  - **F&B (Food and beverage) Industry**
    - Measuring the sugar content of fruit juices, sodas & jams (Candy)
    - Measuring the salinity of sauces and marinades
    - Measuring the alcohol or extract content of beer, wine, or spirits
  - **Medical Industry**
    - Analyzing urine for diagnosis
  - **Manufacturing Industry**
    - Mixing water-based cutting fluids (coolants and lubricants used with metalworking equipment)

Sources of Error

Do you think your results were reliable? Were there any other factors or conditions that could have affected the results of your experiment in unexpected ways?
What could have affected your results, that would need to be controlled differently if you were to repeat the experiment?

- Since on repeat trials, we got almost similar results, therefore experiment shows good reliability. Some potential sources of error, which need better control, could be as follows:
  - Variations in Prism Angles
  - Variation in Laser Light's Angles
  - Inconsistencies in quantity of solute in prisms
- Controlling these variables in future could further improve the experimental reliability.

Extensions

- If we were to conduct this experiment again, we probably would change the types of solutions to see different answers for the other solutions.
- Further Experiments would need to be conducted also by keeping the same solute but with different densities of sugar/salt to learn more about how this experiment is useful to the Candy making companies. .

What you understood

We have understood a lot of new things by doing this very interesting experiment like how a Laser light functions and various types of prisms like hollow prisms and their properties.

We also understood that one could check the sugar/salt content of liquids by testing rather than tasting

We also found that simple Laws of Physics like Snell's Law are widely used in commercial industries like Candy Making

Our curiosity has tremendously increased in learning about more such laws of Physics that govern our daily life and we hope to conduct more experiments in future in various such fields like magnets, electricity etc.

CONGRATULATIONS!!

You have completed your experiment!

Make sure that you enter information from this logbook into the CYSF Digital platform.

You are now ready to create your trifold display and practice your presentation.