ST. TERESA'S COLLEGE

ERNAKULAM-KOCHI-11

(AUTONOMOUS)

(AFFILIATED TO MG UNIVERSITY, KOTTAYAM)

FINAL YEAR B.Sc. PHYSICS

PROJECT REPORT

2021-2022

DETERMINATION OF VELOCITY OF LIGHT THROUGH DIFFERENT LIQUIDS

PROJECT REPORT

Submitted by

ROYCE ROSE K R

Register No: AB19PHY013

Under the guidance of

Dr. MARY VINAYA

In partial fulfilment of the requirement for the award of

BACHELOR DEGREE OF SCIENCE IN PHYSICS

ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM, KOCHI-682011

ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM

ST. TERESA'S COLLEGE (AUTONOMOUS) ESTD 1925

CERTIFICATE

This is to certify that the project report titled **"DETERMINATION OF VELOCITY OF LIGHT THROUGH DIFFERENT LIQUIDS"** submitted by **Royce Rose K R** towards the partial fulfilment of the requirements for the award of degree of bachelor of physics is a record of bonifide work carried out by them during the academic year 2021- 2022.

Supervising Guide

for **Dr. Mary Vinaya**

Head of the department

Dr. Priya Parvathi Ameena Jose

Examiner 1:

Examiner 2: Susan

Department of Physics ★ St. Teresa's College (Autonomous) Ernakulam

Place: Ernakulam

Date: 09-05-2022

DECLARATION

I **Royce Rose K R,** Register No: **AB19PHY013**, hereby declare that this project entitled **"Determination of velocity of light through different liquids"** is an original work done by me under the supervision and guidance of **Dr. Mary Vinaya**, faculty, department of physics of St. Teresa's College Ernakulam is in partial fulfilment for the award of degree of bachelor of physics under Mahatma Gandhi University. I further declare that this project is not partly or wholly submitted for any other purpose and the data included in this project is collected from various sources and are true to the best of my knowledge.

ROYCE ROSE K R

Place: Ernakulam

Date: 09-05-2022

DETERMINATION OF VELOCITY OF LIGHT THROUGH DIFFERENT LIQUIDS

ACKNOWLEDGEMENT

First and foremost, I thank God Almighty for his blessings which made this project possible. I'm grateful to the Lord for making this project a success.

I would like to acknowledge and give my warmest thanks to our guide Dr. Mary Vinaya, Department of Physics, St. Teresa's College, for her guidance and motivation through the stages of our project.

I would also like to thank our faculty members of the department, support staff and our friends who directly and indirectly helped us through their valuable support and criticisms, which ensured the success of my project.

ROYCE ROSE K R

ABSTRACT

This project titled "Determination of velocity of light through different liquids" focusses on determining how the refractive index of various liquids affect the velocity of light passing through the respective liquids.

Velocity can be calculated by using the relation:

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

Where n is the refractive index and its given by:

$$n = \ sin\, i\ /\ sin\, r$$

It is a scientifically proven fact that velocity of light through vacuum is constant equal to 3×10^8m/s whereas the velocity of light slows down as it passes through different media. The findings are based on the experiments conducted. The project experiment involves the usage of spectrometer - hollow prism method to determine the refractive index of different materials and hence the velocity of light through them.

It can be inferred from the results of this experiment that the velocity of light indeed decreases as it passes through different media depending on the respective refractive indices.

CONTENTS

INTRODUCTION

Light (visible light) is electromagnetic radiation that can be seen with the naked eye. The electromagnetic spectrum is enormously vast, ranging from low-energy radio waves to high-energy gamma rays with wavelengths of less than 1×10^{-11} metres. Electromagnetic radiation represents fluctuations in electric and magnetic fields that carry energy at the speed of light (3×10^{8} m/s). Light can also be defined as a stream of photons, which are massless packets of energy that travel at the speed of 3×10^{8} m/s and have wavelike qualities. A photon is the smallest unit of energy that can be transferred, and it was this knowledge that led to the origin of Quantum theory.

Light shows many different phenomena. Eg: Reflection, refraction, dispersion, diffraction, etc. Reflection of light is defined as the bouncing back of light ray after incidence on a smooth surface. The ray of light which strikes the smooth surface is known as incident ray and the ray which bounces back from the surface is called reflected ray.

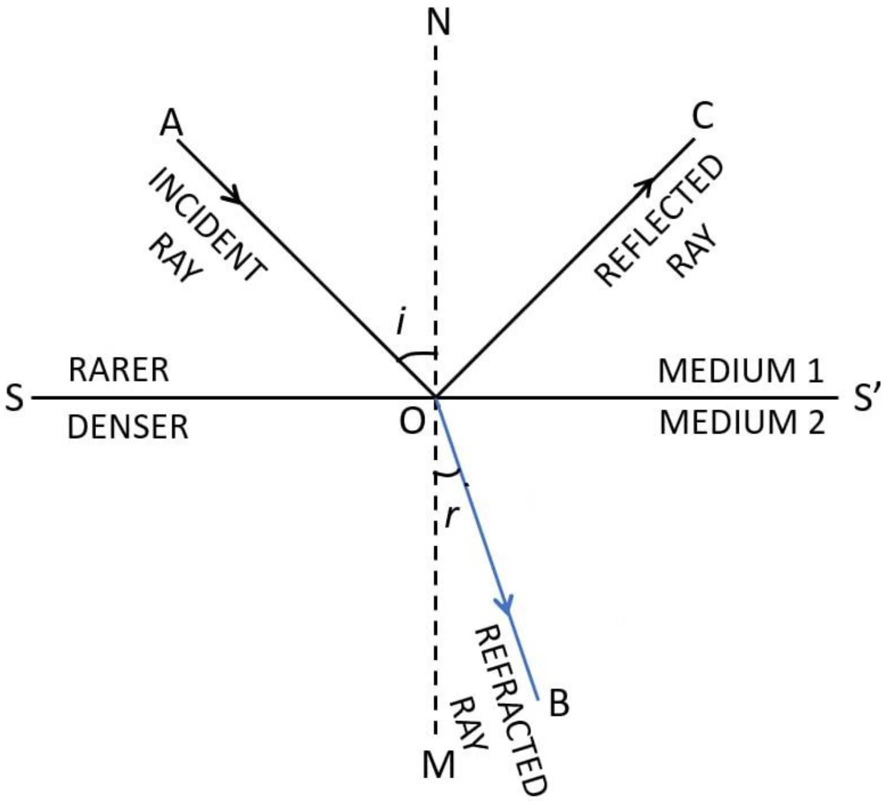
Refraction is defined as the bending of light when it passes from one transparent medium to another. The bending occurs due to density differences between the two media. When the light ray travels from denser to rarer medium, the speed of the light increases and it bends away the normal. Similarly, as a ray of light travels from rarer to denser medium, the speed of light decreases and the ray bends towards the normal.

Refractive index is defined as the ratio of speed of light in vacuum to the speed of light in a particular medium. It is used to measure the concentration of a substance and to find the density of a medium. As the temperature increases, the value of refractive index decreases and vice-versa.

PRINCIPLE

Refractive index, also known as the index of refraction, is the measure of bending of light as it passes from one medium to the other medium. If i is the angle of incidence (the angle between the incidence ray and the normal to the medium) and r is the angle of refraction (the angle between the refraction ray and the normal to the medium), then the refractive index n is defined as the ratio of the sine of angle of incidence to the angle of refraction; i.e,

$$n = \frac{sin\ i}{\sin r}$$



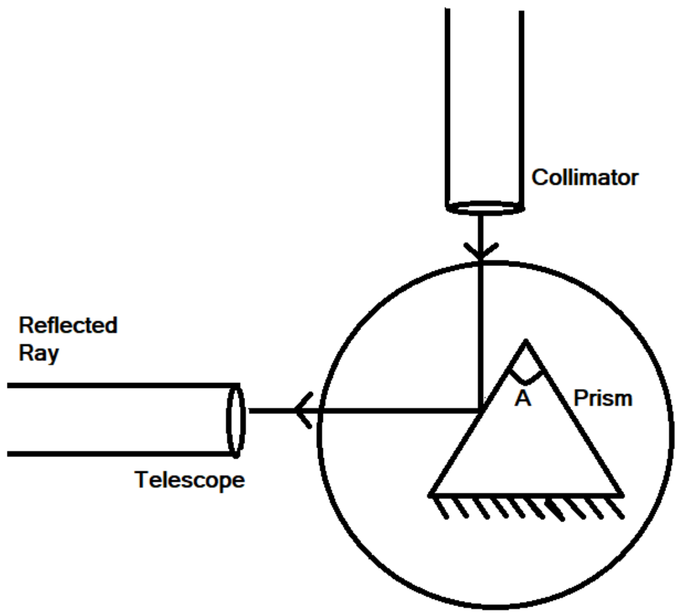
In this project, we focus to determine refractive indices of different liquids using spectrometer and hollow prism by minimum deviation method. The refractive index of the liquid filled in the hollow prism can be determined using the formula,

$$n = \frac{sin\left(\frac{A+D}{2}\right)}{sin\left(\frac{A}{2}\right)}$$

The angle of prism (A) is defined as the angle formed between two lateral faces of the prism. These are the faces through which the light enters into the prism and the light goes out after refraction. The determination of angle of prism (A) is done by the supplementary angle method and it is given by the formula;

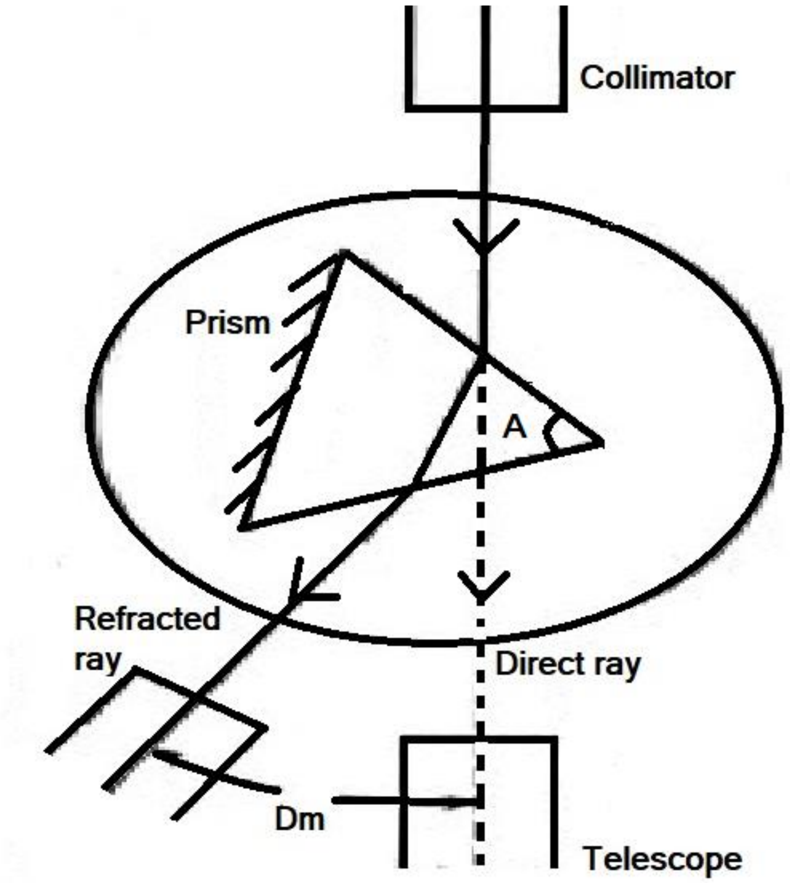
$$A = 180^o - \Theta$$

Where ϴ is the difference between reflected images from face 1 and 2.



Angle of deviation is defined as the angle between the direction of refracted ray and the direction of incident ray as the light travels from one medium to the another. For a given colour of light, the angle of deviation depends on the angle of incidence; as the angle of incidence increases the angle of deviation decreases and reaches a minimum value and then increases. And the smallest angle through which the light is bent by the optical element is called the angle of minimum deviation (D). In minimum deviation, the refracted ray in the prism is parallel to its base, i.e., the light ray is symmetrical about the axis of symmetry of the prism. Here, we can see that the angles of refractions are equal, i.e., $r_1 = r_2$. Also, the angle of incidence and the angle of emergence are equal to each other $(i = e)$. Then the refractive index (n) of the material is given by the formula;

$$n = \frac{sin\left(\frac{A+D}{2}\right)}{sin\left(\frac{A}{2}\right)}$$



Knowing the refractive index, the velocity can be calculated by using the relation;

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

Where c is the velocity of light in vacuum and n is the refractive index of the material.

EXPERIMENTAL SETUP

Apparatus Used

Spectrometer:- It is an optical instrument used to study the spectra of different sources of light and to measure the refractive indices of different materials. It consists of basically three parts, i.e., the collimator, prism table and telescope. Collimator is an arrangement to produce parallel beam of light. It consists of long cylindrical tube with a convex lens at the inner end and a vertical slit at the outer end of the tube. The distance between the slit and lens can be adjusted such that the slit is at the focus of the lens. Also, the width of the slit can be adjusted and thereby limiting the amount of light that enters the collimator. Telescope consists of an eyepiece provided with cross wires at the one end of the tube and an objective lens at the other end co-axially. The distance between the objective lens and the eyepiece can be adjusted so that we get a clear image at the cross wire of the telescope. Prism table is used for mounting the prism, grating etc. It can be rotated about the vertical axis passing through its center and its positions can be known from the readings taken from the two vernier; vernier 1 and vernier 2. The prism table can also be raised or lowered accordingly.

Hollow prism:- it is a prism which is hollow inside and can be filled with various liquids so that their refractive indices can be determined.

Preliminary Adjustments of Spectrometer

The telescope is adjusted to receive parallel rays by turning it towards a distant object and adjusting the distance between the objective lens and the eyepiece to get a clear image that coincides with the cross wire without any parallax error. And the telescope is brought along the axial line with the collimator. The slit of the collimator is illuminated by a source of light. The distance between the slit and the lens of the collimator is adjusted until a clear image of the slit is seen at the cross wires of the telescope. Since the telescope is already adjusted for parallel rays, a well-defined image of the slit can be formed. And the prism is placed on the prism table with its base turned towards the clamp and one of the reflecting face is perpendicular to the line joining two levelling screws. The table is rotated so that the edge point towards the collimator. The reflected image of the slit from one of the face is observed through the telescope, then the image is made to coincide with the crosswire. Then the reflected image from the other face is observed through the telescope and it is made to coincide with the crosswire. Thus, the prism table is levelled.

PROCEDURE

1. **To find the angle of prism**

After the preliminary adjustments, the telescope is clamped in a direction perpendicular to the collimator. The vernier table is then rotated and a reflected image of the slit is obtained of one of the face of the prism, which is recorded through the telescope. Readings of both vernier are noted. The vernier table is unclamped and the reflected image from the other face, is obtained through the telescope. Readings of the both the vernier are noted. The difference between the corresponding readings of the vernier gives θ, the angle through which the vernier table has been rotated. Then the angle of the prism, A=180°- θ is found out.

2. **To find the angle of minimum deviation.**

Place the prism so that its centre coincides with the centre of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. The telescope is turned to view the refracted image of the slit on the other. The vernier table is slowly turned in such a direction that the image of slit is move directed towards the directed ray; ie., in the direction of decreasing angle of deviation. It will be found that at a certain position, the image is stationary for some moment. Vernier table is fixed at the position where the image remains stationary. Using telescope fine adjusting slider, make the slit coincide with cross wire. Note corresponding main scale and vernier scale reading in both vernier (vernier I and vernier II). Carefully remove the prism from the prism table. Turn the telescope parallel to collimator, and note the direct ray readings. Find the difference between the direct ray readings and deviated readings. This angle is called angle of minimum deviation. Refractive index of the material of the prism is determined by using the formula

$$n = \frac{sin\left(\frac{A + D}{2}\right)}{sin\left(\frac{A}{2}\right)}$$

The experiment is repeated using different transparent liquids and the corresponding angle of minimum deviation are found; hence the refractive indices are determined.

OBSERVATIONS

Angle of prism

Value of one main scale division = 30’

No of divisions on vernier scale, x = 30

Least count = $\frac{1}{x}$ x (value of one main scale division) = $\frac{30'}{30}$ = 1’

Readings of	**Vernier 1**			**Vernier 2**		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray from face 1 (a)	269°30’	3	269°33’	89°30’	13	89°43’
Reflected ray from face 2 (b)	150°	19	150°19’	330°30’	4	330°34’
Difference between reflected rays			119°14’			119°9’

Total Reading = MSR + (VSR x LC)
= 269°30’ + (3 x 1’)
= 269°33’

Mean θ = 119°11’30’’
Angle of prism, A = 180° − 119°11’30’’
= 60°48’30’’

ANGLE OF MINIMUM DEVIATION OF WATER (CHLORINATED)

Readings of	**Vernier 1**			**Vernier 2**		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray (c)	82°	20	82°20’	262°	19	262°19’
Direct ray (d)	58°	15	58°15’	238°	11	238°11’
Difference between c and d			24°5’			24°8’

Total reading = MSR + (VSR × LC)

= 82° + (20 × 1’)

= 82°20’

Mean angle of minimum deviation, D = 24°6’30’’

Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.333

Velocity of light through water $= \frac{c}{n}$ = 2.25056264$\times 10^{8}$ m/s

ANGLE OF MINIMUM DEVIATION OF GLYCERINE

Readings of	**Vernier 1**			**Vernier 2**		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray (c)	77°30’	12	77°42’	257°30’	4	257°34’
Direct ray (d)	42°30’	26	42°56’	222°30’	4	222°34’
Difference between c and d			34°46’			35°

Total reading = MSR + (VSR × LC)

= 77°30’ + (12 × 1’)

= 77°42’

Mean angle of minimum deviation, D = 34°53’

Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.4648

Velocity of light through glycerine $= \frac{c}{n}$ = 2.04806116$\times 10^{8}$m/s

ANGLE OF MINIMUM DEVIATION OF ISOPROPYL ALCOHOL (SPIRIT)

Readings of	Vernier 1			Vernier 2		
	MSR	VSR (divisions)	Total Reading	MSR	VSR (divisions)	Total Reading
Reflected ray (c)	67°30’	11	67°41’	247°	9	247°9’
Direct ray (d)	41°	14	41°14’	220°30’	21	220°51’
Difference between c and d			26°27’			26°18’

Total reading = MSR + (VSR × LC)

= 67°30’ + (11 × 1’)

= 67°41’

Mean angle of minimum deviation, D = 26°22’30’’

Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.3624

Velocity of light through isopropyl alcohol $= \frac{c}{n}$ = 2.20199647× 10^8 m/s

ANGLE OF MINIMUM DEVIATION OF 0.9% NaCl SOLUTION

Readings of	**Vernier 1**			**Vernier 2**		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray (c)	66°30’	9	66°39’	246°30’	2	246°32’
Direct ray (d)	42°	28	42°28’	222°	10	222°10’
Difference between c and d			24°11’			24°22’

Total reading = MSR + (VSR × LC)

= 66°30’ + (9 × 1’)

= 66°39’

Mean angle of minimum deviation, D = 24°16’30’’

Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.336

Velocity of light through Sodium Chloride solution $= \frac{c}{n}$ = 2.224550898$\times 10^8$ m/s

ANGLE OF MINIMUM DEVIATION OF LIQUID PARAFFIN

Readings of	Vernier 1			Vernier 2		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray (c)	66°	16	66°16’	246°	8	246°8’
Direct ray (d)	30°30’	9	30°39’	210°	26	210°26’
Difference between c and d			35°37’			35°42’

Total reading = MSR + (VSR × LC)

= 66° + (16 × 1’)

= 66°16’

Mean angle of minimum deviation, D = 35°39’30’’

Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.4737

Velocity of light through liquid Paraffin $= \frac{c}{n}$ = 2.03569247$\times 10^8$m/s

ANGLE OF MINIMUM DEVIATION OF SUNFLOWER OIL

Readings of	Vernier 1			Vernier 2		
	MSR	VSR (divisions)	Total Reading	MSR	VSR (divisions)	Total Reading
Reflected ray (c)	50°30’	19	50°49’	230°30’	9	230°39’
Direct ray (d)	15°	28	15°28’	195°	11	195°11’
Difference between c and d			35°21’			35°28’

Total reading = MSR + (VSR × LC)

= 50°30’ + (19 × 1’)

= 50°49’

Mean angle of minimum deviation, D = 35°24’30’’

Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.471

Velocity of light through sunflower oil $= \frac{c}{n}$ = 2.03942896$\times 10^8$ m/s

ANGLE OF MINIMUM DEVIATION OF ACETONE

Readings of	**Vernier 1**			**Vernier 2**		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray (c)	356°30'	12	356°42'	176°30'	4	176°34'
Direct ray (d)	22°	28	22°28'	202°	16	202°16'
Difference between c and d			25°46'			25°42'

Total reading = MSR + (VSR × LC)

= 356°30' + (12 × 1')

= 356°42'

Mean angle of minimum deviation, D = 25°44'

Refractive index, n $= \frac{\sin \frac{A+D}{2}}{\sin \frac{A}{2}} = 1.3543$

Velocity of light through acetone $= \frac{c}{n} = 2.221516650 \times 10^{8}$ m/s

ANGLE OF MINIMUM DEVIATION OF 10gm OF SUGAR IN 100ml OF WATER

Readings of	**Vernier 1**			**Vernier 2**		
	MSR	**VSR (divisions)**	**Total Reading**	**MSR**	**VSR (divisions)**	**Total Reading**
Reflected ray (c)	345°30’	3	345°33’	165°	4	165°4’
Direct ray (d)	10°30’	11	10°41’	190°	16	190°16’
Difference between c and d			25°8’			25°12’

Total reading = MSR + (VSR × LC)

= 345°30’ + (3 × 1’)

= 345°33’

Mean angle of minimum deviation, D = 25°10’

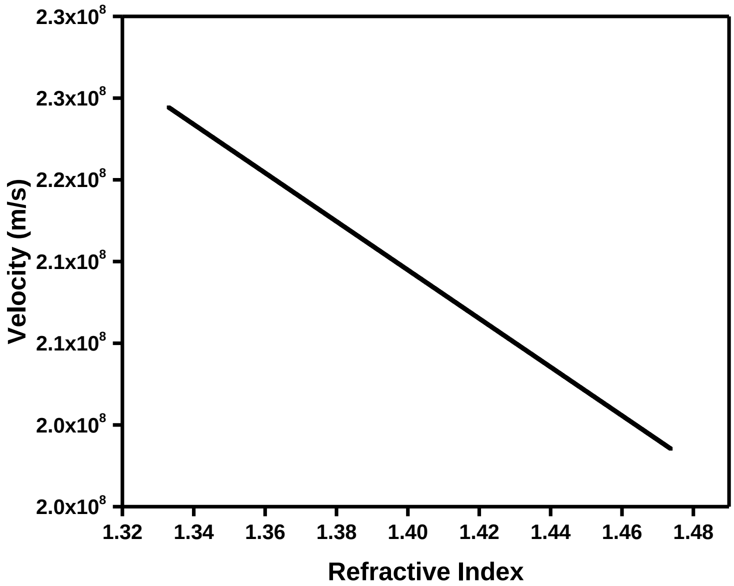
Refractive index, n $= \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ = 1.3472

Velocity of light through sugar water $= \frac{c}{n}$ = 2.22684085$\times 10^8$ m/s

Sl.no.	Liquid	Refractive Index		Velocity of light 10^8 (m/s)
		Standard value	Obtained value	
1	Water (chlorinated)	1.33	1.333	2.25056264
2	Glycerine	1.470	1.4648	2.04806116
3	Isopropyl alcohol	1.377	1.3624	2.20199647
4	0.9% NaCl solution	1.334	1.336	2.22455089
5	Liquid paraffin	1.476	1.4737	2.03569247
6	Sunflower oil	1.473	1.471	2.03942896
7	Acetone	1.358	1.3543	2.22151665
8	10gm of Sugar 100ml of water	1.347	1.3472	2.22684085

RESULTS AND DISCUSSIONS

The variation of velocity of light with refractive indices is shown in the figure given below. The straight line with negative slope indicates the slowing of light rays in higher refractive index medium.



From the observations, we came to the following conclusion

- As the refractive index of the different liquids increases, the velocity of light through the respective liquids decreases.
- The velocity of light through vacuum is a constant given by 3×10^8m/s whereas light slows down as it passes through different media.
- The straight line graph with negative slope point out the inverse proportionality between the velocity of light through the medium and its refractive index .

APPLICATIONS

Refractive index is the property of the material which changes the speed of light as the light passes through the sample material. It tells how fast the light is moving in that medium. Refractive index has many useful applications, they are:

- Refractive index is used for identifying a particular substance and to confirm its purity.
- It is also used for measuring the concentration of a substance.
- It is used for determining the focussing power of lenses and the dispersive power of prisms.
- It tells us about the behaviour of light in different substances.

REFERENCES

1. J.C. Bhattacharya, Refractive index measurement, Optics & Laser Technology, Volume 19, Issue 1,1987, Pages 29-32, ISSN 0030-3992.
2. Fundamentals of optics- S Chand
3. www.hypertextbook.com
4. www.omicsonline.com
5. http://khanacademy.org/science/physics/geometric-optics/reflection-refraction/v/refraction-and-snell-s-law
6. https://courses.lumenlearning.com/physics/chapter/25-3-the-law-of-refraction/
7. https://www.nitj.ac.in/physics/Downloads/LabManual6330.pdfwww.brainkart.com
8. https://www.brainkart.com/article/Basic-Parts-and-Adjustments-of-the-spectrometer_3200/#:~:text=The%20spectrometer%20is%20an%20optical,collimator%2C%20prism%20table%20and%20Telescope.