ESTIMATION OF REFRACTIVE INDEX OF WATER USING VARIOUS OPTICAL PHENOMENA

PROJECT REPORT

Submitted by

MIDHUNA SURESH

Register No: AB20PHY033

Under the guidance of

DR. MARIYAM THOMAS
Department of Physics

Submitted to

Mahatma Gandhi University, Kottayam

In partial fulfilment of the requirement for the award of

BACHELOR'S DEGREE OF SCIENCE IN PHYSICS

ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM, KOCHI-682011

ST.TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM
DEPARTMENT OF PHYSICS

CERTIFICATE

This is to certify that the project report entitled "ESTIMATION OF REFRACTIVE INDEX OF WATER USING VARIOUS OPTICAL PHENOMENA" is an authentic work done by MIDHUNA SURESH, St. Teresa's College, Ernakulam, under my supervision at the Department of Physics, St. Teresa's College for the partial requirements for the award of the degree of Bachelor of Science in Physics during the academic year 2022-23. The work presented in this dissertation has not been submitted for any degree in this or any other university.

Supervising Guide
Dr. Mariyam Thomas
Assistant Professor

Head of department
Dr. Priya Parvathi Ameena Jose
Assistant Professor

Place: ERNAKULAM

Date: 25·04·2023

ST.TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

B.Sc. Physics

PROJECT REPORT

Name: Midhuna Suresh
Register Number: AB20PHY033
Year of Work: 2022-'23

This is to certify that this project "ESTIMATION OF REFRACTIVE INDEX OF WATER USING VARIOUS OPTICAL PHENOMENA" is the work done by MIDHUNA SURESH.

Staff member in charge
Dr. Mariyam Thomas

Head of the department
Dr. Priya Parvathi Ameena Jose

Submitted for the university examination held in St. Teresa's College, Ernakulam.

Date: 25·04·2023

Examiners:

St. Teresa's College (Autonomous) Ernakulam * Dept. of Physics *

DECLARATION

I, Midhuna Suresh, Register No: AB20PHY033, hereby declare that this project entitled **"ESTIMATION OF REFRACTIVE INDEX OF WATER USING VARIOUS OPTICAL PHENOMENA"**, is an original research work done by me under the supervision and guidance of Dr. Mariyam Thomas, Faculty, Department of Physics in St.Teresa's College, Ernakulam in partial fulfilment for the award of the degree of Bachelor of Physics under Mahatma Gandhi University. I further declare that this project work is not partly or wholly submitted for any other purpose and the data included in the project is collected from various sources and are true to the best of my knowledge.

PLACE : Ernakulam
**DATE : ** 25.04.2023

ACKNOWLEDGEMENT

I express my sincere heartfelt gratitude to Dr. Mariyam Thomas, Department of Physics, St.Teresa's College, Ernakulam, for the keen attention and valuable guidance she had rendered to me throughout the course of this project.

I express my deep sense of gratitude to the Department of Physics, St. Teresa's College, Ernakulam, for extending the facilities and corporation required from time to time. I take this opportunity to thank Dr. Priya Parvathi Ameena Jose, Head of the Department of Physics for the generous concern and support.

I express my deep sense of gratitude to all teaching and non-teaching staffs of Physics Department, St. Teresa's College, Ernakulam, for their kind co-operation.

Above all I thank God Almighty for showering his blessings on me in this endeavour.

ESTIMATION OF REFRACTIVE INDEX OF WATER USING VARIOUS OPTICAL PHENOMENA

ABSTRACT

In this project, I have measured the refractive index of water using different experimental methods of various optical phenomena such as using liquid lens, hollow prism, newton's ring apparatus and laser beam. I came to a conclusion regarding the better method to find out the refractive index by comparing their percentage of accuracy.

CONTENTS

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Visible light is a small portion of the spectrum of electromagnetic radiation, which extends from low energy radio waves to high energy X-rays or Gamma Rays. When light rays strike the boundary between two media the rays can undergo several physical processes such as reflection, and refraction. Refraction is defined as the bending of light rays as they move from one medium to another of different optical density. One physical parameter which can give a measure or degree of the bending after refraction is the index of refraction or simply the refractive index. It is a dimensionless parameter that helps us in our Estimation and determination of the degree of bending for a ray of light entering one medium from another. The refractive index 'n' can be defined for a particular material as the ratio of the speed of air in vacuum or free space to the velocity of light through the material. Refractive index also depends on the wavelength of the light ray

REFRACTIVE INDEX

In optics, the refractive index or index of refraction of a material is a dimensionless number that describes how light propagates through that medium.
It is defined as

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

where,
c is the speed of light in vacuum
v is the phase velocity of light in the medium.

The reactive index of water is 1.333, meaning that light travels 1.333 times faster in vacuum than in the water.

The refractive index n of an optical medium is defined as the ratio of the speed of light in vacuum, c = 299792458 m/s, and the phase velocity v of the light in medium, is $n = \frac{c}{v}$. The phase velocity is the speed at which the crests or the phase of the wave moves, which may be different from the group velocity, the speed at which the pulse of light of the envelope of the wave moves

1.2 OBJECTIVES

To make attempts to find the refractive index of a liquid using various experiments of different phenomena and by comparing the results finding out the better way one from them.

- To determine the refractive index of water using LIQUID LENS
- To determine the refractive index of water using HOLLOW PRISM
- To determine the refractive index of water using NEWTON’S RING APPARATUS
- To determine the refractive index of water using LASER BEAM

1.3 THEORY

1.3.1 LIQUID LENS

We can consider the experimental set up as a combination of two lenses, a convex lens (focal length R) and a plano-concave liquid lens (focal length f_L).
Then the resultant focal length of the combination is given by the equation

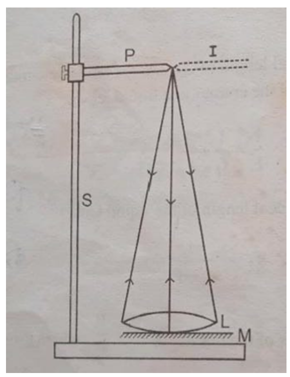
$$\frac{1}{F} = \frac{1}{R} + \frac{1}{f_L}$$

Then the focal length of the liquid lens,

$$f_L = \frac{F\,R}{R-F}$$

And refractive index of the liquid is given by

$$n = 2 - \frac{R}{F}$$



Fig,(1) - Experimental Arrangement

The Optical Phenomenon behind Liquid Lens :

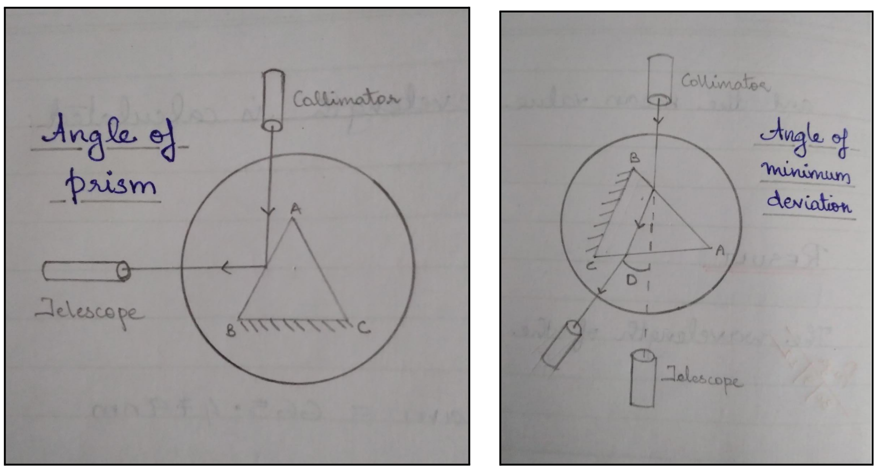
The theory behind the liquid lens is based on the properties of one or more liquids to create magnifications within a small amount of space. The focus of a liquid lens is controlled by the surface of the liquid.
The optical phenomenon behind the experiment of liquid lens to find the refractive index of water is **refraction**. Refraction occurs when light passes through a medium with a different refractive index, causing it to bend or change direction. The amount of bending that occurs depends on the difference in refractive indices between the two media and the angle at which the light enters the interface between them.

1.3.2 HOLLOW PRISM

Refractive index of the liquid

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

Where A is the angle of prism and D is the angle of minimum deviation. The hollow prism is filled with the given transparent liquid, say water without air bubbles.



Fig, (2) - Ray Diagrams

The Optical Phenomenon behind Hollow Prism :

White lights consists of several colors with different wavelength and refractive indices. Upon passage through a prism, white light undergoes dispersion, the phenomenon in which light is separated into its constituent wavelengths of different colors which get refracted differently. These colors are arranged in a definite order according to their speeds in the medium of prism. For a hollow prism, when white light is incident on the first wall of the prism, it enters a denser medium with a higher refractive index. As a result the light will bent towards the normal, that is, it undergo **refraction**

1.3.3 NEWTON'S RINGS

Newton's Rings is an example of fringes of equal thickness. Newton's rings are formed when a Plano-convex lens P of large radius of curvature placed on a sheet of plane glass AB is illuminated from the top with monochromatic light. The combination forms a thin circular air film of variable thickness in all directions around the point of contact of the lens and the glass plate. The locus of all points corresponding to specific thickness of air film falls on a circle whose centre is at O. Consequently, interference fringes are observed in the form of a series of concentric rings with their centre at O. Newton originally observed these concentric circular fringes and they are called Newton's Rings.

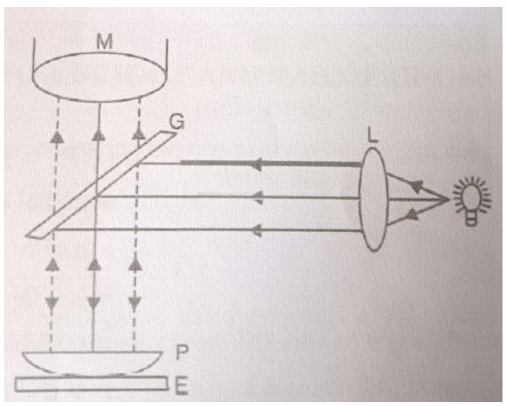


Fig. (3) - The experimental arrangement for observing Newton's Ring is shown below.

Monochromatic light from an extended source S is rendered parallel by a lens L. It is incident on a glass plate inclined at 45° to the horizontal, and is reflected normally down onto a Plano-convex lens placed on a flat glass plate. Part of the light incident on the system is reflected from the glass-to-air boundary, say from point B.

The remainder of the light is transmitted through the air film. It is again reflected from the air-to-glass boundary, say from point C. The two rays reflected from the bottom and top of the air film are derived through division of amplitude from the same incident ray SC and are therefore coherent. The rays R, and R_2 are close to each other and interfere to produce darkness or brightness. The condition of brightness or darkness depends on the path difference between the two reflected light rays, which in turn depends on the thickness of the air film at the point of Incidence.

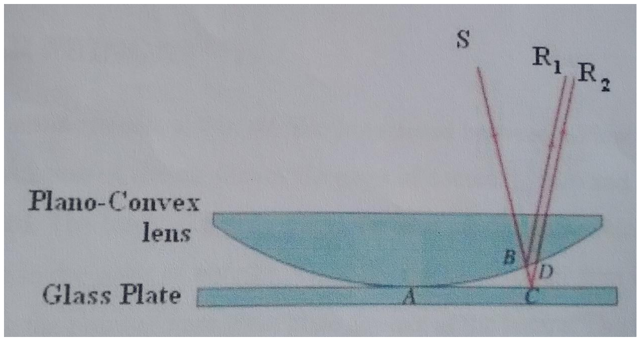


Fig. (4)-Light rays reflected from upper and lower surfaces of the thin air gap.

The Phenomenon behind Newton's Ring :
The phenomenon of Newton's Ring is the **interference** pattern between the partially reflected and partially transmitted rays from both the lower curved surface of the lens as well as the upper surfaces of the glass plate. In physics, interference is a phenomenon in which two waves superpose to form a resultant wave of greater, lower or the same amplitude. Interference usually refers to the interaction of waves that are correlated or coherent with each other, either because they come from the same source or because they have the same or nearly the same frequency. Interference effects can be observed with all types of waves,

1.3.3.1 CONDITION FOR BRIGHT AND DARK FRINGES

The optical path difference between the rays is given by $\Delta = 2\mu t \, cos \, r \, \frac{\lambda}{2}$
Since $\mu = 1$ for air and cos r = 1 for normal incidence of light,
$\Delta = 2t - \frac{\lambda}{2}$ ………………………………… (1)

Intensity maxima occur when the optical path difference $\Delta = m\lambda$. If the difference in the optical path between the two rays is equal to an integral number of full waves, then the rays meet each other in phase. The crest of one wave falls on the crests of the other and the waves interfere constructively. Thus, if $2t - \frac{\lambda}{2} = m\lambda$
$2t = (2m + 1)\frac{\lambda}{2}$ ……………………………… (2)
Hence, bright fringes is obtained.

Intensity minima occur when the optical path difference is $\Delta = (2m + 1)\frac{\lambda}{2}$. If the difference in the optical path between the two rays is equal to an odd integral number of half waves, then the rays meet each other in opposite phase. The crest of one wave fall on the troughs of the other wave and the waves interfere destructively
Hence, if $2t - \frac{\lambda}{2} = (2m + 1)\frac{\lambda}{2}$
$2t = m\lambda$ …………………………………………… (3)
Hence, dark fringes is produced.

1.3.3.2 CIRCULAR FRINGES

In Newton's Ring arrangement, a thin air film is enclosed between a Plano-convex lens and a glass plate. The thickness of the air film at the point of contact is zero and gradually increases as we move outward. The locus of points where the film has the same thickness then fall on a circle whose centre is the point of contact. Thus, the thickness of air film is constant at points on any circle having the point of lens-glass plate contact as the centre. The fringes are therefore circular.

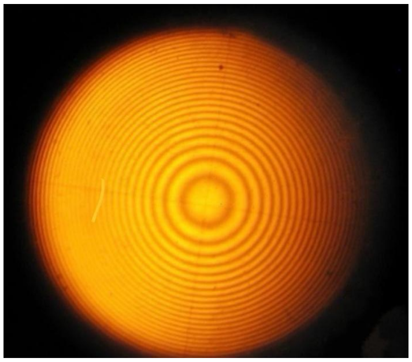


Fig. (5) Circular fringes obtained by Newton's Ring apparatus

1.3.3.3 RADII OF DARK FRINGES

Let R be the radius of curvature of the lens. Let a dark fringe be located at Q. Let the thickness of air film at Q be PQ = t. Let the radius of circular fringe at Q be OQ = r_m (as shown in Fig.6)
By the Pythagoras theorem,

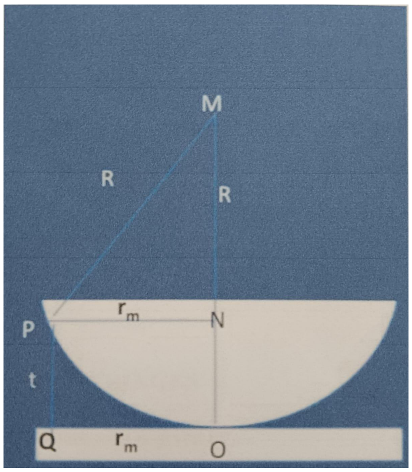


Fig. (6)

$PM^2 = PN^2 + MN^2$

Therefore, $R^2 = r_m^2 + (R - t)^2$ ……………………… (4)

Or, $r_m^2 = 2Rt - t^2$

As $R >> t$, $2Rt >> t^2$ ………………………………. (5)

Therefore, $r_m^2 \sim 2Rt$

The condition for darkness at Q is that

$2t = m\lambda$

Therefore, $r_m^2 \sim m\lambda R$

$r_m^2 = \sqrt{m\lambda R}$ ……………………………………… (6)

The radii of dark fringes can be found out by inserting values 1, 2, 3.......for m. Thus,

$r_1 = \sqrt{1\lambda R}$ or $r_1 \propto \sqrt{1}$
$r_2 = \sqrt{2\lambda R}$ or $r_2 \propto \sqrt{1}$ and so on

It means that the radii of dark rings are proportional to under root of the natural numbers. The above relation also implies that

$r_m \propto \sqrt{\lambda}$

Thus, the radius of the mth dark ring is proportional to square root of wavelength.

1.3.3.3.1 RING DIAMETER

Diameter of mth dark ring. $D_m = 2r_m$
$D_m = 2\sqrt{2Rt}$
$D_m = 2\sqrt{m\lambda R}$ ……………………………………… (7)

1.3.3.4 SPACING BETWEEN FRINGES

It is seen that the diameter of dark ring is given by,
$D_m = 2\sqrt{m\lambda R}$
Where m = 1, 2, 3,.......

The diameters of dark rings are proportional to the square root of the natural numbers. Therefore, the diameter of the ring does not increase in the same proportion as the order of the ring, for example, if m increases as 1, 2, 3,.......the diameters are

$D_1 = 2\sqrt{\lambda R}$

$D_2 = 2\sqrt{2\lambda R}$

$D_3 = 2\sqrt{3\lambda R}$ and so on.

Therefore, the rings get closer and closer, as m increases. This is why the rings are not evenly spaced.

1.3.3.5 DARK CENTRAL SPOT

The central spot is dark as seen by reflection. Newton's Rings are produced due to the superposition of light rays reflected from the top and bottom surfaces of a thin air film enclosed between a Plano-convex lens and a plane glass plate. The occurrence of brightness or darkness depends on the optical path difference arising between the reflected rays. The optical path difference is given by.

$\Delta = 2t - \frac{\lambda}{2}$ .... (8)

At the point of contact 'O' of the lens and glass plate, the thickness of air film is negligibly small compared to a wavelength of light.

Therefore, t ~ 0

Therefore, $\Delta \sim \frac{\lambda}{2}$

The wave reflected from the lower surface of the air film suffers a phase change of л while the wave reflected from the upper surface of the film does not suffer such change,

Thus, the superposing waves are out of step by which is equivalent to a phase difference of 180° (or π rad). Thus the two interfering waves at the centre are opposite in phase and produce dark spot.

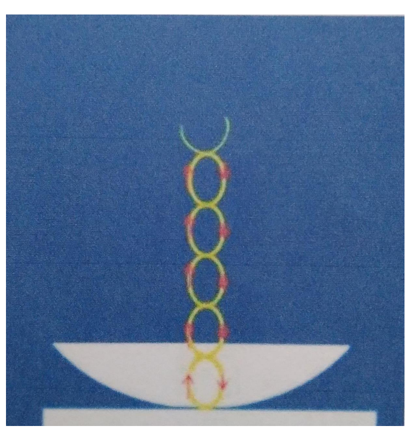


Fig.(7) Dark Central Spot

1.3.3.6 REFRACTIVE INDEX OF A LIQUID

The liquid, whose refractive index is to be determined, is filled in the gap between the lens and plane glass plate. Now the liquid film substitutes the air film. The condition for interference may then be written as

$2\mu\, cos\, r = m\lambda$

As, $t = \frac{r^2}{2R}$

$\frac{2\mu r^2}{2R} = m\lambda$

Or, $r^2 = \frac{m\lambda R}{\mu}$

Therefore, $D^2 = \frac{4m\lambda R}{\mu}$

Following the above relation, the diameter of m[th] dark ring may be expressed as,

$$D_m^2 = \frac{4m\lambda R}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Similarly, the diameter of (m+p)[th] dark ring is given by,

$$D_{m+p}^2 = \frac{4(m+p)\lambda R}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Subtracting equation 9 from 10, we get,

$$D_{m+p}^2 - D_m^2 = \frac{4p\lambda R}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

But we know that,

$$D_{m+p_{(air)}}^2 - D_{m_{(air)}}^2 = 4p\lambda R \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$\mu = \frac{D_{m+p_{(air)}}^2 - D_{m_{(air)}}^2}{D_{m+p_{(LIQUID)}}^2 - D_{m_{(LIQUID)}}^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (13)$$

1.3.4 LASER BEAM

1.3.4.1 To find critical angle θ_c

$\theta_c = \tan^{-1} \frac{R}{2d}$

were, R is the radius of the ring

D is the depth of the liquid poured into the container.

1.2.4.2 To find the refractive index of the liquid

$$\mu = \frac{1}{\sin \theta_c}$$

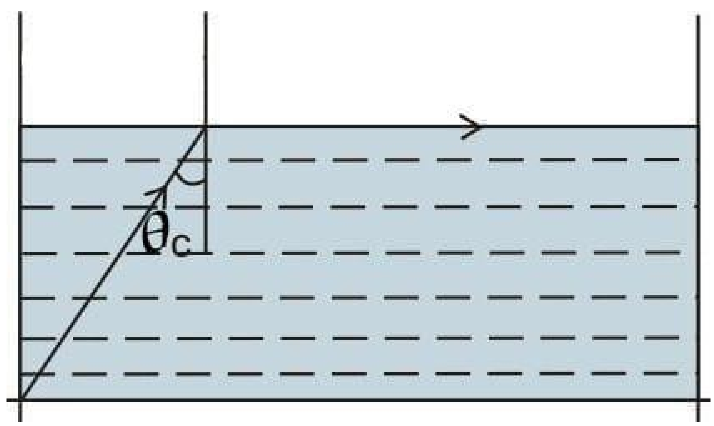


Fig. (8)

CHAPTER 2
EXPERIMENTAL

2.1 EXPERIMENTAL SETUP AND PROCEDURE

2.1.1 LIQUID LENS

A plane mirror M is placed horizontally on the base of a retort stand. The convex lens L is placed on the plane mirror. A bright pointer p is arranged horizontally in the clamp, vertically above the lens. The inverted image of the pin is viewed from vertically above. The pointer is raised or lowered, till the tip of its image coincides with the tip of the pointer without parallax. The distances of the pointer from the top and bottom of the lens are measured. The average distance gives the focal length of the lens. The adjustment is repeated and the mean focal length (R) is determined.

The lens is removed. A drop of the given liquid is placed on the plane mirror. The convex lens is now placed on this drop of liquid with its marked face in contact with the liquid. A thin liquid lens is thus formed between the mirror and the lens. The pointer is adjusted as before and focal length (F) of the combination is determined (F will be greater than R). Through the values of R and F refractive index of the liquid is calculated by the equation

$$n = 2 - \frac{R}{F}$$

Fig. (9) - Liquid Lens Apparatus

2.1.2 HOLLOW PRISM

2.1.2.1 PRELIMINARY ADJUSTMENTS

Eyepiece: The telescope is turned to a white wall. The eyepiece is pushed in or pulled out gently till the cross wire are clearly seen
Telescope: The telescope is turned towards a distant object. By the mean of the rack and pinion arrangement the length of the telescope is varied to get a clear image of the distant object coinciding with the crosswire without parallax. Thus the telescope is adjusted to receive parallel rays.

Collimator: The slit of the collimator is illuminated with sodium light. The telescope is brought in a line with the collimator and the image of the slit is got in the telescope. The slit is made sufficiently wide. The rack and pinion arrangement of the collimator is worked till the image of the slit is clearly seen, coinciding with the crosswires without parallax. Now the collimator is ready to produce parallel rays.

Prism table: The prism table is leveled by an optical method as follows. The prism ABC is placed on the prism table with its base turned towards the clamp and one of the refractive face AB, perpendicular to the line joining the two leveling screws S1 and S2. The table is rotated so that the edge A points towards the collimator. The reflected image of the slit from the face AB is observed through the telescope S1 or S2(or both) are worked till the image is symmetrical with respect to the horizontal crosswire. Then the reflected image from the other face AC is observed through the telescope. The image is made symmetrical as before by working the third screw S.3. The prism table is thus leveled.
The slit is made narrow.

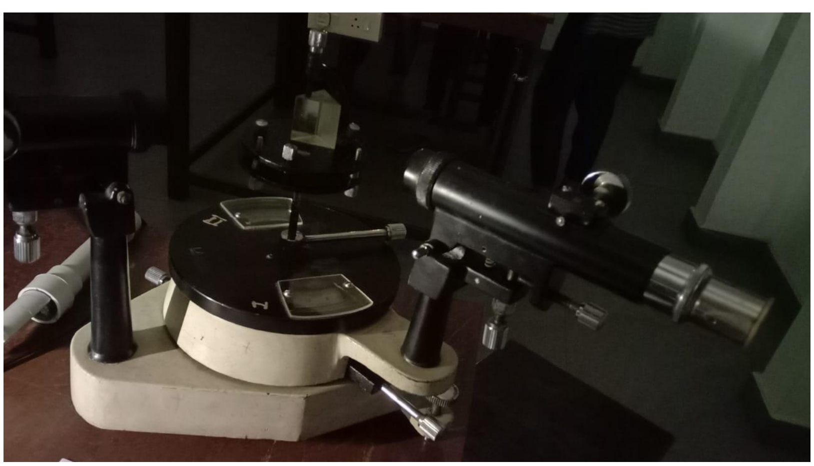


Fig. (10) - Hollow Prism Apparatus

2.1.2.2 TO FIND ANGLE OF PRISM (A)

After the preliminary adjustment, the telescope is clamped in a direction approximately perpendicular to the collimator. The vernier table is rotated and the reflected image from one face AB is obtained through the telescope. The vernier table is clamped. The tangent screw of the prism table is worked till the vertical cross wire coincide with the center of the image. The reading of both the vernier are taken. The vernier table is clamped and fine adjustments are made using its tangential screw.

The reading of the corresponding vernier gives θ; the angle through which the vernier table has been turned.

Then the angle prism $A = (180 - \theta)$

2.1.2.3 TO FIND THE ANGLE OF MINIMUM DEVIATION (D)

The vernier table is unclamped and rotated so that the light from the collimator falls obliquely on one face of the prism. The telescope is rotated so that the refracted image is seen through it. The vernier table is slowly rotated in such a direction that the image moves towards the direct position. The telescope is also rotated in the same direction so that the image is always in the field of view. The vernier table is rotated until the image is found to be remain stationary for a moment and the begins to retrace. This is the minimum deviation position. The vernier table and the telescope are clamped. The tangent screw of the telescope is worked so that the vertical crosswires coincide with the center of the image. The reading of the circular scale and vernier are taken.

The prism is removed. The telescope is released and brought in line with the collimator, so that the direct image of the slit is seen. The direct reading is taken.

Difference between the readings of the corresponding vernier gives the angle of minimum deviation D is determined.

The refractive index of the liquid in the hollow prism is hence calculated.

2.1.3 NEWTONS RING

Light from the sodium vapour lamp is rendered parallel by a short focus convex lens for the parallel rays to fall on the glass plate inclined at 45° to the horizontal get reflected and fall normally on the convex lens. A system of bright and dark concentric circular rings are observed through a microscope arranged vertically above the glass plate. The microscope is properly focused so that the rings are seen most clearly.

Starting from the centre of the fringe system microscope is moved towards the left so that the crosswire is tangential to the p^{th} dark fringe. The microscopic reading is taken. By adjusting the fine adjustment screw the microscope is carefully moved towards the right. The crosswire is adjusted to be tangential to the 22^{th} and 20^{th}...dark ring.

The crosswire is made tangential to the second dark ring on the right side. Readings are taken correspondingly to 2^{nd}, 4^{th}...dark rings as before. The difference between the readings on left and right of each gives the diameter D of the respective ring. Hence $\left(D^2_{m+p} - D^2_m\right)$ are calculated

Now, open and take out the Plano convex lens and put a few drops of distilled water on the plane glass plate and again carefully mount back the lens over the plate P. Thus the diameter and hence $\left(D^2_{m+p} - D^2_m\right)$is calculated. Substitute the corresponding values for air and, water films in the following formula to determine the value of the refractive index of water.

Refractive index of water,

$$\mu = \frac{D^2_{m+p_{(air)}} - D^2_{m_{(air)}}}{D^2_{m+p_{(LIQUID)}} - D^2_{m_{(LIQUID)}}}$$

Fig. (11) - Newton’s Ring Apparatus with Light Source

2.1.4 LASER BEAM

The transparent container is placed on the marked graph paper. Then focus the laser at the center of the graph paper.Then pour some water into the container. After that a circular ring is obtained on the graph paper.

Step 1: remove some water
Step 2: note down the diameter of the circular ring
Step 3: note down the height of the water filled up in the container.
Step 4: repeat the same procedure and take readings for different heights of the water filled.

The optical phenomenon behind the refractive index of water using laser beam is **refraction**
The angle of incidence and the refraction of light, referred to the normal to the interface of the two media at the point of incidence, are related by snell's law. The refractive index (RI) depend on the wavelength of light

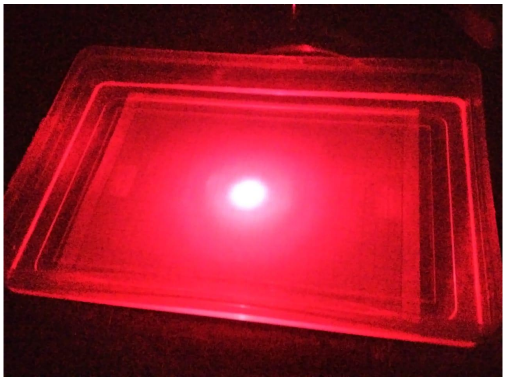


Fig. (12) - Experimental Setup with laser beam

2.2 OBSERVATION

2.2.1 LIQUID LENS

Convex lens placed on Plane Mirror		Focal Length of Convex Lens	Convex lens placed on Plane Mirror with water in between		
Distance between object needle and		$R = \frac{a+b}{2}$ (cm)	Distance between object needle and		$F = \frac{a_1+b_1}{2}$ (cm)
Lens a (cm)	Mirror b (cm)		Lens a_1 (cm)	Mirror b_1 (cm)	
17	18.1	17.55	25.5	26.5	26
16.9	18	17.45	25.4	26.4	25.9
17	18	17.5	25.5	26.4	25.95
16.9	18	17.45	25.5	26.4	25.95
17	18.1	17.55	25.4	26.5	25.95
Mean R		17.5	Mean F		25.95

$$n = 2 - \frac{R}{F}$$

$$= 2 - \frac{17.5}{25.95}$$

$$= 1.32563$$

Refractive Index Of Water using Liquid Lens = 1.32563

2.2.2 HOLLOW PRISM

2.2.2.1 Angle of prism

Value of 1 main scale division = 30 degree = 30'

No of division on vernier scale (x) = 30

Least count = $\frac{1}{X}$ x value of a main scale division = $\frac{30'}{30}$ = 1minute

Reading of	Vernier 1			Vernier 2		
	MSR (cm)	VSR (div)	TOTAL	MSR (cm)	VSR (div)	TOTAL
Reflected ray from 1st phase (a)	310°30’	23	310°53’	130°	20	130°20’
Reflected ray from 2nd phase (b)	190°30’	2	190°32’	10°	4	10°4’
Difference between (a) and (b) θ			120° 21’			120°16’

Mean value of θ = 120°18’30”

Angle of prism (A) = 180 - θ
= 59°41’30”

2.2.2.2 Angle of minimum deviation

Reading of	Vernier 1			Vernier 2		
	MSR (cm)	VSR (div)	TOTAL	MSR (cm)	VSR (div)	TOTAL
Refracted ray (c)	155°	4	155°4’	335°	3	335°3’
Direct ray (d)	178°30’	15	178°45’	358°30’	10	358°40’
Difference between (c) and (d) D			23°41’			23°37’

Mean value of D = 23°39’

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

$= \frac{\sin\left(\frac{59°41'30'' + 23°39'}{2}\right)}{\sin\left(\frac{59°41'30''}{2}\right)}$ 2339’

= **1.33601**

Refractive Index of Water using Hollow Prism = 1.33601

2.2.3 NEWTON'S RING

Value of one main scale reading = 0.05

Number of divisions on Vernier = 50

Least count, LC=0.05/50 = 0.001cm

2.2.3.1 DETERMINATION OF $(D^2_{m+p} - D^2_{m})$ OF AIR

ORDER OF THE RINGS	MICROSCOPIC READINGS						DIAMETER D (cm)	D^2 (cm^2)	$D^2_{m+p} - D^2_{m}$ (cm^2)
	LEFT			RIGHT					
	MSR (cm)	VSR (div)	TR (cm)	MSR (cm)	VSR (div)	TR (cm)			
20	6.15	40	6.190	5.40	2	5.420	0.770	0.592900	0.262275
18	6.15	5	6.155	5.40	23	5.423	0.732	0.535324	
16	6.10	25	6.125	5.45	6	5.456	0.659	0.447561	0.260199
14	6.10	20	6.105	5.45	25	5.475	0.630	0.393900	
12	6.05	40	6.090	5.45	40	5.490	0.600	0.360000	0.262266
10	6.05	30	6.080	5.50	5	5.505	0.575	0.330625	
8	6.05	15	6.065	5.50	40	5.540	0.525	0.275625	0.288659
6	6.05	4	6.030	5.60	4	5.604	0.430	0.184900	
4	6.00	20	6.004	5.65	25	5.675	0.329	0.108241	0.286559
2	5.90	25	5.975	5.70	4	5.704	0.271	0.073441	

Mean $\left(D^2_{m+p} - D^2_{m}\right)$ = 0.2719906 cm^2

2.2.3.2 DETERMINATION OF ($D^2_{m+p} - D^2_m$) OF WATER

ORDER OF THE RINGS	MICROSCOPIC READINGS						DIAMETER D (cm)	D^2 (cm^2)	$D^2_{m+p} - D^2_m$ (cm^2)
	LEFT			RIGHT					
	MSR (cm)	VSR (div)	TR (cm)	MSR (cm)	VSR (div)	TR (cm)			
20	6.75	19	6.769	6.10	12	6.112	0.657	0.431649	0.20792
18	6.75	04	6.754	6.10	29	6.129	0.645	0.390625	
16	6.7	35	6.735	6.15	03	6.153	0.582	0.338724	0.206584
14	6.7	07	6.707	6.15	13	6.163	0.544	0.295936	
12	6.7	03	6.703	6.15	34	6.184	0.519	0.269361	0.20034
10	6.65	28	6.678	6.20	05	6.205	0.473	0.223729	
8	6.65	04	6.654	6.20	25	6.225	0.429	0.184041	0.19608
6	6.6	25	6.625	6.25	03	6.253	0.372	0.138384	
4	6.55	40	6.590	6.25	29	6.279	0.316	0.099856	0.208845
2	6.55	13	6.563	6.30	17	6.317	0.246	0.060516	

Mean $\left(D^2_{m+p} - D^2_m\right)$ = 0.2039538 cm^2

Refractive Index of Water,

$$\mu = \frac{D^2_{m+p_{(air)}} - D^2_{m_{(air)}}}{D^2_{m+p_{(LIQUID)}} - D^2_{m_{(LIQUID)}}}$$

$$= \frac{0.2719906}{0.2039538}$$

$$= 1.33358$$

Refractive Index of Water using Newton's Ring = 1.33358

2.2.4 LASER BEAM

RADIUS R (cm)	DEPTH d (cm)	$\theta_c = \tan^{-1} \frac{R}{2d}$	$\mu = \frac{1}{\sin \theta_c}$
4.2	1.9	47.862	1.3486
3.3	1.5	47.726	1.3515
3.1	1.4	47.911	1.3475
2.5	1.1	48.652	1.3321
2.2	1	47.726	1.3515

Mean $\mu = 1.34624$

Refractive Index of Water using Laser Beam = 1.34624

CHAPTER 3

RESULTS AND DISCUSSIONS

3.1 RESULTS AND DISCUSSIONS

REFRACTIVE INDEX OF WATER USING	OBSERVED REFRACTIVE INDEX	STANDARD REFRACTIVE INDEX	PERCENTAGE ACCURACY
LIQUID LENS	1.32563	1.333	99.45 %
HOLLOW PRISM	1.33601		99.77 %
NEWTONS RING	1.33358		99.96 %
LASER BEAM	1.34624		99.00 %

From the above table it is clear that Newton's Ring Experiment is the better method to find the refractive index of the liquid more accurately.

Newton's rings is a popular interference experiment used to determine the refractive index of a medium. It is considered more accurate than other methods because it provides a high level of precision and is less prone to errors.

One reason for this is that Newton's rings experiment uses monochromatic light, which means that it has a single wavelength. This makes it easier to accurately measure the interference pattern because there is only one wavelength to consider. In contrast, other methods such as the prism method or the minimum deviation method may require the use of multiple wavelengths of light, which can introduce errors due to the dispersion of light.

Another reason for the higher accuracy of the Newton's rings method is that it uses a very small contact area between the convex and the flat glass surfaces, which minimizes errors caused by irregularities or imperfections in the surfaces. Additionally, the rings in the pattern are very sharp and well-defined, which allows for precise measurements of the ring diameters and distances between them.

Overall, the use of monochromatic light and a small contact area between the glass surfaces in the Newton's rings experiment provides a high level of accuracy and precision, making it a popular and reliable method for measuring the refractive index of a medium.

3.2 CONCLUSION

One application of the index of refraction is the analysis of crime scenes. Using the index of refraction, forensic scientists can determine what type of liquid has been left at a scene. Refractive index has the large number of applications. It is mostly applied for identifying a particular substance, confirm its purity, or measure its concentration. Generally it is used to measure the concentration of a solute in an aqueous solution.
So, using the experiment with Newton's Ring Apparatus which uses the optical phenomenon of interference we will obtain the refractive index with more accuracy and thereby we could identify the liquid from the Absolute Indices of Refraction List.

Newton's Ring experiment is widely used for the quality control of optical surfaces because the precision obtained with this method proves to be satisfactory. The dimensions of the rings permit the calculation of the radii of the curvature of the analysed surfaces and the deformation of the interference pattern can be utilized to calculate other parameters such astigmatism. This method also shows how the interference of light can be used in determining the thickness of a thin film.

REFERENCE

- A textbook of optics - Dr. N. Subrahmanyam, Brij Lal, Dr. M.N. Avadhanulu
- phywe.com
- Fundamentals of Optics - F Jenkins and H White
- physical-optics.blogspot.com
- a-levelphysicstutor.com