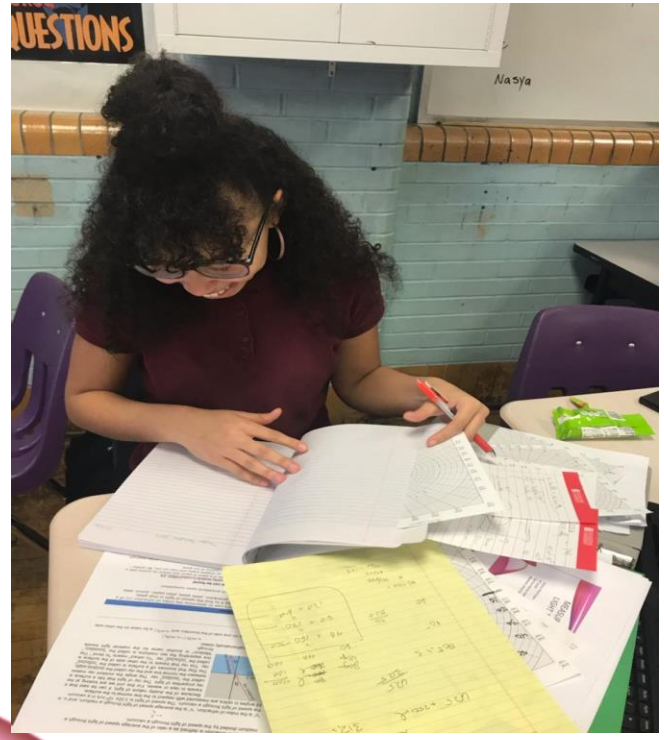
MEASURING THE SPEED OF LIGHT THROUGH VARYING LIQUIDS



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QUESTION

Can different liquids with different densities or compositions slow down the speed of light using Snell's Law?

WHAT I WANTED TO LEARN FROM THIS PROJECT WAS HOW DIFFERENT DENSITIES OR COMPOSITIONS CAN AFFECT HOW LIGHT BENDS.

I think that the speed of light will be slowed down and bend the most through a liquid with the greatest density.

By changing the speed of light, I believe that I may be able to slow a video and focus to read a license plate of a speeding car.

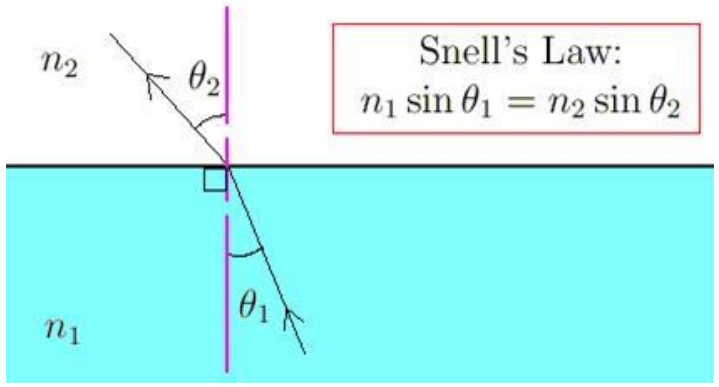
WHAT IS SNELL'S LAW?

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

index of refraction — n

c: *velocity of light in vacuum*

v: *velocity of light in the medium*



Snell's Law is a formula used to describe the relationship between incident and refraction angles, usually referring to light or other waves passing through two different boundaries such as air, glass, or liquids. It was developed by Willebrord Snell in 1621.

This is the equation used for Snell's Law: $N_1 \sin\theta_1 = N_2 \sin\theta_2$

Willebrord Snell
(1580-1626)

MATERIALS USED

- Jack Lift (held my liquids)
- Ring Clamp (held my laser)
- Green Laser (used for incident and refractive angles)
- Sugar Solutions (20%, 40%, and 60% by weight)
- APF-140 Perflurodecalin
- Deionized Water

VARIABLES

Dependent Variable

- θ_2 (Angle of Refraction

Constants

- Temperature at 20° +/- 2
- Type of sugar
- Water
- Laser
- Level
- Height

Independent Variables

- Density of Water
- Molecular Composition of Sugar Solution 20%
- Molecular Composition of Sugar Solution 40%
- Molecular Composition of Sugar Solution 60%
- Density of APF-140 Perflurodecalin

PROCEDURE

Set liquids up on Jack Lift level with Laser Light ½ - 1 centimeter in solutions

Angle Laser Light at 40° and 60° as your INCIDENT ANGLE

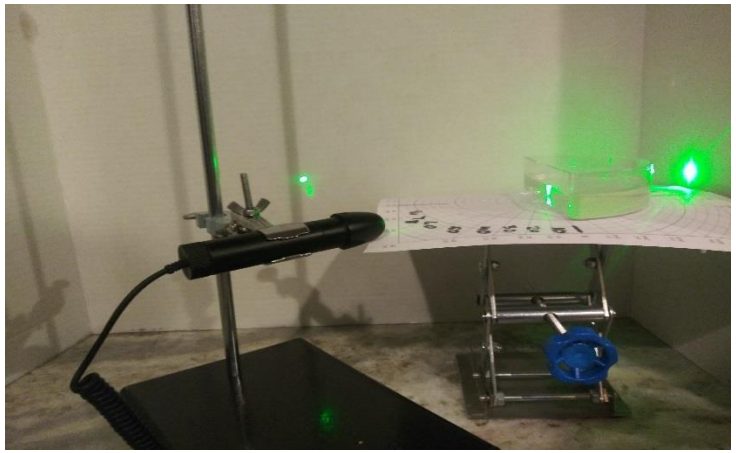
Mark the angle you received on the other side of your liquid - this will be your REFRACTIVE ANGLE

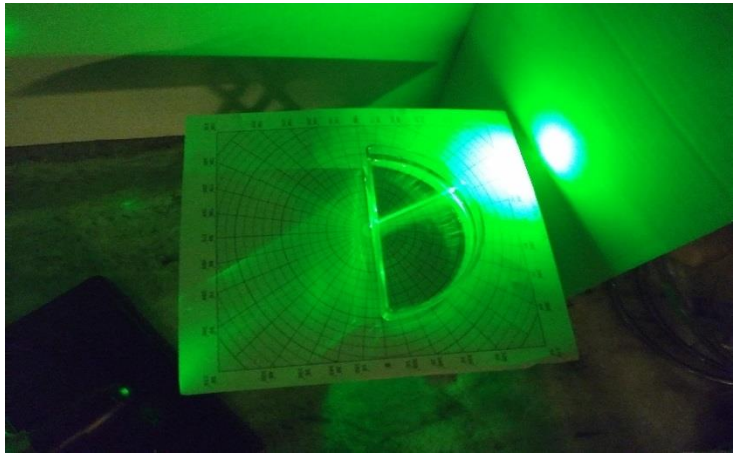
Turn off Laser Light for 10 seconds and repeat previous step two more times

Now complete Snell's Law and the "sine" of the incident and refractive angles

EXPERIMENTAL SETUP

Item on left is ring clamp holding laser light at level with sugar solution being held by a Jack Lift (item on the right)





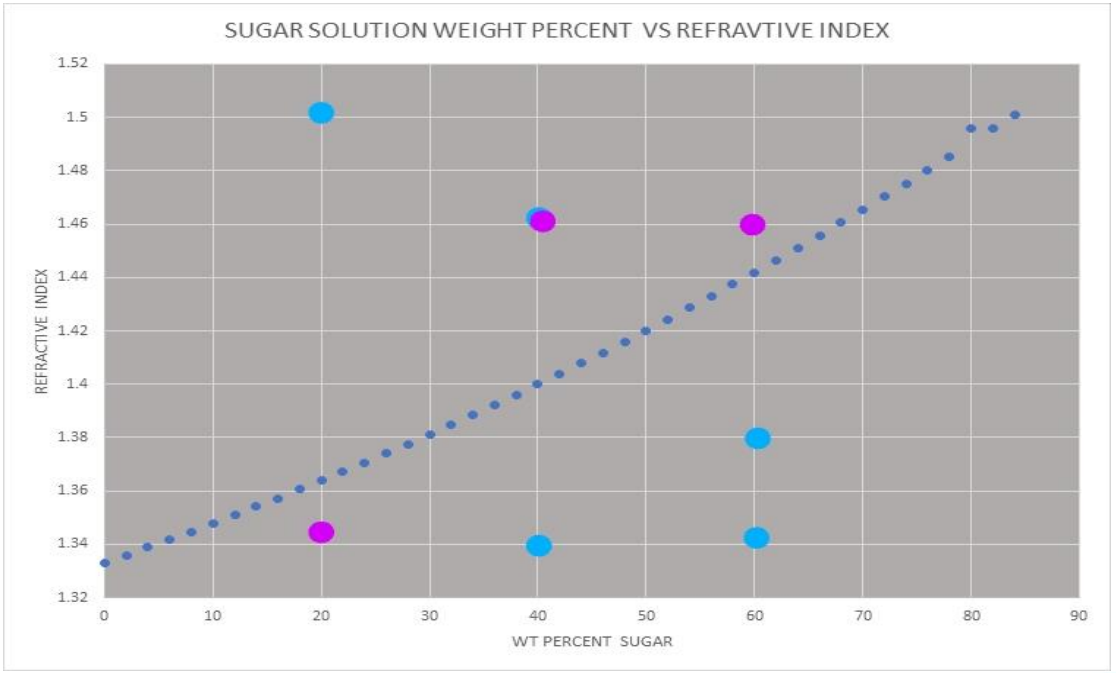
Overview of picture on the left portraying refractive angle (green laser light dot on the far right)

DATA SUMMARY

	30 degrees	40 degrees	45 degrees	Average
20%	N2=1.28	N2=1.28	N2=1.50	1.35
40%	N2=1.47	N2=1.34	N2=1.61	1.47
60%	N2=1.38	N2=1.34	N2=1.67	1.46

Blue Dots Represents N2

Purple Dots Represents Average



CONCLUSION

My experiment did prove that you can slow down the speed of light with liquids of greater densities or compositions. Whether or not I can slow down and focus the resolution of a video on a license plate on a speeding car is currently unknown to me. A future project may revolve only around that hypothesis, proving whether or not that is possible.

LESSONS LEARNED

I have learned that if I do not make sure everything, I do is spot on because if I do not, it can make a drastic change in my conclusion. For example, in the starting of my experiment, when I would first try my trials with my laser light I would not check if I was spot on the center of the protractor paper. Once I saw that mistake I had made and carefully checked that I was precisely where I needed to be, I had a difference of 5° overall. In my math portion of the project, there were multiple times when I divided my θ2 by my θ1 and got a number lower than water (1.33). So then I flipped my θs' and divided θ1 by θ2 and got greater numbers. I only flipped that math for my 30 and 45 degree angles.

HUMAN IMPACT

When someone can truly perfect Snell's Law in an experiment like this, they may be able to slow down and put a video of a license plate on a speeding car in focus for people like police when trying to figure out the license plate.

WHAT ARE OTHERS DOING?

With research I have found out that Stanford University in California and MIT in Boston are researching this same topic. A Stanford physicist can now make art using the speed of light. In MIT, they are making a Board Game involving the Speed of Light. These other projects both show how if you learn just how dense you need your solution to be, just the right angle your laser light should be, you can control how slow the speed of light can be.

SOURCES USED

- “Refractive Indices and Densities of Aqueous Solutions of Invert Sugar” by the Nation Bureau of Standards
    - Multiple tables of refractive index's’ at different solutions
- https://www.dictionary.com/browse/snell-s-law
    - defined Willbrord Snell van Royen famous physics equation “Snell’s Law”
- https://www.khanacademy.org/science/physics/geometric-optics/reflection-refraction/v/refraction-and-snell-s-law
    - explained how to do and use Snell’s Law through two different molecular boundaries

THANK YOU

Thank you to Dr. Frank Schweighardt for his ideas on how to expand my project and teaching me some great things about physics.

Thank you for listening to my experiment, are there any questions?