POORNIMA
COLLEGE OF ENGINEERING

Department of 1st year

Session 2019-2020

Engineering Physics Lab Manual

Year: 1st Year

Lab Code: - 1FY2-20 / 2FY2-20

Edited By:
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Vision

To create knowledge based society with temper,team spirit and dignity of labor to face the global competition challenges.

Mission

To evolve and develop skill based systems for effective delivery of knowledge so as to equip young professional with dedication & commitment to excellence in all spheres of life.

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Lab Objective: Course Name: 1FY2-20/2FY2-20 Engineering Physics Lab

Course Outcomes

After completion of this course, students will be able to –

LO 1 Find out the characteristics of optical fiber and laser.

LO 2 Determine wavelength of different spectral lines and height of an object by sextant

LO 3 Analyze the band gap of semiconductor and type of semiconductor through hall effect

LO 4 Students will show an ability to communicate effectively and work as a team member ethically

PROGRAM OUTCOMES (PO)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

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6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

LO-PO Mapping Matrix of Course

	PO-1 (Engineering Knowledge)	**PO-2 (Problem Anal**	**PO-3 (Design/ Development of Solutions)**	**PO-4 (Conduct Investigations of Complex Problems)**	**P**	**PO-6 (Engineer and Society)**	**PO-7 (Environment and Sustainability)**	**PO-8 (Ethics)**	**PO-9 (Individual and Team Work)**	**PO-10 (Communication)**	**PO-11 (Project Management and Financ**	**PO-12 (Life-Long Learning)**

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		y s i s)									e)	
LO-1	**1**											
LO-2	**2**											
LO-3		**1**										
LO-4								**2**	**3**	**2**		

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Rubrix for Physics Lab-(1FY2-20)

Category	Excellent(4)	Very good (3)	Good (2)	Need to improvement(1)
Scientific Concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.
Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
Drawings/Diagrams	Clear, accurate diagrams are included and make the experiment easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
Calculations	All calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.
Error Analysis	Experimental errors, their possible effects, and ways to reduce errors are discussed.	Experimental errors and their possible effects are discussed.	Experimental errors are mentioned	There is no discussion of errors.

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LAB RULES

DO'S

1. Feel that practical are essentials to lay the foundation for understanding the subject.
2. Have knowledge of the theoretical background of each experiment.
3. Display your skill in handling the apparatus.
4. Handling every apparatus carefully.
5. Every graph should obtain title of the experiment, scale chosen and the results obtained from the graph. The scale should be properly chosen so that the entire graph should be utilized.
6. Make as many observations as possible. Large number of data will eliminate random errors and systematic errors.
7. Calculations must be done meticulously. For this, the knowledge of using calculators and mathematical tables is essential.
8. Put your heart and soul in the experiment.
9. If you get wrong result others than the expected one, study your observation thoroughly and find out where you went wrong. Repeat the experiment until you get the correct observation, leading to the correct and expected result.
10. Consult your teacher, or your friend who had already done the experiment before entering the physics lab. This will help you to overcome difficulties while doing the experiment.

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DON'TS

1. Don't neglect the importance of practical.
2. Without any theoretical knowledge of the experiment your activities in the physics lab will be like a clown in a circus.
3. Without skill it is impossible to get positive result for the apparatus beyond repair.
4. Carelessness will damage always give wrong result and poor look.
5. Improperly drawn graphs always give wrong result and poor look
6. Don't be lazy in making observation. Avoid copying someone else's observation.
7. Don't depend on your friend's calculator. Have your on calculator and mathematical tables. Don't beg or borrow or steal your neighbor's calculation accessories.
8. There should not be any distraction. Don't play with your friend or the apparatus while doing the experiment.
9. Don't cook up results. It is very bad habit. Don't be discouraged if you get a wrong result. Don't consult your friend. Get your doubts cleared by your teacher.
10. Don't think you can away with cooked up reading from record notebook of former students. When you face the examiner conducting your practical examination, you may cut a sorry figure.

INSTRUCTIONS

Students have to perform all the prescribed experiments.

1. Student will be allotted the experiment one turn earlier.
2. Student will read about the allotment experiment and write following points in record.

- Date
- Experiments number
- Diagram on LHS page
- Object
- Apparatus used
- Theory (Formula with explained symbols)
- Observation
- Calculation on LHS of page
- Observation table
- Results
- Precaution
- Source of error
- Viva voce

3. Student should get their observations checked and signed by teacher in-change.
4. Student should handle apparatus carefully.
5. Student should rearrange the apparatus and disconnect the electrical connected after performing experiment.
6. Before leaving lab, he/she should get experiment allotted for next time

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7. The concerning experiment manual should be returned before leaving the lab.

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SYLLABUS

Engineering Physics Lab

Lab Code-2FY2-20

Mark- Evaluation

Schedule Per Week: 2 Hrs.

Maximum Marks : 50
Sessional 30
RTU(Main) Exam : 20

ENGINEERING PHYSICS LAB

1. To determine the wave length of monochromatic light with help of Michelson's Interferometer.
2. To determine the wave length of sodium light by Newton's Ring.
3. To determine the wave length of prominent lines of mercury by

   Plane diffraction grating with the help of spectrometer.
4. To study the variation of a semiconductor resistance withtemperature and hence determine the Band Gap of the semiconductor in the form of reverse biased P-N junction diode.
5. To determine the height of water tank with the help of a Sextant.
6. To determine the dispersive power of material of a Prism for Violet Red and yellow colors of Mercury light with the help of a spectrometer .
7. To study the Charge & Discharge of a condenser and hence determine

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time constant (Both current and voltage graphs are to be plotted).

8. To study the Hall effect and determine the Hall voltage and Hall cofficients .

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9. To determine coherent length and coherent time of laser using He-Ne Laser.

10. To measure the numerical aperture of an optical fiber.

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EVALUATION SCHEME

(To be verified from RTU syllabus)

Name of Exam	Conducted By	Experiment Marks	Viva Marks
I Mid Term	PCE	15	05
II Mid Term	PCE	15	05
Average of Mid Term I & II		10 Marks	
End Term	RTU	15	05

Name of Exam	Conducted By	Performance Marks	Attendance Marks
Sessional	PCE	15	05

Distribution of Lab Record Marks per Experiment

Attendance	Record	Performance	Total
2	3	5	10

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LAB PLAN

Total number of Experiment - 10

Total number of turns required - 12

Number of turns required for:-

Experiment Number	Turns	Scheduled Week
Experiment -1	1	Week 1
Experiment -2	1	Week 2
Experiment -3	1	Week 3
Experiment -4	1	Week 4
Experiment -5	1	Week 5
I Mid Term	**1**	**Week 6**
Experiment -6	1	Week 7
Experiment -7	1	Week 8
Experiment -8	1	Week 9
Experiment -9	1	Week 10
Experiment -10	1	Week 11
II Mid Term	**1**	**Week 12**

Distribution of lab hours

Activity	Time (in minutes)
Attendance	05
Explanation of Experiment & Logic	30
Performing the Experiment	60
File Checking	40
Viva/Quiz	30
Solving of Queries	15

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List of Experiments (With Rotor Plan)

Rotor-1

1.To determine the wave length of sodium light by Newton's Ring.

2. To determine coherent length and coherent time of laser using He-Ne Laser.

3.To determine the wave length of prominent lines of mercury by plane diffraction grating with the help of spectrometer.

4.To study the variation of a semiconductor resistance with temperature and hence determine the Band Gap of the semiconductor in the form of reverse biased P-N junction diode.

5.To determine the height of water tank with the help of a Sextant.

Rotor-2

1.To determine the dispersive power of material of a Prism for Violet Red and yellow colors of Mercury light with the help of a spectrometer.

2.To study the Charge & Discharge of a condenser and hence determine time constant (Both current and voltage graphs are to be plotted)

3.To determine the wave length of monochromatic light with the help of Michelson's Interferometer.

4. To study the Hall effect and determine the Hall voltage and Hall cofficients

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5. To measure the numerical aperture of an optical fiber.

Zero Lab

Introduction to Lab

1. Relevance to Branch:

"Physics is mother of all the branches of Engineering."

BRANCH	RELEVANCE TO BRANCH	Future Scope
CS/IT	Silicon valley Engineers should be able to understand that the micro chips on which they are embedding the codes are part of material science physics. To work on microchips, it is must to them to understand how to work on these chips.	IT /CS Engineers uses CDs, chips, Pen drives they all are made by laser effects and diffraction grating.
CIVIL/ME	Any architect can make the structure of the building on map, for which he needs the knowledge of dimensions. Measurements are based on fundamental physics. Which kind of glasses he should use for the proper reflection of light in the windows he need to understand the quality of glass. A mechanical engineer makes or purchases the car; he himself judges the quality of vehicle on the base of parameters speed, mileage, accelerations.	Before making any house you need to see the quality level of that place. Like due to cyclonic effects in Japan constructors build houses made of wood to escape from big losses.
EE/EC	Any circuit is incomplete without the basic knowledge of resistance, current, ammeter, galvanometer which a student studies first in physics before electronics. The chip designing need laser techniques. The basic knowledge is demanded. Any EC Engineer can understand the wireless communication if he knows the basic of optical fibre and the way it is used in propagating the signal from one end to the other.	To become a successful electronic designer you need to study the basic fundamentals of electronics and their parameters.

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2. Relevance to Society:

Society's reliance on technology represents the importance of physics in daily life. Many aspects of modern society would not have been possible without the important scientific discoveries made in the past. These discoveries became the foundation on which current technologies were developed. Discoveries such as magnetism, electricity, conductors and others made modern conveniences, such as television, computers, phones, what's app and other business and home technologies possible. Modern means of transportation, such as aircraft and telecommunications, have drawn people across the world closer together all relying on concepts in physics.

Due to physics experiments society could able to obtain various resources like electricity, freezing, boiling, vehicles, solar cell, and robotics.

3. Relevance to Self:

"Any sort of technology which we use in our daily life is related to Physics."

Being Engineer my concepts of engineering are born and justified just by the basic fundamentals of science. Science came first, their after Engineering was created.

4. Pre- Requisites (Connection with previous year): -

Physics is one of the major subjects in science stream as it deals with Nature and natural phenomena fundamental principles and concepts which form a base for all branches of science and engineering. All the students are already been a part of science stream as they had opted out PCM in XII. Since first standard they are studying science and Engineering

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EXPERIMENT No. -1

OBJECT: - To determine the wavelength of sodium light by Newton's ring.

APPARATUS: - A plano-convex lens of large radius of curvature about , traveling microscope, optical arrangement for Newton's rings, Sodium lamp , spherometer , magnify glass, plan glass plate etc.

FORMULA: - The mean wavelength of D_1 and D_2 lines of sodium light is given by

$$\lambda = \frac{(D^2_{n+p} - D^2_n)}{4pR}$$

Where D_{n+p} = diameter of (n + p)th ring

D_n = diameter of nth ring

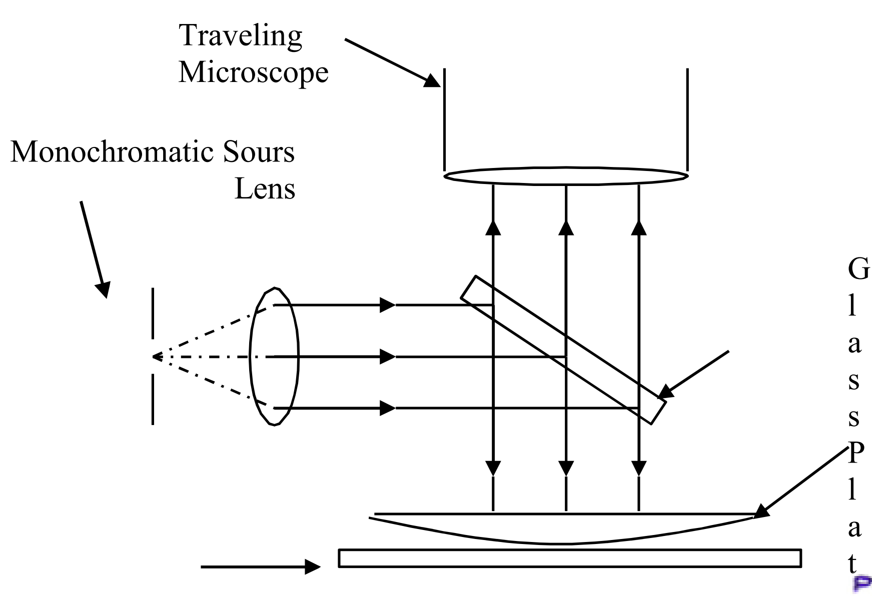
n and p = integers

R = radius of curvature

L=distance

h = difference of the readings of the between two legs of spherometer. spherometer on plane and curved surface of the lens.

DIAGRAM:-



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Plane Glass Plate

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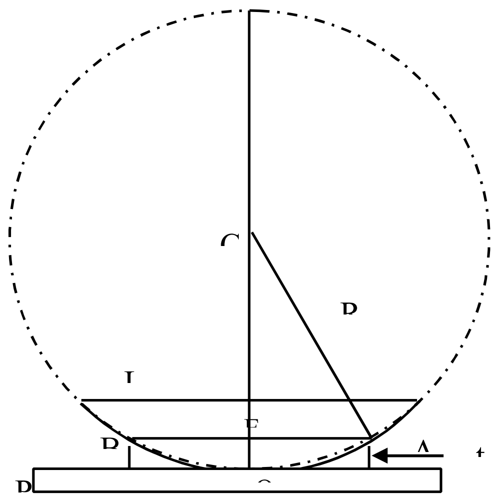
Production of Newton's Rings

PROCEDURE: -

1. The glass plate G in the Newton's rings apparatus is set such that it makes an angle of 45° with the direction of incident light from the source and reflects the light on the



lens.

2. The pIano-convex lens is placed below the microscope with its plane surface upwards. This can be judged by gently striking the edge of the pIano-convex lens with the finger.
3. The microscope is moved in the vertical direction by means of rack and pinion arrangement till the rings are seen distinctly.
4. The centre of the fringes is brought symmetrically below the cross wires by adjusting the position of the lens and the microscope.
5. The microscope is moved in horizontal direction to one side of the fringes such that one of the cross wires becomes tangential to the 18th ring. The reading on the scale is noted.
6. The microscope is moved and the cross wire is successively made tangential to the 16th, 14th, and so on till the 18th ring on the other side is reached. The reading on the scale for all these positions is noted.

7. The observations are not taken on the first two or three rings, which are wide enough.
8. The radius of curvature of the curved surface or the plano-convex lens is determined using spherometer. The observations with the spherometer are first taken on the curved surface and then on the plane surface.
9. The spherometer is then placed on the notebook and gently pressed to obtain the impression of the three legs of the spherometer. The three points are joined and mean distance between the legs is determined.

10. **OBSERVATIONS:**

One division of main scale x = cm.

No. of divisions on the venire scale n = ……….

Least count of the microscope = x /n = cm

(A) Determination of the diameter of Newton's rings:

S. No.	No. of the ring	Micrometer reading						Diameter D = a - b cm	$(D)^2$ cm^2	$(D_{n+p})^2$- $(D)^2$ cm^2	Mean value of $(D_{n+p})^2$ - $(D)^2$ cm^2 for p=8
		Right end (a)			Left end (b)						
		m.s. cm	v.s. cm	Total Reading (a) cm	m.s. cm	v.s. cm	Total reading (b) cm				
1.	18									$(D_{18})^2$- $(D_{10})^2$ =	
2.	16										
3.	14									$(D_{16})^2$- $(D_8)^2$ =	
4.	12										
5.	10									$(D_{14})^2$– $(D_6)^2$ =	
6.	8										
7.	6									$(D_{12})^2$– $(D_4)^2$ =	
8.	4										

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(B) Determination of height(h)

Pitch of screw x= cm
No. of division on the scale n=………………
least count of spherometer (x/n) = cm

<table>
<tr><td rowspan="3">S.No.</td><td colspan="6">Spectrometer Reading</td><td rowspan="3">h = b-a cm</td><td rowspan="3">Mean h cm</td></tr>
<tr><td colspan="3">Zero reading on plane surface(a)</td><td colspan="3">Reading on curved surface (b)</td></tr>
<tr><td>M.S. cm</td><td>V.S.</td><td>Total reading (a) Cm</td><td>M.S. Cm</td><td>V.S</td><td>Total reading (b) cm</td></tr>
<tr><td>1.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="5"></td></tr>
<tr><td>2.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>4.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

CALCULATIONS: -

(i) l = ……… cm h = cm

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

(ii) Mean $(D_{n+p})^2 - (D_n)^2$ = ………. cm^2 R = ……….cm p = ……….

$$\lambda = \frac{(D^2_{n+p} - D^2_n)}{4pR}$$

RESULT: -

Mean wavelength of sodium light = Å
Standard value = 5893 Å
Percentage error =………

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PRECAUTIONS: -

1. Glass plate and convex lens should be cleaned thoroughly before using.
2. PIano-convex lens should be of 1arge radius of curvature.
3. Source of light should be broad extended one.
4. Before measuring the diameter of rings, the range of microscope should be properly adjusted.
5. In order to avoid any error due to back-lash of the screw in the traveling microscope, the micrometer screw should be moved only in one direction for the measurement of diameter of rings.
6. Cross-wire should be focussed on the bright ring tangentially.
7. Radius of curvature of the lens shou1d be measured accurately.
8. Number of rings should be measured accurately. First three or four rings should be left out for measurement, as they are not well defined

VIVA VOCE

Q1. Why do we call these fringes Newton ring?
Ans. The concentric circular fringes obtained by this method were observed first of All by Newton n and so are called Newton's rings.

Q2.Why are these fringes circular?
Ans. The air film between the curved surface of lens and the plane glass plate is of variable thickness. Points of constant thickness in this air film lie on circles with the point of contact of the lens with the glass plate at the center. Since, every fringe is the locus of a constant thickness of air film so it is circular.

Q3.Why is broad source of light needed in seeing Newton rings?
Ans. To view the entire Newton rings pattern, a broad extended light source is needed.

Q4.On what factors does the diameter of rings depend?
Ans. The diameter of rings depend upon
(1) The wavelength of light used (2) the refractive index of the film between the lens and glass plate (3) the radius of curvature R of the lens.

Q5.The rings are broader at the center and go on getting thinner as the order of fringes increases. Why is it so?
Ans. The radii of the rings are proportional to the square root of the natural number of rings increase and so the rings get closer and closer.

Q6. Why the central fringe dark?
Ans. The thickness of air film at the contact of lens with glass plate is zero and two interfering ray due to reflected light are opposite in phase and produce zero intensity. Hence central fringe is black.

Q7.What will happen if glass plate is replaced by plane mirror?
Ans. No ring will be visible with plane mirror because no part of light will be transmitted through it. Hence the reflected light and the transmitted part will superimpose over each other and uniform illumination will be produced.

Q8.What will happen when white light is used in Newton ring experiment?
Ans. few colored and over lapping circular rings will be observed near the central dark spot.
Q9.Where are the rings formed?
Ans. The rings are formed in the air film between the curved surface of lens and glass plate.

Q10.What will happen when a few drops of transparent liquid are introduced between the lens and glass plate?

Ans. The diameter of rings shrink by a factor of root μ,where is the refractive index of the liquid.

Q11.Do you get rings in the transmitted light?
Ans. Yes, in this case the pattern of the rings is complementary of the reflected light.

Q12.Sometimes the center is bright. Why?
Ans. This happen a dust particle comes between the two surfaces at the point of contact.

Q13,How can you determine R?
Ans. This can be determined either by spherometer.

Q14. Why do you make the light fall on the convex lens normally? What will happen if the light incident obliquely?
Ans. The light is allowed to fall normally so that angel of incident and reflection be zero that cosθ may be taken as unity. In case of oblique incidence, the diameter of rings will increase.

Q15.Can you determine the wavelength of light even if u get a bright spot in reflected light?
Ans. The formula for the determination of is independent of the order n of the ring at the center hence wavelength of light can also be determined by it without any error coming in.

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EXPERIMENT No. - 2

Object: - To study the Hall effect and determine the Hall voltage and Hall Coefficients.

Apparatus:

Two solenoids, Constant current supply, Four probe, Digital gauss meter, Hall effect apparatus (which consist of Constant Current Generator (CCG), digital milli voltmeter and Hall probe).

Theory:

If a current carrying conductor placed in a perpendicular magnetic field, a potential difference will generate in the conductor which is perpendicular to both magnetic field and current. This phenomenon is called Hall Effect. In solid state physics, Hall effect is an important tool to characterize the materials especially semiconductors. It directly determines both the sign and density of charge carriers in a given sample.

Consider a rectangular conductor of thickness ***t*** kept in XY plane. An electric field is applied in X-direction using Constant Current Generator (CCG), so that current ***I*** flow through the sample. If ***w*** is the width of the sample and ***t*** is the thickness. There for current density is given by

$$J_x = I/wt \qquad (1)$$

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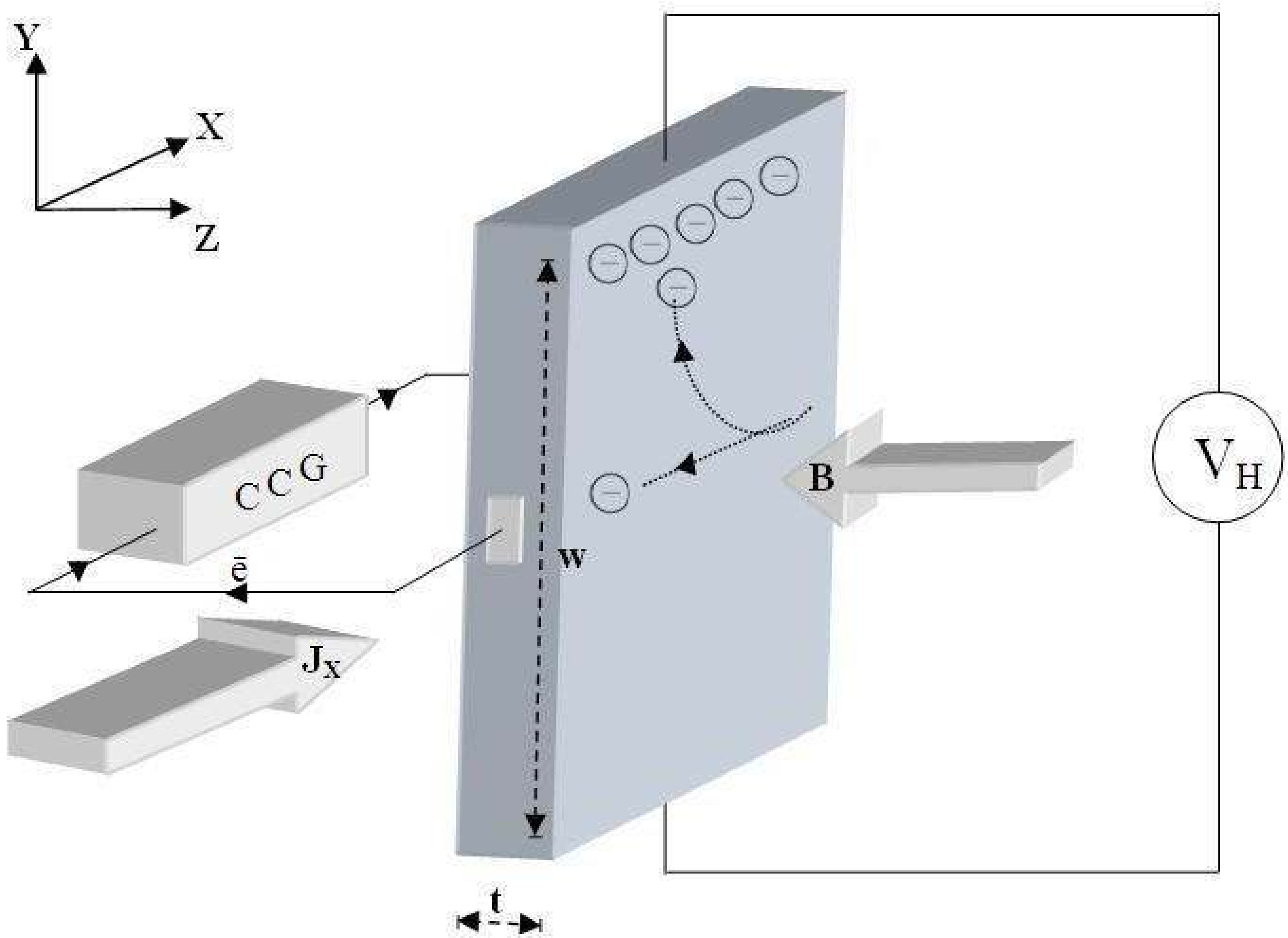

Fig.1 Schematic representation of Hall Effect in a conductor.
CCG – Constant Current Generator, J_X – current density
$\bar{e}$ – electron, ***B*** – applied magnetic field
t – thickness, ***w*** – width
V_H – Hall voltage

If the magnetic field is applied along negative z-axis, the Lorentz force moves the charge carriers (say electrons) toward the y-direction. This results in accumulation of charge carriers at the top edge of the sample. This set up a transverse electric field $\mathbf{E}_y$ in the sample. This develop a potential difference along y-axis is known as Hall voltage V_H and this effect is called Hall Effect.

A current is made to flow through the sample material and the voltage difference between its top and bottom is measured using a volt-meter. When the applied magnetic field B=0,the voltage difference will be zero.

We know that a current flows in response to an applied electric field with its direction as conventional and it is either due to the flow of holes in the direction of current or the movement of electrons backward. In both cases, under the application of magnetic field the magnetic Lorentz

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force, $F_m = q(v \times B)$ causes the carriers to curve upwards. Since the charges cannot escape from the material, a vertical charge imbalance builds up. This charge imbalance produces an electric field which counteracts with the magnetic force and a steady state is established. The vertical electric field can be measured as a transverse voltage difference using a voltmeter.
In steady state condition, the magnetic force is balanced by the electric force. Mathematically we can express it as

$$eE = evB \qquad (2)$$

Where 'e' the electric charge, 'E' the hall electric field developed, 'B' the applied magnetic field and 'v' is the drift velocity of charge carriers.
And the current 'I' can be expressed as,

$$I = neAv \qquad (3)$$

Where 'n' is the number density of electrons in the conductor of length l ,breadth 'w' and thickness 't'.
Using (1) and (2) the Hall voltage V_H can be written as,

$$V_H = Ew = vBw = \frac{IB}{net}$$

$$V_H = R_H \frac{IB}{t} \qquad (4)$$

by rearranging eq(4) we get

$$R_H = \frac{V_H * t}{I * B} \qquad (5)$$

Where R_H is called the Hall coefficient.

$$R_H = 1/ne \qquad (6)$$

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Procedure:

- Connect ‘Constant current source’ to the solenoids.
- Four probe is connected to the Gauss meter and placed at the middle of the two solenoids.
- Switch ON the Gauss meter and Constant current source.
- Vary the current through the solenoid from 1A to 5A with the interval of 0.5A, and note the corresponding Gauss meter readings. Set 1000 gauss magnetic field
- Switch OFF the Gauss meter and constant current source and turn the knob of constant current source towards minimum current.
- Fix the Hall probe on a wooden stand. Connect green wires to Constant Current Generator and connect red wires to milli voltmeter in the Hall Effect apparatus
- Replace the Four probe with Hall probe and place the sample material at the middle of the two solenoids.
- Switch ON the constant current source and CCG.
- Carefully increase the current I from CCG and measure the corresponding Hall voltage V_H. Repeat this step for different magnetic field ***B***.
- Thickness ***t*** of the sample is measured using screw gauge.
- Hence calculate the Hall coefficient R_H using the equation 5.
- Then calculate the carrier concentration ***n***. using equation 6.

Observation : Then calculate Hall coefficient and carrier concentration of that material using the equation

Where R_H is the Hall coefficient And ***n*** is the carrier concentration

$R_H = V_H t / (I *$

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B)

$R_H = 1/ne$

- Repeat the experiment with different magnetic file.

Observation Table:

S.No.	Prove Current I(mA)	Magnetic Field B (Tesla)	Zero field Potential Offeset Voltage (V0)	Hall Voltage for one side of the prove with offeset Voltage (VH+)	Hall Voltage for second side with Offeset Voltage (VH-)	Hall Voltage of one side without Offeset Voltage V+=(VH+-V0)	Hall Voltage of second side without Offeset Voltage V-=(VH- -V0)	Mean Voltage V=(V+ - V-)/2	Hall Cofficient RH=(VH*t)/I*B
1									
2									
3									
4									
5									
6									
7									

Calculation:-

$$R_H = V_H t/(I*B)$$

Where R_H is the Hall coefficient
t is the thickness of the sample
I is the prove current
B is the magnetic field

Result:-

Hall coefficient of the material = ...

Carrier concentration of the material = m^{-3}

:

Precautions:-

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- The magnet power supply can furnish large currents at dangerous voltage levels; do not touch exposed magnet coil contacts.
- The oven gets hot.
- AC leads from Variac to oven can be dangerous; they should not be exposed.

- Never suddenly interrupt or apply power to a large magnet. Large inductive voltage surges may damage the insulation. Start with controls set for zero current and gradually increase current. When turning off, smoothly decrease current to zero and then turn off.
- Turn on water before turning on magnet coil.
- Do not exceed magnet current of 10 A.
- Do not exceed Hall probe current of 0.4 A
- Do not exceed an oven temperature of 100°C (a few degrees more for a brief time will do no harm).
- Do not leave the magnet current at a high setting for any length of time beyond the minimum needed for data acquisition - it affects the monitor (obviously).

Viva-Voce:

What is Hall Effect?

Ans. When a current carrying conductor is placed in a magnetic field mutually perpendicular to the direction of current a potential difference is developed at right angle to both the magnetic and electric field. This phenomenon is called Hall effect.

Define hall co-efficient.

*Ans. It is numerically equal to Hall electric field induced in the specimen crystal by unit current when it is placed perpendicular in a magnetic field of 1 weber/(meter*meter).*

Define mobility.

Ans. It is the ratio of average drift velocity of charge carriers to applied electric field.

Why is Hall potential developed?

Ans. When a current carrying conductor is placed in a transverse magnetic field the magnetic field exerts a deflecting force (Lorentz Force) in the direction perpendicular to both magnetic field and

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drift velocity this causes charges to shift from one surface to another thus creating a potential difference.

What is Fleming's Left Hand Rule?

Ans. Stretch thumb, first finger, middle finger at right angles to each other such that fore finger points in the direction of magnetic field, middle finger in the direction of current then thumb will point in the direction of the force acting on it.

How does mobility depend on electrical conductivity?

Ans. It is directly proportional to conductivity.

Define Hall angle.

Ans. It is the angle made with the x direction by the drift velocity of charge carrier is known as hall angle.

Which type of charge has greater mobility?

Ans. In semiconductors, electron has greater mobility than holes.

What happens to the hall coefficient when number of charge carriers is decreased?

Ans. Hall coefficient increases with decrease in number of charge carriers per unit volume.

Name one practical use.

Ans. It is used to verify if a substance is a semiconductor, conductor or insulator. Nature of charge carriers can be measured

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EXPERIMENT No. – 3

OBJECT: To determine the wavelength of prominent lines of plane diffraction grating with the help of spectrometer.

APPARATUS: Spectrometer, mercury lamp, plane diffraction grating, reading lens, spirit level, tourch, magnify glass etc.

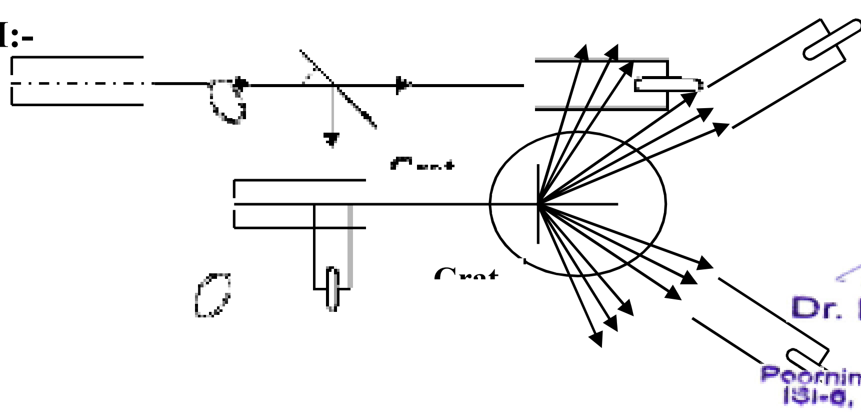
FORMULA: The wavelength of light emitted by the source is given by

$$\lambda = \frac{(e+b)\sin\theta}{n}$$

Here λ = wavelength of light, (e + b) = grating element

θ = Angle of diffraction, n = order of spectrum.

DIAGRAM:-



PROCEDURE:

(A) Adjustment of spectrometer:

1. Adjustment of the telescope:

Turn the telescope towards a white wall and the distance between its objective and the eyepiece is so adjusted that the field of view becomes completely luminous. Now the eyepiece is displaced inside the tube till the cross-wire becomes distinctly visible. Now the telescope with objective is directed towards a distant tree or pole and they are viewed through the telescope. The distance between the objective and the eyepiece is adjusted with the help of rack and pinion arrangement such that a distinct and clear image of the object is seen. Thus the telescope is ready to focus all the parallel rays at the crosswire.

2. Adjustment of Collimator:

Place the mercury lamp in front of the slit of collimator and align the telescope with the collimator such that the image of the slit is seen through the telescope. The distance between the slit and the lens of the collimator is adjusted with the help of its rack and pinion arrangement until a distinct image is seen through the telescope. In this position the light rays coming out of the collimator will be parallel to each other.

(B) Adjustment of grating for normal incidence of light:

1. The slit of the spectrometer is illuminated by a source of light whose wavelength is to be determined.

   The telescope is directed towards the collimator and the image of the slit is viewed on the cross-wire. Let the reading of the circular scale for this position of the telescope be 'a'.
2. The telescope is turned through 90^0 so that the reading of circular scale becomes either a + 90^0 or a – 90^0. In this position the telescope and collimator axes are mutually perpendicular to each other. Now the telescope is clamped.
3. The grating is placed symmetrically at the centre of prism table. The prism table is rotated gradually (but the circular scale must not rotate) so that the reflected image of the slit is on vertical crosswire. In this position the grating will make an angle of 45^0 with the incident ray.

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4. Keeping the telescope fixed the prism table is turned with vernier through 45^0 or 135^0 so that the grating plane becomes normal to the incident rays.
5. To make the slit parallel to the rulings of the grating, the slit is rotated in its own plane till spectral line becomes clear and parallel to the cross-wire.

(B) Adjustment for determination of the angle of diffraction :

1. The telescope, in alignment with the collimator, is turned towards left or right and the first line of first order spectrum is seen on the crosswire. The angular position of the telescope is determined with the help of both the venires V_1 and V_2.
2. Now the telescope is turned in the opposite direction and again the first line of the first order spectrum is viewed on the cross-wire. Again the angular position of the telescope is noted on both the venires V_1 and V_2.
3. The difference of two venire readings as taken above is equal to twice the angle of diffraction. Hence half of this difference gives the angle of diffraction□.
4. Rotate the telescope further to obtain second order spectrum and repeat the same process for second order spectrum lines and the angles of diffraction are determined.
5. The grating element is determined from the number of lines per inch supplied by the manufacturer.
6. Finally wavelength of each spectral line is determined from (e + b), □ and n.

OBSERVATIONS AND OBSERVATION TABLE:

(i) Determination the grating element:

Number of lines per inch on grating = 15,000

Grating element (e + b)= 2.54 / 15000 = 1.69×10^{-4} cm.

(ii) Determination the angle of diffraction□:

Least count of main scale x =………

Number of divisions on the venire scale m =………

Least count of venire scale = x / m

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(A) Order of spectrum n = 2

S. No.	Colour of light	window	Towards right of the central image (a)			Towards left of the central image (b)			2□ = a - b	□	Mean □
			MS	VS	TR	MS	VS	TR			
1.	Violet	V_1									
		V_2									
2.	Green	V_1									
		V_2									
3.	Yellow	V_1									
		V_2									

(B) Order of spectrum n = 1

S. No.	Colour of light	window	Towards right of the central image (a)			Towards left of the central image (b)			2□ = a - b	□	Mean □
			MS	VS	TR	MS	VS	TR			
1.	Violet	V_1									
		V_2									
2.	Green	V_1									
		V_2									
3.	Yellow	V_1									
		V_2									

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CALCULATIONS: -

(A) For violet colour

$$\lambda_v = \frac{(e+b)\sin\theta}{n} = \ldots\ldots\ldots$$

(B) For green colour

$$\lambda_g = \frac{(e+b)\sin\theta}{n} = \ldots\ldots\ldots\ldots$$

(C) For yellow colour

$$\lambda_y = \frac{(e+b)\sin\theta}{n} = \ldots\ldots\ldots$$

RESULT: -

For mercury light source:

Mean wavelength of λ_v =……….

λ_g =……….

λ_y =……….

Standard value of λ_v = 4047 Å

λ_g = 5460 Å

λ_y = 5790 Å

Percentage errors =………

PRECAUTIONS:

1. The slit should be as narrow as possible but the knife-edges of the slit should not touch each other.
2. The telescope and the collimator should be separately set for parallel rays.
3. The height of the prism table should be so adjusted that the light must fall on the centre

rulings surface of the grating.

4. While taking observations the telescope and the prism table must be clamped.
5. The reading lens should be used for taking readings on both the verniers.
6. The ruled surface of the grating must face the telescope and it should not be touched with hand.

VIVA-VOCE:

What is diffraction?

Ans. The phenomenon of bending of waves around the obstacle and entering in the region of the geometrical shadow of the obstacle is called diffraction of waves.

What is the difference between interference and diffraction?

Ans. Interference is due to the superposition of light waves coming from two coherent source whereas diffraction is due to interference of secondary wavelets coming from different point of the same wave front.

What is a diffraction grating?

Ans. Diffraction grating is a plane glass plate on which a large number of equidistant, parallel and fine lines are drawn by means of a fine diamond point worked with a ruling engine.

How many types of grating are there?

Ans. There are two types of grating (*i*) transmission grating and (*ii*) reflection grating.

What is grating element?

Ans. The distance between the midpoints of two successive slits is called grating element. This is denoted by (e + b) in the grating formula where e is the width of transparent part and b is the width of transparent part.

How many lines are drawn on a grating?

Ans. The number of lines drawn on a grating varies from 10,000 to 15,000 per inch and the width of ruled surface varies from 2 to 4 inches.

Is the grating used in the laboratory a real grating?

Ans. No, replica of master grating is used in the laboratory.

Why do you keep the ruled surface towards the telescope?

Ans. If the ruled surface is towards the telescope, the light falling normally on the glass plate enters it undeviated and then only diffraction takes place at the ruled surface. In this case the angle measured will be true angle of diffraction

Why do you adjust the grating normal to the incident light?

Ans. Grating formula $(e + b) \sin \theta = n\lambda$ has been deduced on the condition that the incident wave falls normally on the grating.

What is meant by order of spectrum?

Ans. The light waves of different wavelengths are diffracted by the grating at different angles of diffraction. The angle of diffraction of the light waves of same wavelength depends upon the whole number n = 0, 1, 2, 3…… . This whole number is called order of the spectrum. n = 0 corresponds to zeroth order spectrum, n = 1 corresponds to first order spectrum etc.

How many orders can be obtained with the help of grating?

Ans. $n_{max} = (e + b)/\lambda$

depending upon the grating element and the wavelength of light.

Are the intensities of light equal in all orders of the spectrum?

Ans. No, the intensity of spectrum decreases as the order of spectrum increases.

Do you observe any difference in the spectrum of mercury lamp as formed by a prism and a grating?

Ans. Yes, the order of colours in the two cases is opposite.

increase in the same space.

Why is the intensity of prism spectrum more intense than that of grating spectrum?

Ans. In case of prism the whole dispersed light is concentrated in one spectrum where as in case of grating the whole light is distributed over the different orders of the spectrum.

On what factors does the dispersive power of the grating depend?

Ans. The dispersive power of the grating depends upon (*i*) the grating element (*ii*) the angle of diffraction and (*iii*) the order of the spectrum.

What is the difference between the dispersive poser and the resolving power of the grating?

Ans. The ability to increase the angle of diffraction of the two spectral lines close to each other is known as dispersive power of the grating. It is given by $d\theta/d\lambda$ where $d\theta$ is the

What will happen when the width of lines on grating become equal to the spacing between them.

Ans. The spectra of even order (n = 2, 4, 6, 8…….) will be absent.

Is the angular dispersion same in all orders of the spectrum?

Ans. No, the angular dispersion increases with the increase of the order of spectrum.

What will happen to the angular dispersion if the number of lines in the same space be doubled?

Ans. Since the angular dispersion is inversely proportional to the grating element. Therefore, The angular dispersion will increase as the number of lines

EXPERIMENT No. - 4.

OBJECT: - To study the variation of a semiconductor resistance with temperature and hence determine the band gap of the semiconductor in the form of reverse biased P-N junction diode.

APPARATUS: - A semiconductor diode, a micro ammeter, a battery, a mercury thermometer, key and connecting wires.

THEORY AND FORMULA:-

Current I trough the PN junction diode in forward bias voltage V is given by

$$I = I_s\left[\exp\left(-\frac{qV}{kT}\right) - 1\right] \qquad (1)$$

Where I = Current in microampere.

T = Temperature of diode junction in degree Kelvin.

q = charge of an electron

K = Boltzman's constant in eV per degree Kelvin.

I_s = Reverse saturation current

When PN junction is In the reverse bias with large voltage, the exponential term in eq. (1) becomes negligible. Hence $I = -I_s$

Saturated value of current in reverse bias (I_s) for a p-n junction diode is given by

$$I_s = A_s \exp\left(-\frac{E_g}{kT}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ (1)$$

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Where ΔE = Band gap in electron - volt.

A_s = Constant

Diode resistance at saturation

$$R = \frac{V}{I_s} = \frac{V}{A_s} \exp\left(+\frac{\Delta E_g}{kT}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

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Taking log on both side of eq. (2), we obtain

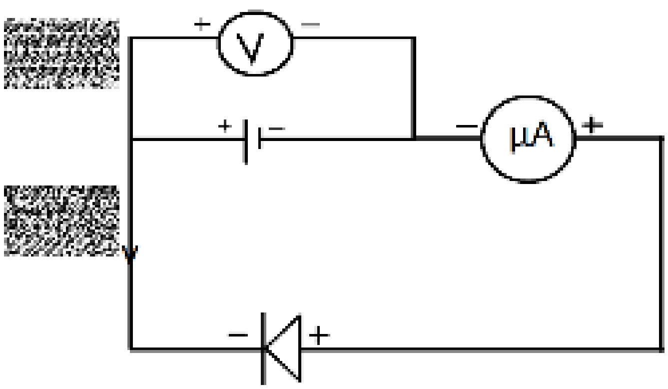
$$Log_{10} R_s = \log_{10} \frac{V}{A_s} + (5.04\,\Delta E_g).\left(\frac{10^3}{T}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Graph between (10^3 / T) as abscissa and $\log_{10} I_s$ as ordinate will be a straight line having a slop = ΔE. Hence band gap ΔE_g

ΔE_g = slope of the line / 5.04 (3)

ΔE_g = 0.198 x slope of the line

CIRCUIT DIAGRAM:-



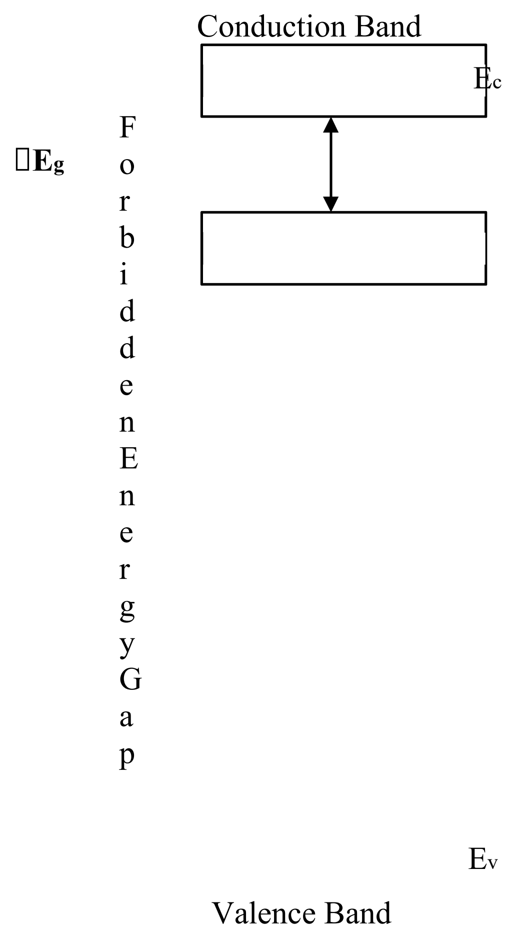


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Figure:- 1.Circuit Diagram of Band Gap

Figure:-2. Energy Band Diagram

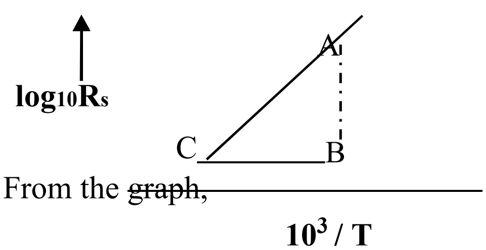
PROCEDURE: -

1. The electrical connections are made as shown in diagram. It should be noted that positive of the battery is connected to N and negative terminal to P of the diode for reverse bias.
2. Temperature is increased up to 60 – 70^{0}C.
3. The value of current is noted for different temperature.
4. A graph is plotted between (10^3 / T) along X-axis and $\log_{10}$I along Y-axis and the slop of this line is determined from the graph.

OBSERVATION TABLE: -

S.No.	Current I_s (□A)			Temperature of diode T		10^3 / T (K^{-1})	R_s =V/I_s	$\log_{10}R_s$ (□A)
	↑	↓	I_s (average)	in ^{0}C	in K			
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9								
10								

CALCULACTION: -



From the graph,

$$Slope = \frac{AB}{BC} = ...$$

$$\therefore \text{Energy gap } □E_g = 0.198 \frac{AB}{BC}$$

$$= \quad\quad eV$$

RESULT: -

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The energy band gap for a given semiconductor = eV

Standard value for Germanium = 0.72 Ev

Standard value for Silicon = 1.10eV

Percentage error =……….

PRECAUTIONS:-

1. The diode should be reverse biased.
2. The reverse bias should not be increased beyond a certain limit otherwise it may get damaged.
3. The cooling rate should be slow so that the diode gets necessary time to attain the temperature of the liquid.
4. The liquid should not be heated beyond $65^0 – 70^0$C.
5. Water should be stirred continuously so that temperature of the water remains uniform.

VIVA VOCE

Q1. What is a band gap?
Ans. This is energy gap between the conduction and valence bands of a semiconductor.

Q2.What is band gap in a good conductor?
Ans. There is no band gap as the bands overlap in the good conductors. There is very little band gap in some conductors.

Q3.How is reverse current produced across a P-N junction and on what factors does it depend?
Ans. When a P-N junction is reversed biased, then current is due to minority carriers whose concentration is dependent on energy gap or band gap.

Q4.What are semiconductors?
Ans. Semiconductors are those materials whose resistivity lies between those of conductors and insulators i.e. it is the order of 10^4 to 10^{-1}ohm meter.

Q5.What are intrinsic and extrinsic semiconductors?
Ans. A pure semi conductor like germanium or silicon is called a pure semiconductor. When some pentavalent or trivalent is added to a semiconductor in order to increase its conductivity, it is called the extrinsic semiconductor.

Q6.What are N-type and P-type semiconductors?
Ans. Pure semiconductors are 4^{th} group elements. If a trivalent impurity like Al, B, Ga, In etc. is added to it, the semiconductor is called P-type. When a pentavalent impurity, like P, As, Sb, Bi etc. is added to it, it is called the N-type semiconductor.

Q7.What do you mean by forward and reverse biasing of junction diode?
Ans. If the positive terminal of the battery is connected to P-side and negative terminal to the N-side of the junction that is called the forward biasing. On reversing the connections either of battery or of the diode, it is said to be reverse biased.

Q8.What is depletion layer?
Ans. In a semiconductor diode, at the junction the drift of the electrons and holes takes place causing a potential barrier which stops further drift of electrons and holes. This layer is called depletion layer.

Q9.What is the effect of impurities on the conductivity of semiconductors?
Ans. It increases the conductivity of the semiconductor.

Q10.What are the order of current in forward and reverse bias arrangement?

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Ans. In forward bias, the current is of the order of mill amperes where as in reverse biasit is of the order of microamperes.

Q11.What is diffusion currents?

Ans. A directed movement of charge carriers constitutes an electric current. Diffusion takes place die to the existence of a non-uniform concentration of carriers.

Q12.Define Hall effect phenomena and derive an expression for Hall voltage?

Ans. When a magnetic field is applied perpendicular to a current carrying conductor or semiconductor, a voltage is developed across the specimen in a direction perpendicular to both the current and the magnetic field. This phenomenon is called the Hall effect and the voltage so developed is called Hall voltage.

Q13.On what factors does the reverse current depend in reverse bias arrangement?

Ans. The current in reverse bias arrangement depends on the temp. of the PN junction and the energy band gap.

Q14.What is Zener effect?

Ans. When the bias voltage exceeds a certain limit in reverse bias arrangement, the current abruptly increases. This is due to the avalanche breakdown . This effect is called Zener effect.

EXPERIMENT No 5

OBJECT: To determine the height of an object with the help of a sextant.

APPARATUS: A sextant, a measuring tap and chalk pieces of two different colors.

FORMULA: Height of an object

$$H = \frac{x}{\cot\theta_1 - \cot\theta_2} + h_r = h + h_r \qquad \text{(i)}$$

Where θ1, θ2 are the angels subtended by the top at the two positions of the sextant

$x = x_1 - x_2$ is the distance between two points at the same level of the sextant

h is the height of an object above the reference mark.

h_r is the height of the reference mark from the ground .

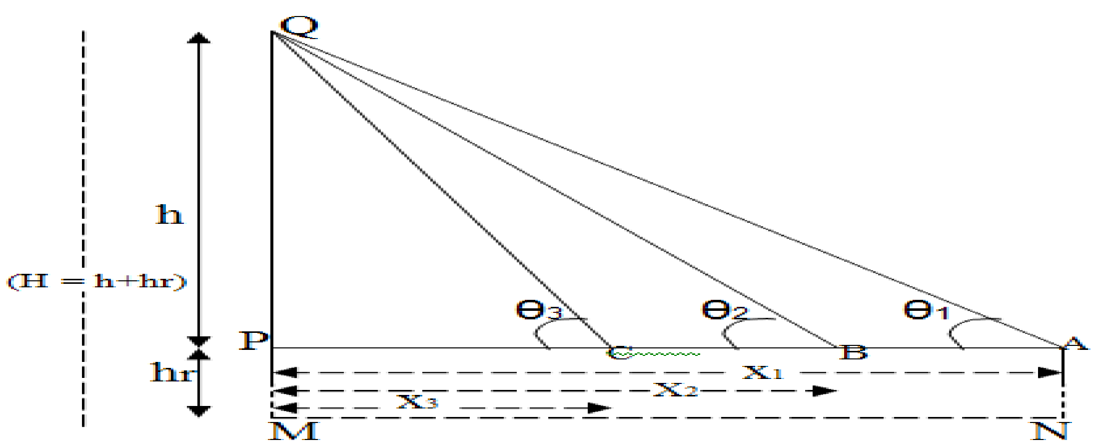

Fig-1

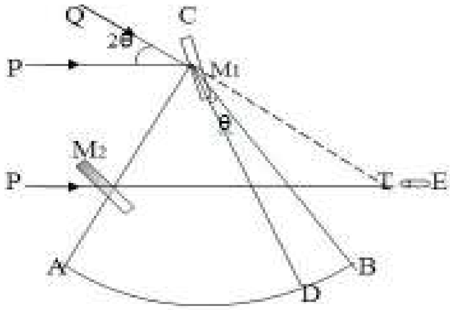

Fig-3

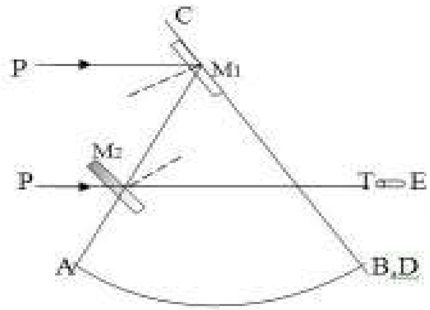

Fig-2

PROCEDURE:

1. First of all find out the least count of Main scale, circular scale and venire scale.
2. Draw a short horizontal line as a reference point P on the wall at the leave of the eye.
3. Draw another horizontal line parallel to reference line at Q by colored chalk, whose height from the ground we have to find out.
4. See the reference mark P through the transparent portion of the horizontal glass by telescope T from a distance of 4 to 5 meters away from the wall keeping the plane of the graduated circular scale vertical.
5. Now rotate the movable arm CD of the sextant till the two images of the reference mark, one seen through the transparent portion of horizontal glass and another seen on the polished portion of the horizontal glass are at the same level. In this position the reading on the scale is noted. This reading is called zero error.
6. Now rotate the index arm so that the upper portion of horizontal line moves down in the right of the field of view till the top of the object Q is seen in the right half, then adjust with the heap of venire so that the horizontal lines of different colors in the left half and right half are at the same level or coined. In this position the reading on the scale is noted. The difference of the reading and the zero reading given the angle of elevation at that observation point.
7. Take three sets of observation at different distance.
8. Now calculate the height of an object by putt up the values in formula and take the average of it.

OBSERVATION AND OBSERSERVATION TABLE:-

(A) <u>For least count of an instrument</u>

- Least count of main scale x = 1°
- Least count of circular scale = x/n = 1°/60 = 1/60*60’ = 1’
- Least count of venire scale = x’/n’ = 1’/5 = (1/300)° = 1/300*60 = 12”
- Total reading TR = MSR+CSR+VSR = MSR+(1/60)°*CSD+(1/300)°*VSD

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(B) Observation table for angle of elevation:

Sr. No.	Distance (m)	Zero error (a)				Angular Elevation (b)				Angle of Elevation (b-a)=θ
		MSR (deg.)	CSD (deg.)	VSR (deg.)	TR (a) (deg.)	MSR (deg.)	CSD (deg.)	VSR (deg.)	TR (b) (deg.)	
1.										
2.										
3.										
4.										
5.										

Where MSR – Main Scale reading
CSD – Circular Scale Division
VSD – Venire Scale Division

(C) Height of the reference mark from the ground **"Gr"** = m
(D) Actual Height of an object from the ground level **"Ha"** = m

CALCULATION:-

Determine h for every set with the help of the formula given below-

From the observation table

For point A, $x1=$ ……… m; $\theta 1=$ ……….
For point B, $x2=$ ……… m; $\theta 2=$ ……….
For point C, $x3=$ ……… m; $\theta 3=$ ……….

Now

$h1= (x1 - x2) / (\cot\theta 1-\cot\theta 2) =$ …………… = m
$h2= (x2 - x3) / (\cot\theta 2-\cot\theta 3) =$ …………… = m
$h3= (x3 - x4) / (\cot\theta 1-\cot\theta 3) =$ …………… = m
……………………………………………………………..

Calculate the mean value of h
i.e. mean $h = (h1+h2+h3+h4+h5) / 5$ (in meter)

Then height of the object is

$H = G_r+h =$ ……… + ……… = ……….

Percentage error = Actual height-Observation height/Actual height*100

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RESULT: - The height of the given object H = ………..
Actual height of an object Ha = ………...
Percentage error = %

PRECAUTIONS:-

1.)Plane of the index mirror M_1 and M_2 should be perpendicular to the plane of the arc.
2.) In the zero reading , the index mirror M_1 and the horizon mirror M_2 should be parallel.
3.) The axis of the telescope must be parallel to the planes to the plane of the graduated circular scale and must pass through the center of the horizon glass.
4.) Zero reading must be found separately at every observation point A,B,C
5.) The axis of the telescope should pass through the center of the horizon mirror M_2.

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VIVA VOCE

1.) Why the sextant is called sextant?
Ans. It consists of a rigid triangular frame being the sector of a circle having an angle of 60^0.

2.) What is the principle of sextant?
Ans. The deviation produced in a ray by successive reflections from two inclined mirrors is constant for all the angles of incidence and is twice the angle between the mirrors.

3.) What is the use of coloured glasses mounted on the sextant?
Ans.These coloured glasses work as a filters and they must be used to reduce the intensity of light specially when the measurements are made with the bright objects like the sun.

4.)what are sextant degrees and why are they so marked?
Ans. To felicitate a direct reading from the circular scale , the circular arm is graduated in half degrees and such markings are called sextant degrees.

5.) What are the uses of sextant ?
Ans. It is used for navigation purpose , determination of angular diameters of sun and moon,navigation to find latitude and longitude at a particular place.

6.)can it measure the height of the building ?
Ans. Yes ,sure.

7.) Can it measure the depth of well ?
Ans. Yes, sure

Is zero correction error in a particular instrument?
Ans. NO

How it can be used in navigation systems?
Ans. For measuring the altitudes of sun and moon.

How it helps in measuring the distances?
Ans. By finding latitude and longitudes.

How does it helps in finding terrestrial objects? Ans. By determining the verticaland horizontal distances.

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EXPERIMENT No. – 6

OBJECT: To determine the dispersive power of the material of a prism by spectrometer.

APPARATUS: Spectrometer, Prism, Spirit level, Reading lens and Mercury lamps.

FORMULA: The dispersive power of the material of a prism is given by-

$$\omega = \frac{\theta}{\delta_y} = \frac{\delta_v - \delta_r}{\delta_y} = \frac{\mu_v - \mu_r}{\mu_y - 1} \quad \text{--------------- (i)}$$

Where θ=Angle between two extreme colors

δv=Angle of minimum deviation for extreme violet color.
δr=Angle of minimum deviation for extreme red color.
δy=Angle of minimum deviation for mean yellow color.
μ_v=Refractive index of the material of a prism for extreme violet color.
μ_r=Refractive index of the material of a prism for extreme Red color.
μ_y=Refractive index of the material of a prism for yellow mean color.

Refractive index is given

$$\mu = \frac{\sin\frac{A + \delta_m}{2}}{\sin\frac{A}{2}}$$

Where A=Angle of prism. and δm=Angle of minimum deviation.

DIAGRAM:-

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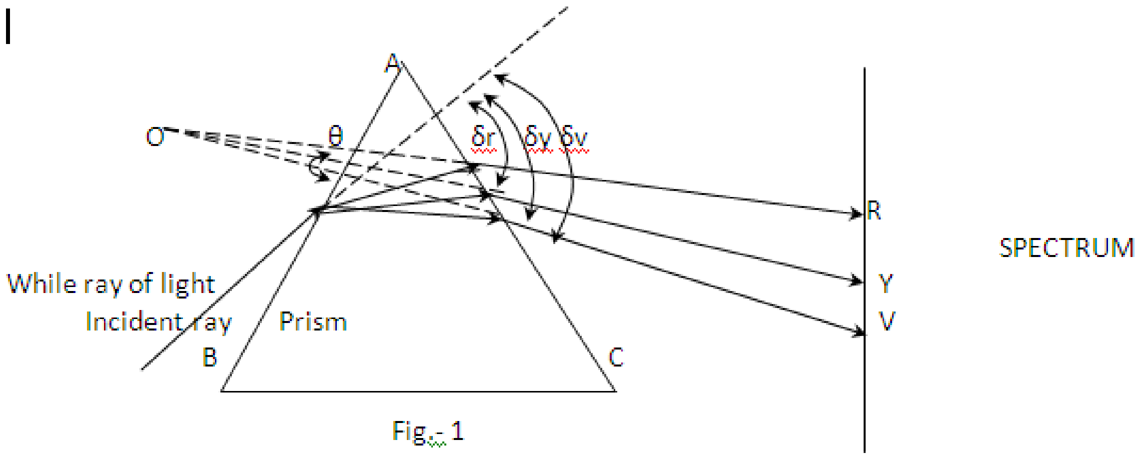

Fig.- 1

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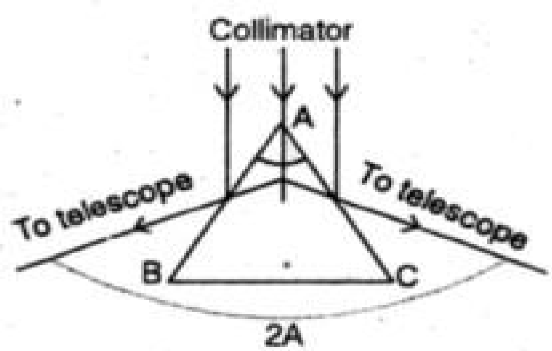

Fig.-2

PROCEDURE:

To obtain pure spectrum by spectrometer the following adjustment must be made-

- The Prism table is leveled with the help of spirit level.
- The slit of collimator should be made narrow, vertical and symmetrical on both sides.
- **Adjustment of Collimator:**
  - **(i)** It consists of a tube mounted horizontally on the arm of spectrometer.
  - **(ii)** The vertical slit consist of two sharp edges, which of them one is fixed and other can be moved parallel to it with the help of a screw.
  - **(iii)** Finally keep the collimator slit near the window of source.
- **Adjustment of Prism table:**
  - **(i)** The prism table has three leveling screws attached to its base.
  - **(ii)** The height of prism table can be adjustment by a clamping screw.
  - **(iii)** Now the position of table can be read by verniers moving on the circular scales.
- **Adjustment of Telescope:**
  - **(i)** The telescope is turned towards an illuminated source of light.
  - **(ii)** Now see through the eye piece and then adjust the distance between object and eye piece and get a well defined image of object at the cross wires.
  - **(iii)** Thus in first arrangement, the telescope is focused for parallel rays while in second, the collimator produces a beam of parallel rays.
- **Determination of the Angle of Prism:**
  - **(i)** Place the prism on prism table with its refracting edge at the centre and ground face perpendicular to the collimator axis as shown in fig.- 2.

(ii) The reflected light from each face of prism gives on image of the slit let for this see the reflected light from face on the right side.

(iii) Similarly get an image of slit on the left side formed by reflection of light from the other face of the prism and note the both readings.

(iv) The difference of these two angles will double (i.e. 2A) of prism angle.

(v) Hence repeat the process several times and find the mean value of A.

- **Measurement of Angle of Minimum Deviation:**

(i) Place the prism symmetrically at the centre of prism table with it ground face away from collimator.

(ii) Set the telescope at about 45 to axis of collimator. Now rotate prism table towards left or right through a very small angle to make a small angle to normal.

(iii) Now, rotating the prism table, spectrum will also rotate. Move the telescope also to keep the spectrum in the field of view. A stage comes when the spectrum just starts returning back. This position is minimum deviation position. At this orders VIBGYOR.

(iv) Now turn the telescope and set it cross wire on red line of spectrum. Now set the cross wire on this line and note the reading of both the verniers. Similarly set the cross wire on different colours line i.e. Yellow, Violet respectively and note the readings.

- **Direct Image:**

To obtain the direct image, remove the prism from the prism table and turn telescope to obtain direct image. Set the telescope infront of collimator as the cross wire coincide with image of slit. Note the readings of both verniers.

OBSERVATIONS AND OBSERVATION TABLE:

1. One division of M.S. x= (degree)
2. No. of division of V.S. n= ………………………
3. Least count of V.S. x/n= (degree)

(a) Table for angle of prism (A)

S. No.	Vernier Scale	Reflection from face AB				Reflection From face AC				Difference 2A= (P-Q)	Mean value 2A
		MSR (deg.)	VD (deg.)	VSR (deg.)	TR (a) (deg.)	MSR (deg.)	VD (deg.)	VSR (deg.)	TR (a) (deg.)		
1.	V1										
	V2										
2.	V1										
	V2										

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(b) Table for angle of Minimum Deviation (δm)

S.No.	Colours	Scale	Reading for Minimum Deviation Image				Reading for Direct Image				δm= a-b (deg.)	Mean δm (deg.)
			MSR (deg.)	VD (deg.)	VSR (deg.)	TR (a) (deg.)	MSR (deg.)	VD (deg.)	VSR (deg.)	TR (b) (deg.)		
1.	Red	V1										
		V2										
2.	Yellow	V1										
		V2										
3.	Violet	V1										
		V2										

CALCULATIONS: -

(i) Angle of prism = Degree.

(ii) The refractive index for different colours is given by

$$\mu_V = \frac{\sin\left(\frac{A+\delta_V}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\mu_Y = \frac{\sin\left(\frac{A+\delta_Y}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\mu_R = \frac{\sin\left(\frac{A+\delta_R}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

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(iii) Dispersive power of prism's material

$$\omega = \frac{\mu_v - \mu_r}{\mu - 1} \qquad \text{OR} \qquad \omega = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(iv) Dispersive power of crown glass $\omega_{st} = 0.015$

% error = $(\omega_{st} - \omega) / \omega_{st} \times 100\%$ ……………………….

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RESULT: -

The dispersive power of prism's material is ………, and
Percentage error = %

PRECAUTIONS:

(i) The telescope should be focused for infinity and the collimator should be adjusted to give a paralleled beam of light.
(ii) The axis of telescope and collimator, and the plane of prism table should be horizontal.
(iii) The slit should be as narrow as possible.
(iv) The prism table should be leveled as that the maximum light must fall on the entire surface of prism.
(v) At the time of observation, the telescope and the prism table should be clamed.
(vi) The telescope should be used on both verniers to note the readings.
(vii) Before observation, clean to prism and lens.
(viii) The circular scale table should be kept fixed during experiment.

VIVA-VOCE:

Q. 1. What is meant by dispersion?
Ans. When a white light's ray passes, it is separated in to rays of its constituent colours. This phenomenon is known as dispersion.

Q. 2. What is normal dispersion?
Ans. If the reflective index μ increasing with the decreasing order of wavelengths, then the dispersion is said to be normal.

Q. 3. What is anomalous dispersion?
Ans. If the refractive index is higher for longer wavelengths, then the dispersion is said to be anomalous.

Q. 4. What is angle of deviation?
Ans. The angle between the incident ray and the emergent of light is known as the angle of deviation?

Q. 5. What is the use of collimator in the spectrometer?
Ans. The collimator makes the light rays coming from the light source parallel to each other.

Q. 6. What is the type of your mercury lamp?
Ans. Mercury lamp is a hot cathode positive column type white light source.

Q. 7. What is the angle of prism?
Ans. The angle between the refracting surface of the prism is called angle of prism.

Q. 8. Which prism out of crown and flint glasses is used for better dispersion?
Ans. Flint glass, because $\omega_f > \omega_c$.

Q. 9. What do you mean by angular dispersion?
Ans. Angular dispersion of any two colours (wavelengths) is the difference between the deviations of those wavelengths (colours).

Why is Huygens's eyepiece not used in the telescope or spectrometer?
Ans. Because it does not contain cross wire for talking observations.

Q. 11. Can any other device also disperse the light?
Ans. Yes, the diffraction gratings also disperse white light.

Q. 12. Can you determine the dispersive power of a prism using sodium light?
Ans. No, this is not possible because sodium light is quasi-monochromatic light and emits onl two yellow lines.

Q. 13. On what factors does it depend?
Ans. It depends on the nature of material and on the wavelength for which it is determine.

Q. 14. What is the best source of light for determine dispersive power of prism?
Ans. Neon lamp. Because it emits the light in all regions of the visible spectrum.

Q. 15. How does a ray pass through a prism at minimum deviation?
Ans. Inside the prism the ray passes parallel to the base of the prism.

Q. 16. What are the names of the seven colours of sunlight spectrum?
Ans. The seven colours are- Violet, Indigo, Blue, Green, Yellow, Orange and Red (VIBGYOR).

Q. 17. Does the deviation depend on the angle of prism?
Ans. Yes, greater the angle of prism more is the deviation.

Q. 18. Does the deviation depends on the colours?
Ans. Yes, the deviation is less for red then for violet light.

Q. 19. What is eye-piece?
Ans. Eye-piece is a magnifier designed to give more perfect image then obtained by a single lens.

Q. 20. Does the deviation depends on the length of prism's base?
Ans. No, it is independent of the length of base.

Q. 21. Will the angle of minimum deviation change, if the prism is immersed in water.
Ans. Yes, the refractive index of glass in water is less then in air. Hence the angle of minimum deviation is less.

Q. 22. What is the working temperature of a mercury lamp?
Ans. The working temp. of mercury lamp is a approximately 6000ºC.

Q. 23. What is the construction of Ramsden's eye-piece?
Ans. Ramsden's eyepiece consists of two Plano concur lenses each of focal length *f* separated by a distance equal to 2*f*/3.

Q. 24. How does refractive index μ vary with wavelength?
Ans. Higher is the wavelength, smaller is the refractive index.

Q. 25. Do the light rays of different colours travel with the same velocity in air?
Ans. In air, the light rays of different colours travel with the same velocity.

Q. 26. What is normal spectrum?
Ans. When the rate of change of the deviation with wavelength of light ($d\delta/d\lambda$) is same for all parts of spectrum, then the spectrum is said to be nor

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EXPERIMENT No. – 7

Object: - To study the charging and discharging of a capacitor and hence determine time constant.(both current and voltage graphs are to be plotted.)

Apparatus: - Connecting Leads, D.C. Source Battery, Resistance of various values R_1, R_2, R_3, Condensers of different capacities (C_1, C_2, C_3), Millimeter, Voltmeter keys, Stopwatch etc.

Theory & formula: -

i) Time constant (t) in the circuit at any time t is given by:

(a) Voltage during charging at t = RC = T

$$V_c(t) = V_o[1-e^{-t/t}] = V_o[1-e^{-1}] = V_o(1-1/e)$$

$$V_c(t) = V_o[1-1/2.718] = 0.63V_o \qquad (1)$$

(b) Voltage during discharging at t = RC = T

$$V_c = V_o\, e^{-t/RC} = V_o\, e^{-1}$$

$$= V_o.(1/2.718) = 0.37V_o \qquad (2)$$

ii) Time constant (t) in the circuit at any time t is given by:

(a) Current during charging at t = RC = T

$$I(t) = I_o\, e^{-t/RC} = I_o\, e^{-1}$$

$$=- I_o\,(1/2.718) = 0.37\, I_o \qquad (3)$$

(b) Current during discharging at t = RC = T

$$I(t) = I_o\, e^{-t/RC} = I_o\, e^{-1}$$

$$=- I_o\,(1/2.718) = -0.37\, I_o \text{ -------------------}$$

Q = Charge on condenser in coulomb.

$V_c(t)$ = Voltage across condenser in volt.

I(t) = Current in the circuit in ampere.

R = Resistance in the circuit in ohm (Ω).

C = Capacity of a condenser in farad.

Q_o,V_o,I_o = Maximum charge, Voltage and Current respectively.

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t = RC = T = time constant in second.

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Circuit diagram:-

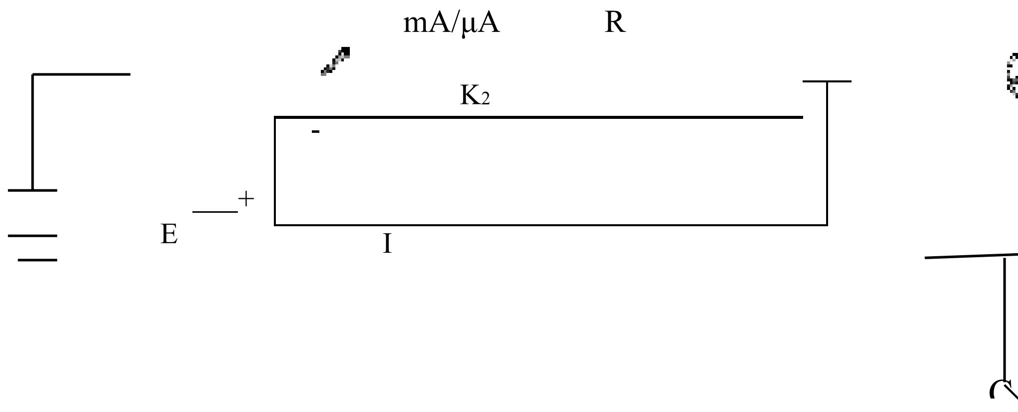

Fig.- 1 Circuit Diagram

Where

E = EMF of the battery; K_1, K_2 = One way key
R = Resistance in circuit; C = Condenser in circuit RC = Circuit; I = Current in circuit

Procedure:-

During Charging Time-

1. Make connections as shown in figure- 1.
2. The value of resistance R and Condenser c are so selected that the time constant RC is large (Approximately RC= 50 or 100 Seconds).
3. When key K is pressed/ON, current in the circuit gets started. Condenser starts charging. The stop watch is also started simultaneously to note time.
4. The reading of the Voltmeter (Vc) is noted after every 20/25 seconds till it becomes almost constant. [Vc(t)*t]
5. The condenser can be discharging by taking plug outside the key K and connect Q to P. ie making short circuit and the step 4 is repeated. ie Vc(t) is noted for discharging of condenser.
6. Now repeat the step 3 and 4 and note the readings in ammeter (multemeter) instead of voltmeter for same set of time. This given current I(t) during charging of condenser. [I(t) Vrs t]
   This can also be achieved by formula I(t) = Vc(t)/R.
7. Now repeated step 5 and note readings on ammeter for the same set of time. This given current during discharging of condenser.
8. Steps 3 and 4 can be repeated if we want to take voltage, across resistance R [$V_R(t)$] during charging time and step 5 can be repeated for discharging of a condenser and various readings can be taken.

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Observation:-

Least count of a Voltmeter = x/n = …………… = Volt.

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Values of V_0 = Volt
R = ohm
C = Farad

(A) Table for values of voltage across C in time t [Vc(t)] :-

S. No.	Voltage during Charging		Voltage during Discharging	
	Time (t) in second	Vc(t) in Volts	Time (t) in second	Vc(t) in Volts
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

(B) Table for current across R in time t [Table for values I(t) in time 't'.] :-

S. No.	Current during Charging I(t)		Current during Discharging I(t)	
	Time (t) in second	I(t) (Amp.)	Time t (Sec.)	I(t) (Amp.)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Calculation:-

(i) Plot a graph between Vc(t) versus t while charging and discharging of a condenser. Determine the maximum voltage Vo (where readings got stable). Calculate Vc(t) =
0.63 Vo and Vc(t) = 0.37 Vo from the graph of charging of condenser find the time corresponding to this value 0.63 Vo.

(ii) Similarly the time corresponding to 0.37 Vo on the graph of discharging of condenser must be obtained. This should also be equal to time constant T= RC, as shown fig.- 6.

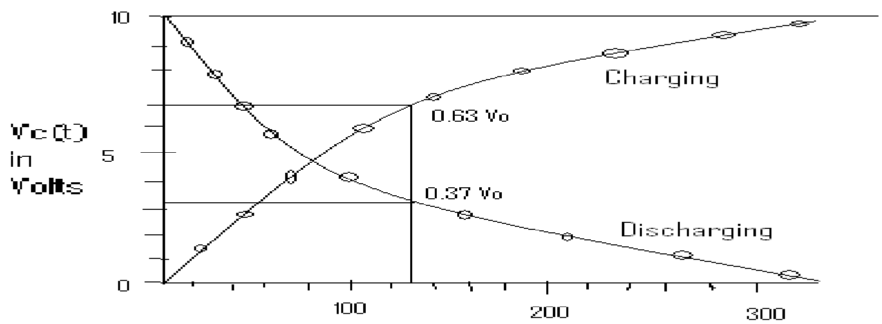

Fig.- 6 Variation in voltage for charging and discharging of Condenser.

(iii) Now plot a graph I and t. From I(t)-t graph for charging of condenser time corresponding to 0.37 Io (maximum current) should be noted. Further for I(t)-t graph for discharging of condenser the time corresponding to 0.63 Io should be noted. Both these timing should match the theoretical value of time constant Tc= RC. As shown in fig.- 7.

Fig.- 7 Variation in current for charging and discharging of a Condenser.

From graph
i) From Vc(t) and t
Tc1= (t1+t2)/2 = Sec
ii) From I(t) and t
Tc2= (t1+t2)/2 = Sec

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iv) Average Tc= (Tc1 +Tc2)/2 = Sec

Theoretical value of time constant Tc= RC = ……. * Sec

Percentage error= (Theoretical value of Tc - Experimental value of Tc) / Theoretical value of Tc * 100 = %

Precautions:-

1. The values of resistance R and capacity C must be so chosen that the time constant of circuit in large ie = 100 to 200 Sec.
2. It is not possible to take voltmeter reading and ammeter reading simultaneously. Hence voltmeter and ammeter reading should be taken one after the other.
3. While discharging the condenser, current decreases quite quickly. Therefore, note current reading quickly and accurately.
4. The reading of stopwatch should be taken very carefully.
5. As the stopwatch is not synchronized with the apparatus, we should be more careful in manual reading.

VIVA- VOCE

Q. 1. What is condenser?
Ans. It is a pair of conductors of opposite charges, on which sufficient quantity of charge may be accommodated.
Q. 2 Define the capacity of condenser?
Ans. The capacity of a condenser is numerically equal to that electric charge which raises its potential by unity.
Q. 3. What is the unit of capacity?
Ans. The unit of capacity is farad.
Q. 4. What is time constant of R-C circuit?
Ans. The product R-C is called time constant of the circuit. It is equal to the time taken by the condenser to raise its charge to 0.63 of its maximum value.
Q. 5. Can you define time constant in terms of discharge of capacitor?
Ans. yes. It is equal to time taken by condenser to reduce its charge to 0.37 of its maximum value.
Q. 6. What value of time constant will you choose if quick discharge is desired?
Ans. Low value of RC.
Q. 7. Mention the factors on which the capacity of a condenser depends?
Ans. It depends upon the following factors-
(a) Shape or area of the plates.
(b) Distance between the plates.
(c) Dielectric medium between the plates.
Q. 8. What will happen if R is reduced to zero in an RC circuit?
Ans. The charging or discharging will take place instantly.
Q. 9. What is the function of a dielectric?
Ans. It increases εr times the capacity of a condenser, where εr is the dielectric constant of the medium. It can be defined as-
ε_r = permittivity of medium / permittivity of vacuum or air = $\varepsilon / \varepsilon r$ It is a dimensionless quantity and is different for different media.
Q. 10. Mention one important application of RC circuit?
Ans It is used to quench the discharge in nuclear detectors specially in given counter.
Does any other current correspond to charging and discharging of a capacitor?
Q11. Which current flows through capacitor?
Ans. Yes, it is called as displacement current. Due to time varying electric field between the plates, an electric current also flows across the space between the plates of a condenser. This current is known as the displacement current and is defined as
$I_D = (\varepsilon_0)d\o/dt = (\varepsilon_0 A)dD/dt$.

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Experiment No-8

OBJECT :- To determine the coherent length and coherent time of laser using He-Ne Laser.

APPARATUS :- Optical Bench, LASER Source, Optical Screen, Diffraction Gratting

THEORY AND FORMULA:-The wave length λ of any spectral lines can be calculated by

the formula : $$(e+b)\sin\theta = n\lambda$$

$$\text{or } \lambda = \{(e + b)\sin\theta\}/n$$

where $(e + b)$ = grating element

θ = angle of diffraction

n = order of the spectrum

Coherent length L_c is given by

$$L_c = \lambda^2/\Delta\lambda$$

For He-Ne Laser $\Delta\lambda$ = 0.01 Å

(given) and coherent time τ_c is given by

$$\tau_c = L_c / c$$

Where c is velocity of light

DIAGRAM:

Figure:- Energy Level Diagram of He-Ne LASER

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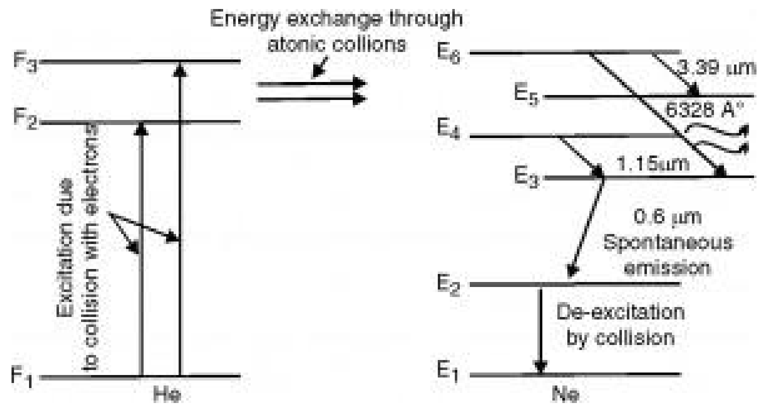
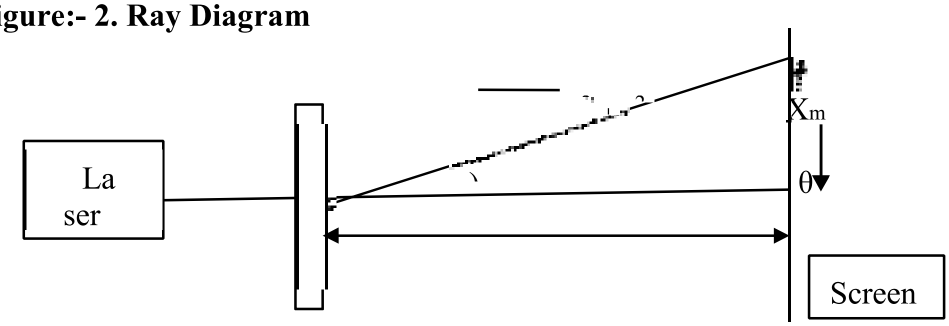

Energy exchange through
atonic collions
F3
F2
F1
Excitation due
to collision with electrons
He
E6
E5
E4
E3
E2
E1
3.39 μm
6328 A°
1.15μm
0.6 μm
Spontaneous
emission
De-excitation
by collision
Ne

Figure:- 2. Ray Diagram



PROCEDURE :-

On the optical screen well defined spectrum is obtain. In the middle of it there is a central maxima and on its either side there are formed maxima of increasing order. The distances of maximas of different order from central maxima are noted from the graph paper of optical screen and noted in observation table. The positions of riders of grating and optical screen are also noted.
Thus one can observe and record the profile of the LASER spectrum at screen.

OBSERVATION :-

(1) Position of rider of diffraction grating $x_1 =$ cm

(2) Position of rider of optical screen $x_2 =$ cm

$X = x_2 - x_1 =$ cm

No. of lines on grating (N) = LPI

OBSERVATION TABLE :-

S.No.	Distance between Grating & Screen f (cm)	Order of Maxima	Distance from zeroth order x_m (cm)			$\sqrt{(x^2_m + f^2)}$ (cm)	$\sin\theta = [x_m/\sqrt{(x^2_m+f^2)}]$
			R.H.S. (cm)	L.H.S. (cm)	Average x_m (cm)		
1.		I					
		II					
2.		I					
		II					
3.		I					
		II					

CALCULATION :-

(i) Calculation of grating element :

No. of lines on grating N = (LPI)

Grating element (e + b) = 2.54/N = cm

(ii) Calculation of λ

$$\lambda = [(e + b)\sin\theta]/n$$

Using this formula calculate λ for 1st and 2nd order of spectrum. Calculate mean wave length.

$$\lambda = (\lambda_1 + \lambda_2)/2 = \quad \text{cm}$$
$$= \quad \text{Å}$$

Calculation of coherent length

$\Delta\lambda$ = 0.01 Å (given)

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$\Delta l = \lambda^2/\Delta\lambda$, Coherent Time $\tau = \Delta l/C$

RESULT :-

The wavelength of He-Ne LASER is λ = ……… Å

Coherent length of Laser = ……. Å

Coherent Time of Laser = …..

sec. Standard value of λ = 6328 Å

PRECAUTIONS :-

1. Height of LASER source, slit, lens, grating and optical screen on all riders should be same.
2. All riders must be aligned along one common axis.
3. Slit, grating and optical screen should be vertical and parallel to each other.
4. Grating should be fixed for normal incidence.

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VIVA-VOCE

What is Laser

Ans. It is a device to produce a strong monochromatic, collimated and highly coherent beam of light.

What is meant of laser?

Ans. The word LASER is an acronym for "Light Amplification by Stimulated Emission of Radiation".

What is the principle of laser?

Ans. The laser works on the principle of stimulated emission or induced emission. It emits coherent light by population inversion

What is the difference between mercury source and laser source?

Ans. Comparison between Mercury Source and Laser Source

(a) Light emitted from mercury light source is all direction while laser source produces light emitting in only one direction.

(b) When mercury light passes through the grating it produces line spectrum while light from laser sources produces spots.

(c) Laser source higher order maxima can observed but mercury source have limit up to second order maxima.

Is He-Ne laser is four energy level laser system? Ans. Yes, He-Ne laser is four energy level system.

Give an example of three level laser.

Ans. Ruby laser

Define the coherence time.

Ans. The average time interval for which the field remains sinusoidal (means definite phase relationship exists) is known as "coherence time" or temporal coherence" of the light beam .

Define the coherence length.

Ans. The average length of wave trains for which the field is sinusoidal is known as "coherent length" or "longitudinal coherent length".

Mention the basic characteristics of laser light source.

Ans. Laser light is monochromatic, high intense, directional and coherent.

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What do you mean by solid angle?

Ans. The angle subtended by an area to a certain point is called solid angle.

Solid angle $\omega = A/r^2$

What is wavelength of light emitted from He-Ne laser?

Ans. The wavelength of light emitted by He-Ne laser is 6328 Å.

What do you mean by spontaneous emission?

Ans. This is a process in which a light source such as an atom molecule or nucleus in an excited state undergoes a transition to a state with a lower energy, e.g. the ground state and emits a photon.

Whit do you mean by stimulated emission?

Ans. In this process, a photon interacts with the atom in an excited state., and two atoms drop to a lower energy level. A photon created in this manner has the same phase, frequency, polarization and direction of travel as the photon of the incident wave.

What do you mean by 'Population Inversion'.

Ans. It means number of atoms in higher energy level greater than the number of atoms in lower energy level.

Which is the active gas in He-Ne gas laser?

Ans. Ne gas

Define metastable state.

Ans. In a state that is not truly stationary but is almost stationary. The life time of metastable in unusually long (10^{-3} Sec.).

What type of pumping source we use in He-Ne gas laser?

Ans. Electric discharge.

What is the role of diffraction grating in your experiment? Ans. It diffraction the incident laser light

How many orders do you achieve in your experiment?

Ans. 2 order.

In which state stimulated emission takes place in He-Ne gas laser?

Ans. $E_6 \rightarrow E_3$

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Experiment No.9

OBJECT: - To measure the Numerical Aperture of an Optical Fiber.

APPRATUS: -Laser source, Laser power supply, Optical Fiber, Two holder for optical fibre with uprights, screen, optical bench

THEORY AND FORMULA:-

If a light ray is incident an one of the fiber at an angle of α with the normal. Then it follows from the Snell's law

$$n_0 \sin\alpha = n_1 \sin\beta = n_1 \sin(90-\gamma) = n_1 \cos\gamma$$

where n_0 is the refractive index of the medium outside. The optical fiber n_1 and n_2 are the refractive index of the material of the core and the cladding then for angle of incidence γ at the cladding layer $\gamma \geq i_c$

Hence $\cos\gamma \leq \cos i_c$

or $\leq \sqrt{(1-\sin^2 i_c)}$

or $\leq \sqrt{[1-(n_2/n_1)^2]}$ as $\sin i_c = n_2/n_1$,

or $n_1 \cos\gamma \leq \sqrt{[(n_1)^2 - (n_1)^2]}$

or $n_0 \sin\alpha \leq \sqrt{[(n_1)^2 - (n_1)^2]}$

at angle of critical incidence (i_c)and numerical aperture (NA) of the fiber is given by

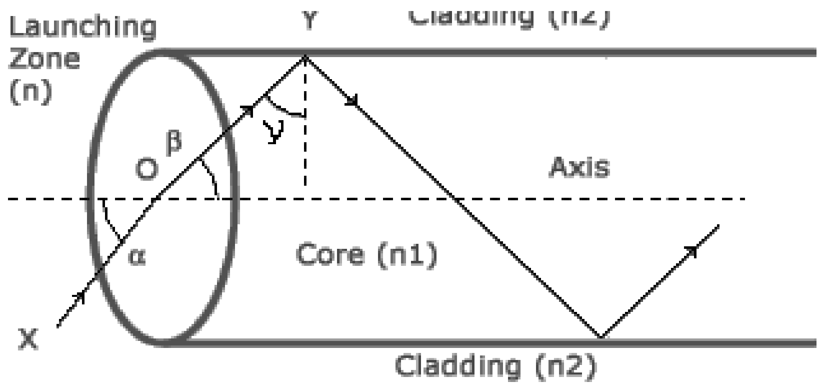
$$NA = \sqrt{n_1^2 - n_2^2}$$

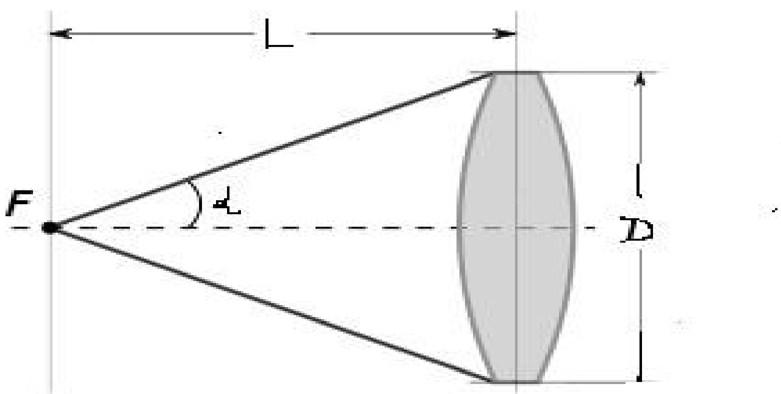
As $n_0 = 1$in air, NA= sinα

$$NA = \frac{D}{\sqrt{\;}}$$

Where D is Diameter of the circle and L is the Distance between screen & optical fiber cable.

Figure:-





PROCEDURE:-

Measurement of Numerical Aperture –

1. Switch on the laser source and adjust it properly so as to focus the laser on one end of the optical fibre

2. Keep a white screen with concentric circles in a vertical position with radii
   05,7.5,10,12.5,15…..mm) .

3. Adjust the distance of the screen so that the spot coincide with one of the concentric circles

4. Distance f of white screen from the optical fiber end are measured, when light spot coincides with one of the concentric circle of diameter D.

5. Calculate the numerical aperture.

OBSERVATION TABLE:-

S.No.	f (cm)	D (cm)	NA	θ (degree)
1				
2				
3				
4				
5				

CALCULATIONS:-

Compute NA from the formula

Numerical Aperture = $D/\sqrt{(4f^2 + D^2)} = \sin\theta$

RESULT: - The Numerical Aperture of given optical fiber (at 632.8 nm wave length) =.......

PRECATIONS:-

1. Attach the fiber optical cord properly.
2. Distinguish the outer and inner pink light spots and thus make measurement of D.
3. Make sure that the wave length selected is 660mm. As the wave length 850mm corresponds to IR rays and defection mechanism for which is altogether different.

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VIVA –VOCE

1. What is optical fiber?

Ans. Optical fiber is a ultra –thin cylindrical wavelength made of fiber glass/plastic through which optical or microwave single can be transmitted.

2. On what principle it is based?

Ans. It is based on the principle of total internal reflection.

3. What are the various parts of the optical fiber?

Ans. Optical fiber consists of three parts:
Core: It is the innermost region having diameter of the order of few micron.
Cladding: Core is surrounded by a material of slightly lower refractive index called cladding.
Protective jacket: Cladding is surrounded by another layer called jacket. It is made of plastic or polymer.

4. What is the purpose of cladding?

Ans. Cladding makes the light to confine within the core that is why the refractive index of cladding is always kept lower then that of the core.

5. What is the purpose of protective jacket?

Ans. The protective jacket provides protection agnist moisture, crushing and other environmental damages.

6. Why ultra pure glass is required in the manufacture of optical fiber ?

Ans. Because a tiny impurity in the fibre could cause the light pulse to lose its power.

7. What is numerical aperture?

Ans. It us measure of amount of light that can be accepted to pass through the fiber.

8. On what factors it depends?

Ans. It depend s only on the refracture index of core and cladding materials.

9. What is acceptance angle?

Ans. Acceptance angle α =sine$^{-1}(\sqrt{n^2 1 - n^2 2})$.This angle is a measure of light gathering power of the optical fiber.

10. What are the characteristic features of optical fiber?

Ans. (i) Extremely low of attenuation
(ii) Flexibility
(iii) High capacity of transmitting information
(iv) No signal leakage
(v) Total immunity to of external damages
(vi) Small size and weight

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11. What is core?

Ans. The light- conducting central portion of an optical fiber, composed of material with a higher index of reflection then the cladding. The portion of the fiber that transmits light.

12. What is cladding?

Ans. Material surrounds the core of an optical fiber .Its lower index of reflection, compared to that of the core, causes the transmitted light to travel down the core.

13. What is coating?

Ans. The material surrounding the cladding of a fiber. Generally a soft plastic material that protects the fiber from damage.

14. What is physical meaning of 'numerical aperture'?

Ans. It means light gathering capacity

.

15. Why ordinary light is incoherent?

Ans. Normally, spontaneous emission dominated stimulated emission.

16. What type of information can be sent through fiber optic cable?

Ans. Through fiber optic cables video, audio speech, text material and computer data can be transmitted.

17. What are the applications of optical fiber?

Ans. Optical fiber are widely used in fiber-optic combination, which permits remission over longer distance and at higher data rates that other form of communications . Optical fibers are also used to form sensors and a variety of other applications.

18. What is multimode fiber?

Ans. Fiber which supports many propagation paths or transverse modes are called multimode fiber MMF). Multimode fibers generally have a large –diameter core, and used for short-distance communication links or for applications where high power must be transmitted.

19. What is single mode fiber?

Ans. Fibers which support only a single mode are called single mode fiber (SMF) Single mode fibers are used for most communication links that 200 meters.

20. What are differences between optical fiber cable and copper cable?

Ans. Traditional copper cable transmits information by means of electrons. Where in fiber optic cable the information is transmitted in the form of light signals.

21. What is the relation between relative refractive index difference (Δ) and numerical aperture (NA)?

Ans. $N.A. = n_{core}\sqrt{2\Delta}$.

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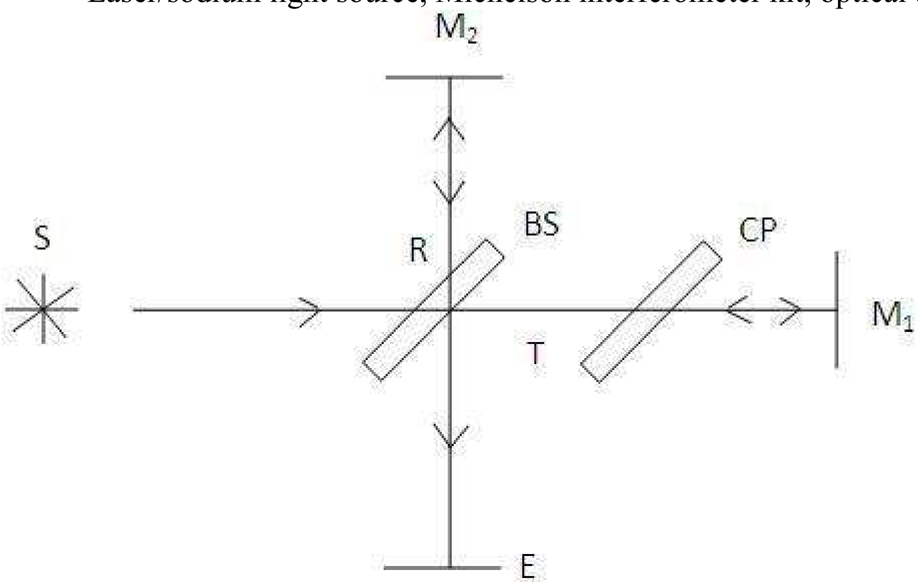
Experiment No.10

Object :

To determine the wavelength of a laser using the Michelson interferometer.

Apparatus:

Laser/sodium light source, Michelson interferometer kit, optical bench, meter scale.



n a monochromatic source can be
s appear or disappear at the centre.
umber *N* of fringes appearing or
ust be moved

Fig. 1

$$\lambda = \frac{2d}{N}$$

Procedure for performing the real lab:

- The laser beam must strike at the center of the movable mirror and should be reflected directly back into the laser aperture.
- Adjust the position of the beam splitter so that the beam is reflected to the fixed mirror.
- Adjust the angle of beam splitter to be 45 degrees. There will be two sets of bright spots on the screen, one set from the fixed mirror and another from the movable mirror.
- Adjust the angle of the beam splitter to make the two sets of spots as close together as possible.
- With the screws on the back of the adjustable mirror, adjust the mirror's tilt until the two sets of spots on the screen coincide.
- Expand the laser beam slowly by rotating the collimating lens in front of the laser.
- Align the laser with the interferometer and make certain that the fringes are moving when the micrometer screw is turned.
- Mark a point on the screen and note the micrometer reading.
- As the screw is moved, the fringes begin to displace. Count the number of fringes N that move past the mark (either inward or outward). To avoid the effects of backlash in the micrometer screw, turn the micrometer handle one full turn before starting the count.
- Note the micrometer readings at the beginning and end of the count. Calculate the distance d' the mirror is moved, according to the beginning and ending micrometer readings. Repeat the procedure several times. Average the readings.
- With a known wavelength laser, use $\Delta d = N\lambda/2$ to calculate the actual distance moved. Once the calibration constant is known, if the laser source has an unknown wavelength, it can be calculated with the same equation.

Observations :

Least Count =   cm
Calibration constant of the apparatus= ....
No: of fringes, N =..........

Distance moved for N fringes, Δd =   cm.

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Observation Table :

S. No.	No. Of Fringes (N)	Distance (Cm) D			Difference in Distance (Cm) Δd
		M.S	C.S.	T.R.	
1					
2					
3					
4					
5					

Result:

The wavelength of the given laser source = nm.

Precautions:

1. Avoid touching the face of the front-surface mirrors, the beamsplitter, and any other optical elements!
2. The person turning the micrometer should also do the counting of fringes. It can be easier to count them in bunches of 5 or 10 (i.e. 100 fringes = 10 bunches of 10 fringes).
3. Use a reference point or line and count fringes as they pass.
4. Before the initial position X1 is read make sure that the micrometer has engaged the drive screw (There can be a problem with "backlash"). Just turn it randomly before counting.
5. Avoid hitting the table which can cause a sudden jump in the number of fringes.

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VIVA-VOCE

1. What do you mean by interferometer ?

Ans. Interferometer is a device used to determine the wavelength of light which is based on the phenomenon of interference.

2. What type of glass plats G_1 and G_2 are ?

Ans. The glass plats G_1 and G_2 are optically plane glass plates of thickness and of the same material.

3. What is the function of the semi silvered glass plate ?

Ans. This plate divides the amplitude of incident wave in two parts by partial reflection and partial transmission.

4. How interference fringes are produced by Michalon's interferometer ?

Ans. Due to phenomenon of partial reflection and partial refraction and by division of amplitude of incident wave interference fringed are produced.

5. Are two mirrors used in Michelson interferometer experiment simply plane mirrors

? Ans. Mirrors are optically plane and highly silver polished plane mirrors.

6. Where is thin film formed in this apparatus ?

Ans. It is formed between the mirror M_1 and the image of the mirror M_2.

7. Where the circular fringes are formed ?

Ans. Circular fringes are formed at infinity and can be seen by telescope.

8. Why the monochromatic light is preferred in this experiment ?

Ans. Monochromatic light is preferred to obtain circular fringes which are bright and dark.

9. What are localized fringes ?

Ans. When two mirrors are not exactly perpendicular to each other. In such case straight or parabolic fringes are observed. These fringes are called localized fringes.

10. What changes will appears if the white light source is used ?

Ans. With white light source, we observed a central white fringe and some coloured fringes symmetrically on the both side of the central fringes.

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Experiment No.11

Object: To determine the specific resistance of a given wire with the help of Carey foster's bridge.

Apparatus: Carey Foster's Bridge, Laclanche cell, galvanometer, a rheostat of low resistance (or two one ohm coils), decimal resistance box, copper strips, a key, a resistance of known length..

Theory and Formula:

$$Y = X + \rho(l_1 - l_2)$$

Where Y is the unknown resistance X is the known resistance (from resistance box), ρ is the resistance per unit length of bridge wire and l_1 and l_2 are the balancing lengths from left side when resistance box is in left side and right side respectively.

1. When Y=0 (copper strip) and X=R_1 (from resistance box)

$$\rho = \left(\frac{R_1}{l_2 - l_1}\right)$$

2. When Y = resistance of unknown resistance wire and X = R (from resistance box), the respective balancing lengths are l_3 and l_4.

$$\therefore Y = R + \rho(l_3 - l_4)$$

$$Y = R + \frac{(l_3 - l_4)R_1}{(l_2 - l_1)}$$

The specific resistance of a wire

$$K = Y\frac{\pi r^2}{l}$$

Where r and l are the radius and length of a resistance wire.

Figure1: To determine the resistance per unit length of the bridge wire

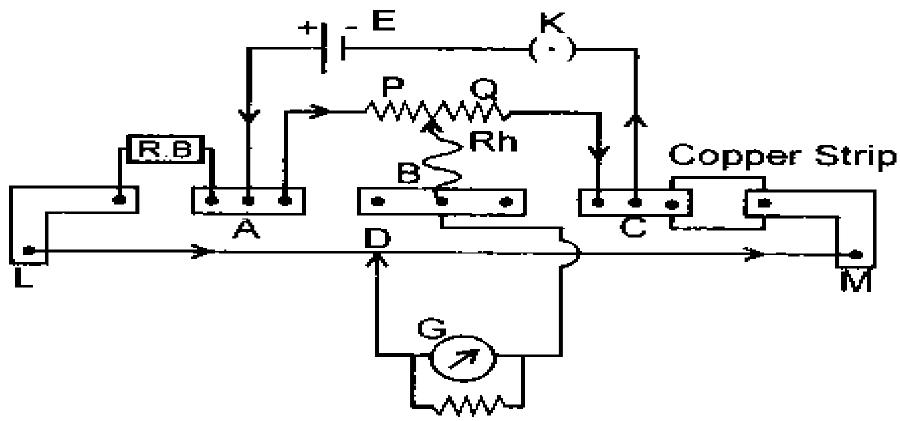
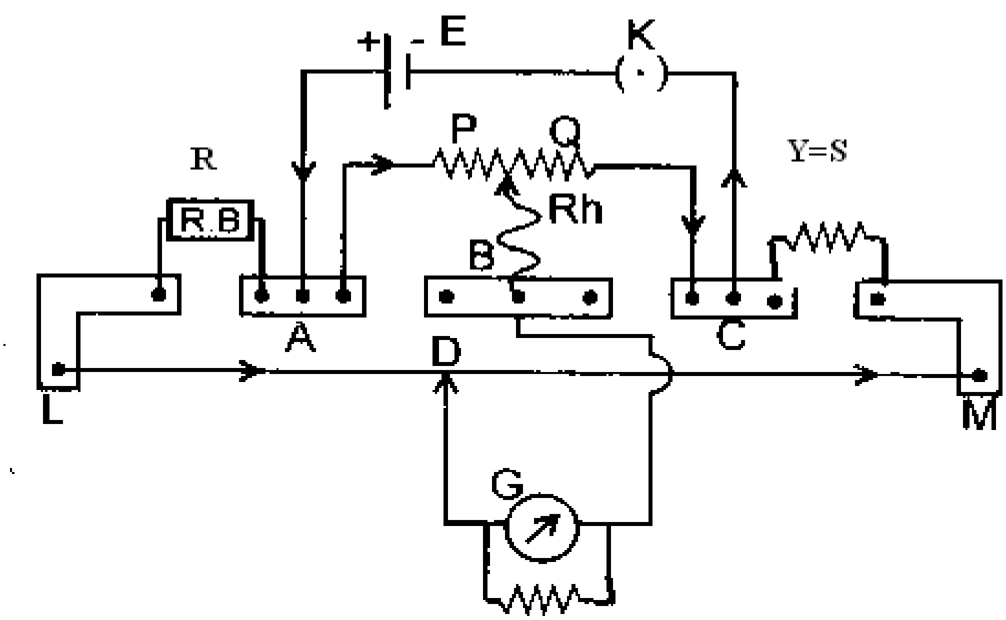

E
K
P
Q
Rh
R.B
B
Copper Strip
A
C
D
L
M
G

Figure2: To determine the resistance of unknown wire



Observation table:

(A) Determination of ρ:
(B)

S.No.	Resistance introduced in R.B. R_1 (ohm)	Position of null point when resistance R_1 is		(l_2-l_1) (cm)	$\rho = \left(\frac{R_1}{l_2 - l_1}\right)$ Ohm/cm
		In left gap l_1 (cm)	In right gap l_2 (cm)		
1					
2					
3					
4					
5					

Mean ρ = ohm/cm

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(C) Determination of resistance Y :

S. No.	Resistance introduced in R.B. (R)ohm	Position of null point when resistance R is		(l_3-l_4) (cm)	$Y = R + \rho(l_3 - l_4)$ (ohm)
		In the left gap l_3 (cm)	In the right gap l_4 (cm)		
1					
2					
3					
4					
5					

Mean Y = ohm

(D) Length of wire l = cm.

(E) Determination of radius of wire :

1. Pitch of the screw gauge (one division of main Scale) x = Cm
2. Total no. of division on circular Scale -------------------- n = ……………

3. Least count of the screw gauge -------------------------- x/n=… cm

S. No.	Diameter of wire in						Mean diameter (mm)
	One direction			Perpendicular direction			
	MS (mm)	CSD(mm)	TR (mm)	MS(mm)	CSD (mm)	TR (mm)	
1							
2							
3							
4							
5							

Mean diameter = mm
Mean radius r = mm
Mean radius r = cm

Calculations:

(a) ρ = …………. Ohm/cm; (b) Y = Ohm
(c) l = …………. cm (d) r = cm

$$K = Y\frac{\pi r^2}{l}$$ =………………………

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Result:

Specific resistance of the material of a wire K = Ohm-cm.
Standard value : Manganin K = 42 X 10^{-6} ohm-cm
Nichrome K = 103 X 10^{-6} ohm-cm
Percentage error =……………

Sources of Errors and Precautions:

1. While making connections see that undue resistances due to loose contacts or some coating on the ends of the connecting wire, do not get involved in the experiment.
2. The resistance of the four arms of the bridge must be of the same order to achieve high sensitivity.
3. The cell key must be closed only when observations are to be taken. Unnecessary flow of current will cause heating of the wire and will change the resistance per unit length of the wire.
4. The wire is assumed to be uniform with a constant value of ρ throughout the length of the wire. The value of R while determining ρ should therefore change for different sets so that $(l'_2 - l'_1)$ covers practically the whole length of the wire. The value of ρ thus determined will be the average value for the whole wire and the error due to uniformity of wire will be minimized.
5. The value of R while determining ρ and the value of (X-Y) while determining the unknown resistance should not exceed the resistance of the whole length of the wire.
6. When the bridge is out of balance a shunt should always be used with the galvanometer, but for finding the exact balance point the shunt must be removed.
7. The jockey should be pressed gently and it should not be used keeping it pressed. This will introduce non-uniformity in the wire.
8. To increase the accuracy the balance point must be near the middle of the wire.
9. The unknown resistance wire should not be directly connected between the terminals as every time when the connections are interchanged a different length of wire will be coming in between the terminals. The ends of the wire should be soldered to two copper strips and connections should be made by these strips.

VIVA-VOCE

1. What is the difference between a meter bridge and a Carey-Foster's bridge?
Ans**.** Both bridges are based on the principle of wheat stone's bridge. The accuracy and sensitivity of the meter bridge is increased by modifying it to Carey-Foster's bridge.

2. What type of wire is used in this bridge?
Ans**.**The bridge wire is made of managing since it has uniform area of cross-section.

3. Why it is necessary to measure the average resistance per unit length?
Ans**.** Due to non-uniformity in the cross-section of the bridge wire, the value of ρ is different at different portions of the wire. Therefore the average value of ρ is considered.

4. Why the null points are taken at the extremities of the bridge wire?
Ans**.** When the null points lie at the extremities, the difference (l2-l1) is fairly large and the measurement of resistance is more accurate.

5. Does the presence of end errors affect the result?
Ans**.** While deriving the formula the end error cancelled and therefore the measurement is independent of end errors.

6. What should be the values of the resistance used in the inner gap?
Ans. Their values must be nearly equal foe maximum sensitivity of the bridge wire.

7. What will happen if current is passed for a long time in the bridge wire?
Ans**.** The resistance of the bridge wire will change due to continuous flow of current and therefore the null point will shift.

8. What do you mean by the resistance of a conductor?
Ans. The ratio of the potential difference between the ends of a conductor to the current flowing in it is called the resistance of the conductor.

9. On what factors does it depend?
Ans**.** Resistance of a conductor is directly proportional to its length (l), inversely proportional to the area of cross-section (A). It also depends upon the nature of material and temperature of the conductor.

10. What is specific resistance?
Ans. Specific resistance of a substance is defined as the resistance of a piece of that substance having unit length and unit area of cross-section.

$$K = RA/l$$

If A= 1 and l= 1, then K= R

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11. What is the unit of specific resistance?

Ans. K= RA/l ohm- ^{2}/metre ohm-metre Thus the unit of specific resistance is ohm-metre. metre

12. Is specific resistance same for all materials?

Ans. No. It depends on the nature of the material. Hence it is different for different materials.

13. What is the effect of temperature on resistance? Ans. It increases with increase in temperature.

14. What is the minimum difference in resistance that can be measured with this bridge? Ans. It is equal to the resistance of the one metre length of the bridge wire.

15. What is the maximum difference in resistance that can be measured with this bridge?

Ans. It is equal to the resistance of the Total length of the bridge wire.

16. What is the working principle of Carey-Foster's bridge?

Ans. When the resistance in the outer gaps of the bridge are interchanged, the position of null point shifts. This difference in the value of two resistance is equal to the resistance of that much length of the bridge wire by which the null point has shifted.

17. What will happen if the two resistance in the inner gaps are not equal?

Ans.If the difference between them is large, the sensitivity of the bridge will be reduce and the null point will be pushed towards one end. The percentage error in the measurement of the length will increase.

18. Why should you use decimal ohm box?

Ans. The resistance R introduced in resistance box should be such that when the resistance is outer gaps are interchanged, the null point should be covered on the length of the bridge wire. Thus the maximum resistance is equal to the resistance of the bridge wire. In order to have several readings for this part of the experiment, a deci-ohm box is more suitable.

19. Instead of using two coils in the inner gaps, can we use a rheostat?

Ans**.** It is more preferable to use a rheostat for the following two reasons:

(i) The resistances obtained with the rheostat are equally affected by external conditions.

(ii) The null point can be easily obtained on any portion of the bridge wire simply by altering the position of the variable contact. This is obviously not possible with two separate coils having fixed resistance.

20. But by using a rheostat we do not know the values of two resistance in the inner gap. Is it not?

Ans.This is not necessary. In the formula for the bridge the values of inner resistance do not occur at all.

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