POORNIMA INSTITUTE OF ENGINEERING & TECHNOLOGY, JAIPUR

DEPARTMENT OF FIRST YEAR

Lab Manual and Student Guide

ENGINEERING PHYSICS LAB

1/2FY2-20

Branch	**Computer Science**	**Name of Lab**	**Engineering Physics**
Session	2020-2021	Subject Code	1/2FY2-20
Year	I Year	Faculty	Dr.Mukesh Chandra
Semester	I and II	Lab Assistant	Mr. Lakshmi Kant Gupta

Document No.	PIET/I Year/2020/Odd	Created By	Dr. Mukesh Chandra
Version		Verified By	
Authorized By (HOD)	Dr. Sama Jain		

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COURSE OBJECTIVES:

- To impart physical measurement skills.
- To make the students understand coherence between theoretical and practical measurement
- Develop the skills needed to set up the equipment required to test models or theory developed in the lecture course
- Be able to interpret results and develop correct conclusions.
- Maintain a laboratory notebook and write formal reports of practical workout.

The Outcomes of Engineering Physics are:
CO1/2FY2-20.1: Students able to verify concept of interference and diffraction pattern by experiment.
CO1/2FY2-20.2: Students will be competent to explain coherence in light and apply this theory in optical fibre communication.
CO1/2FY2-20.3: Students able to understand that how to make an instrument for measure height of tower (object) by applying optics.
CO1/2FY2-20.4: Students able to explain experimentally about properties semiconductor material
CO1/2FY2-20.5: Students we be competent to explain experimentally about electrostatics and properties of conducting materials.

Program Outcome:	
PO1:	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2:	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3:	**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.
PO4:	**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.

PO5:	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6:	**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.
PO7:	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.
PO8:	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9:	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10:	**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 receive clear instructions.
PO11:	**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 team, to manage projects and in multidisciplinary environments.
PO12:	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage independent and life-long learning in the broadest context of technological

COs.– POs. Mapping :

Relationship of Course Outcomes to B.Tech I Year Program outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
COPY102.1	3	2	2	1	-	-	1	-	-	-	-	1
COPY102.2	2	3	3	1	-	-	1	-	-	-	-	1
COPY102.3	3	2	3	1	-	-	1	-	-	-	-	1
COPY102.4	3	3	2	1	-	-	1	-	-	-	-	1
COPY102.5	3	3	2	1	-	-	1	-	-	-	-	1

LAB RULES

Responsibilities of Users

Users are expected to follow some fairly obvious rules of conduct:

Always:

- Enter the lab on time and leave at proper time.
- Wait for the previous class to leave before the next class enters.
- Keep the bag outside in the respective racks.
- Utilize lab hours in the corresponding.
- Turn off the machine before leaving the lab unless a member of lab staff has specifically told you not to do so.
- Leave the labs at least as nice as you found them.
- If you notice a problem with a piece of equipment or the room in general (not working) please report it to lab staff immediately. Do not attempt to fix the problem yourself.

Never:

- Don't abuse the equipment.
- Do not disturb any experiment, which is not related your experiment.
- Do not try to resolve technical problem when your experiment equipment does not work
- Do not create noise in laboratory.
- Do not go outside of lab without permission of lab instructor..
- No food or drink is allowed in the lab. Don’t bring any external material in the lab, except your lab record, copy and books.
- Don’t bring the mobile phones in the lab. If necessary then keep them in silence mode.
- Please be considerate of those around you, especially in terms of noise level. While labs are a natural place for conversations of all types, kindly keep the volume turned down.

If you are having problems or questions, please go to either the faculty, lab in-charge or the lab supporting staff. They will help you. We need your full support and cooperation for smooth functioning of the lab.

INSTRUCTIONS

Before entering in the lab

- All the students are supposed to prepare the theory regarding the next experiment.
- Students are supposed to bring the practical file and the lab copy.
- Previous experiment should be written in the practical file.
- All the students must follow the instructions, failing which he/she may not be allowed in the lab.

While working in the lab

- Students should report to the concerned lab as per the time-table schedule.
- Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
- After completion of the experiment, certification of the concerned staff incharge in the observation book is necessary.
- Students should bring a practical note book and should enter the readings / observations into the note book while performing the experiment.
- The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.
- The group-wise division made in the beginning should be adhered to, and no mix up of students among different groups will be permitted later.
- The components required pertaining to the experiment should be collected from stores in-charge after duly filling in the requisition form.
- When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
- Any damage to apparatus that occurs during the experimentation, should be brought to the notice of lab in-charge, consequently, the cost of the repair or new apparatus should be brought by the students.
- Students should be present in the labs for the total scheduled duration.
- Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.
- Procedure sheets/data sheets provided to the students' groups should be maintained neatly and to be returned after the experiment.

POORNIMA INSTITUTE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF FIRST YEAR

ENGINEERING PHYSICS LAB (PY-102)

Zero Lab

1) Name of the lab with code: Engineering Physics Lab (PY-102)

2) Self-Introduction:

- **a) Name** : Dr. Mukesh Chandra
- **b) Qualification** : Ph.D.(Physics)
- **c) Designation** : Associate Professor
- **d) Subject Taught** : Engineering Physics
- **e) Lab taken** : Physics
- **f) E-mail ID** : mukseh.chandra@poornima.org

3) Introduction of Students:

An interactive session will be held with the students wherein they will be asked to introduce themselves, covering the following points:-

- **a)** Academics Merit/ Weak
- **b)** Co-curricular Activity
- **c)** Day Scholar/ Hosteller
- **d)** Medium Hindi/ English
- **e)** Family Background Urban/ Rural
- **f)** Learning Style seeing/ hearing/ doing

4). Introduction to Lab:-

- ➢ The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments. Conduct the experiments with interest and an attitude of learning.
- ➢ You need to come well prepared for the experiment
- ➢ Work quietly and carefully (the whole purpose of experimentation is to make reliable measurements!) and equally share the work with your partners.

- Be honest in recording and representing your data. Never make up readings or doctor them to get a better fit for a graph. If a particular reading appears wrong repeat the measurement carefully. In any event all the data recorded in the tables have to be faithfully displayed on the graph.
- All presentations of data, tables and graphs calculations should be neatly and carefully done.
- Bring necessary graph papers for each of experiment. Learn to optimize on usage of graph papers.
- Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs. Come equipped with calculator, scales, pencils etc.
- Do not fiddle idly with apparatus. Handle instruments with care. Report any breakage to the Instructor. Return all the equipment you have signed out for the purpose of your experiment.

5) Syllabus :

6) Lab Outcomes:

After completing this course the student must demonstrate the knowledge and ability to:

1. Students can understand the importance of laws of Physics in the practical applications.
2. Students gain knowledge in various techniques and related working principles to devices or components.

3.. Design new experiments in Engineering.

4.. Identify the appropriate application of particular experiment.

5.. Understand the applications of physics experiments in day to day life.

7) Relevance with Branch :

Branch	**Relevance to Branch**
CS/IT	Solid state physics is responsible for semiconductors, which are responsible for semiconducting diodes and transistors, which are in turn at the heart of every memory chip and processor in every computer in the world. Most of the specifics of circuits are governed by equations studied in electrodynamics. Before this, computers were made by vacuum-tube diodes, which were also a cute physics trick.

Civil Engg.	The way to make sure the thing you're building will work properly is to analyze it using the laws of physics. The laws of physics can tell you about forces, tension, harmonic vibrations and oscillations, tensile strength, elasticity, and all kinds of other concepts that you can use to make calculations about your bridge. Put simply, if you understand the laws of nature, then you can use that knowledge to predict what will happen to the things you build. Engineering involves applying physics in technical ways -- applying it to technology.
Electrical/Electronics Engg.	Electrical engineering primarily focuses on applying electricity and magnetism principles from physics to make useful devices and materials. There is often a lot of overlap between electrical engineering and physics, especially in the area of solid state physics. Electronics totally depend on physics-solid state physics, we must know the physics of the crystal structure in order to enhance electronics. As we know now scientist are working in 45nm technology, this can be done only when we know the crystal structure and the material characteristics, their electrical characteristics.

7) Overview of Experiments/Syllabus:

1. To determine the wave length of sodium light by Newton's Ring.
   (Case Study: Determination of refractive index of water)
2. To determine the specific rotation of glucose (sugar) solution using polarimeter.
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 sextant.
6. To determine the dispersive power of material of a prim for violet and yellow colour's of mercury light with the help of spectrometer.
7. To study the charge and discharge of a condenser and hence determine the same constant (both) current and voltage graphs are to be plotted.

8. To verify the expression for the resolving power of a Telescope.
9. To determine the coherence length and coherence time of laser using He – Ne laser.
   (Case Study: Find out the quality factor and Coherence width)
10. To determine the specific resistance of the material of a wire by Carey Froster's bridge.

8) Lab Plan:

a) Relation with other labs:

The objective of this lab is to teach students the importance of engineering Physics Lab through involvement in experiments. This lab helps to have knowledge of the world due to constant interplay between observations and hypothesis, experiment and theory in engineering. Students will gain knowledge in various areas of physics so as to have real time applications in all engineering streams.

b) Connection with previous year and next year & theory Subjects:

Engineering Physics lab will connect in all engineering branches next year for execution of laws of physics which will be directly or indirectly involve in engineering study. Engineering students will be developed new instrumentation and new techniques for different application in their respective branch with help laws of engineering Physics.

Lab schedule per week:

Two hours per batch per week

6) Books / Websites-

www.vlab.ac.in

5) University Examination System:-

Sr. No.	**Name of the Exam**	**Max. Marks**	**% of passing marks**	**Syllabus coverage (in %)**	**Conducted by**
1	I Mid Term Exam	20	8	50%	PGC
2	II Mid Term Exam	20	8	50%	**PGC**
3	University (End) Term Exam	20	8	100%	University

Place: PIET, Jaipur
Date:

SYLLABUS

Engineering Physics Lab

S.No.	List of Experiments
1	To determine the wave length of monochromatic light with the 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 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 sextant.
6	To determine the dispersive power of material of a prim for violet and yellow colour's of mercury light with the help of spectrometer.
7	To study the charge and discharge of a condenser and hence determine the same constant (both current and voltage graphs are to be plotted).
8	To measure the numerical aperture of an optical fibre.
9	To determine the coherence length and coherence time of laser using He – Ne laser.
10	To study the Hall Effect and determine the Hall Voltage and Hall Coefficient.

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Engineering Physics Lab (1FY2-20/2FY2-20)

ROTOR-I

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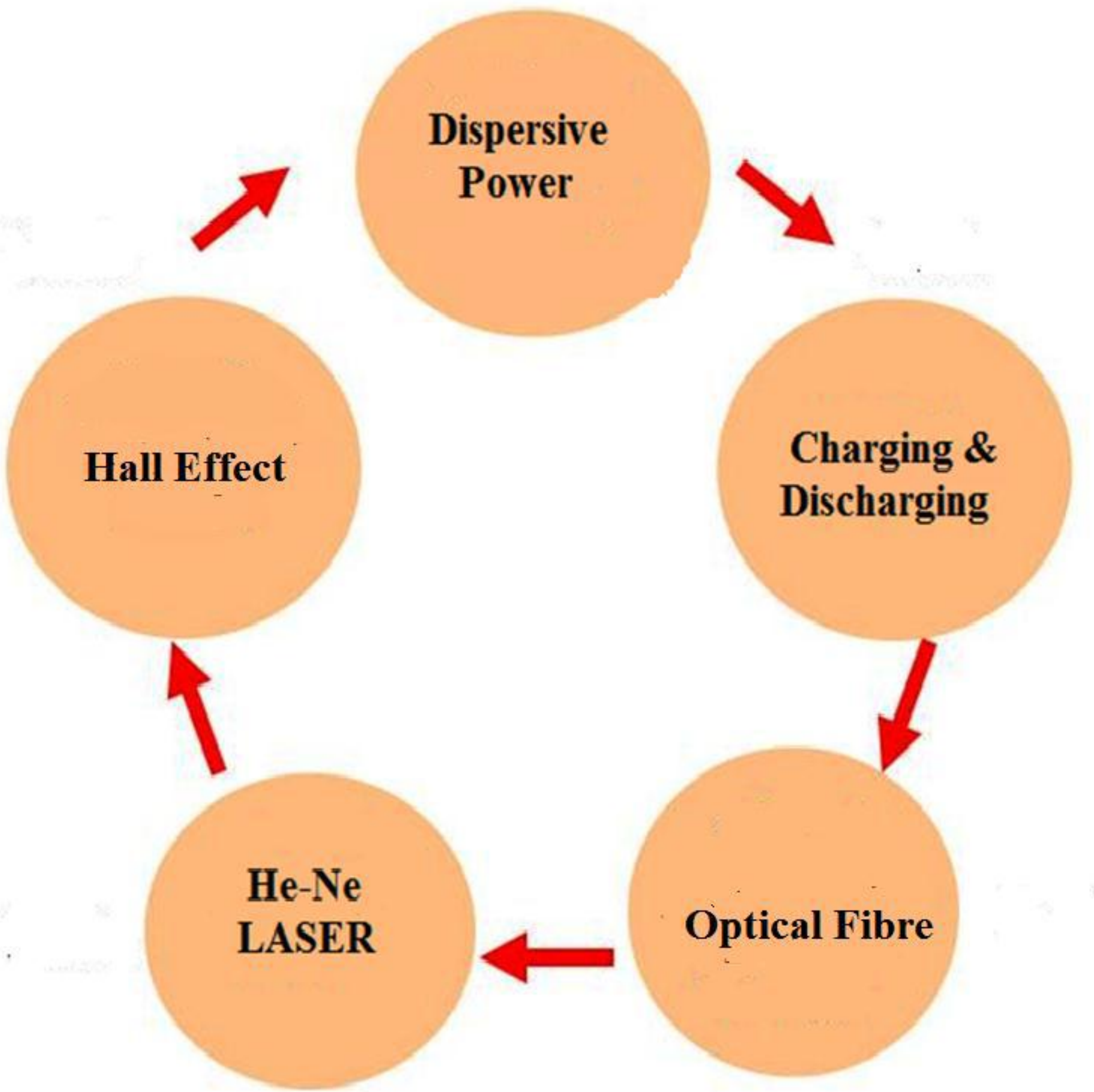
Engineering Physics Lab (1FY2-20/2FY2-20)

ROTOR-II



S.No.	Experiment	Mode of Conduct(Activity)	Turn/Week
1	Newton's Ring	Experiment	1 ,2,3,4,5
2	Michelson's Interferometer	Virtual Lab	2,3,4,5,1
3	Diffraction Grating	Experiment	3,4,5,1,2
4	Energy Band Gap	Experiment	4,5,1,2,3
5	Sextant	Experiment	5,1,2,3,4
I Mid Term			
6	Dispersive Power	Experiment	6,7,8,9,10
7	Charging & Discharging	Experiment	7,8,9,10,6
8	Hall Effect	Virtual Lab	8,9,10,6,7
9	He-Ne Laser	Experiment	9,10,6,7,8
10	Optical fibre	Experiment	10,6,7,8,9

Mention Lab Activities- Virtual Lab, Mini Project, Case Study, Presentations, Applications based experiments, Survey.

MARKS SCHEME

RTU Marks Scheme

Maximum Marks Allocation		
Internal	External	Total
30	20	50

Marks Division

Mid Term – I & II		
Performance	Viva	Total
15	5	20
Mid Term Average marks=15		
Attendance & Performance		
Performance	Attendance	Total
10	5	15
End-Term Practical		
Performance	Viva	Total
15	5	20

Internal Assessment System

Total Marks –

Attendance	Discipline	Performance	Record	Viva	Total

Distribution of lab hours

Attendance	05 minutes
Explanation of the concept	15 minutes
Explanation of experiment	15 minutes
Performance of experiment	70 minutes
Evaluation & Viva	15 minutes
Total	**120 minute**

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- To make the students understand coherence between theoretical and practical measurement
- Develop the skills needed to set up the equipment required to test models or theory developed in the lecture course
- Be able to interpret results and develop correct conclusions.
- Maintain a laboratory notebook and write formal reports of practical workout.

PHYSICAL CONSTANTS

Planck constant h:	$6.6260755 \times 10^{-34}$ J·s
Boltzmann constant k_B:	1.380658×10^{-23} J/K (= $8.617385 \cdot 10^{-5}$ eV/K)
Elementary charge e:	$1.60217733 \times 10^{-19}$ C
Avogadro number NA:	6.0221367×10^{23} particles/mol
Speed of light c:	2.99792458×10^{8} m/s
Electron rest mass m_e:	$9.1093897 \times 10^{-31}$ kg
Proton rest mass m_p:	$1.6726231 \times 10^{-27}$ kg
Neutron rest mass m_n:	$1.6749286 \times 10^{-27}$ kg
Acceleration due to gravity g:	9.80665 m/s^2

Procedure:

Formal Lab Report

Title of Lab Activity: Engineering Physics Lab

1. Object/Aim:	Right Hand Page
2. Materials and Apparatus Required:	Right Hand Page
3. Theory and Formula:	Right Hand Page
4. Procedure :	Not Required
5. Diagram/Fig:	Left Hand Page
6. Observations:	Right Hand Page
7. Calculations:	Left Hand Page
8. Graphs:	Left Hand Page
9. Results & Conclusion:	Right Hand Page
10. Precautions & Errors:	Right Hand Page

11.Post-Lab questions if required (Viva-Voce questions and Answers) :

Experiments

Experiment No.: 1

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

Apparatus Required: Traveling microscope, sodium vapour lamp, plano-convex lens, plane glass plate, magnifying lens, etc.

Formula:

The wavelength of light is given by the formula

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}$$

Where, Dn+p = diameter of $(n+p)^{th}$ ring

Dn= diameter of nth ring,

p = an integer number,

R = radius of curvature of the curved face of the plano- convex lens.

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

Where l = distance between two legs of spherometer.

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

Diagram:

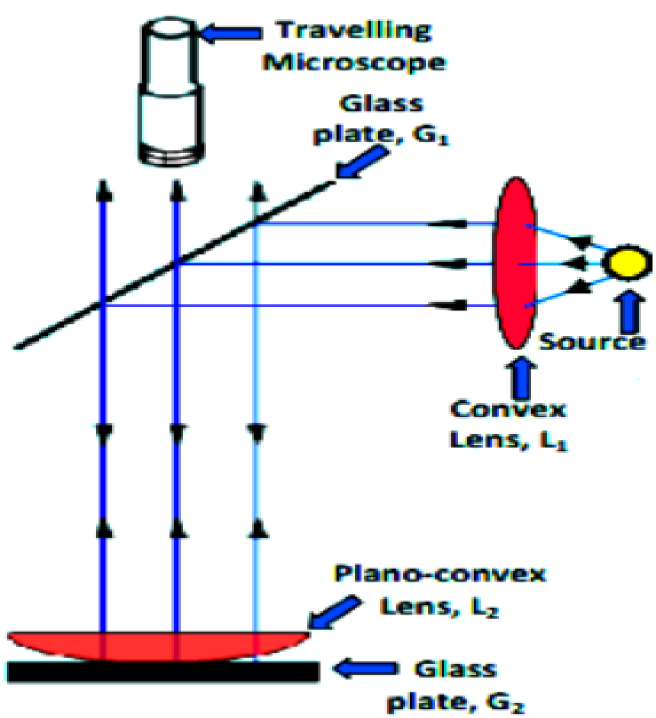


Fig. 1

Principle: It is based on Interference by division of amplitude in a wedge shaped film of variable thickness. The film of air is enclosed between a plane glass plate and plano-convex lens.

Procedure:

1.If a point source is used only then we require a convex lens otherwise while using an extended source, convex lens L_1 is not required. Before starting the experiment the glass plates G_1 and G_2 and the plano-convex lens L_2 should be thoroughly cleaned. The centre of lens L_2 illuminated by adjusting the inclination of glass plate G1 at 45° as shown in figure 1

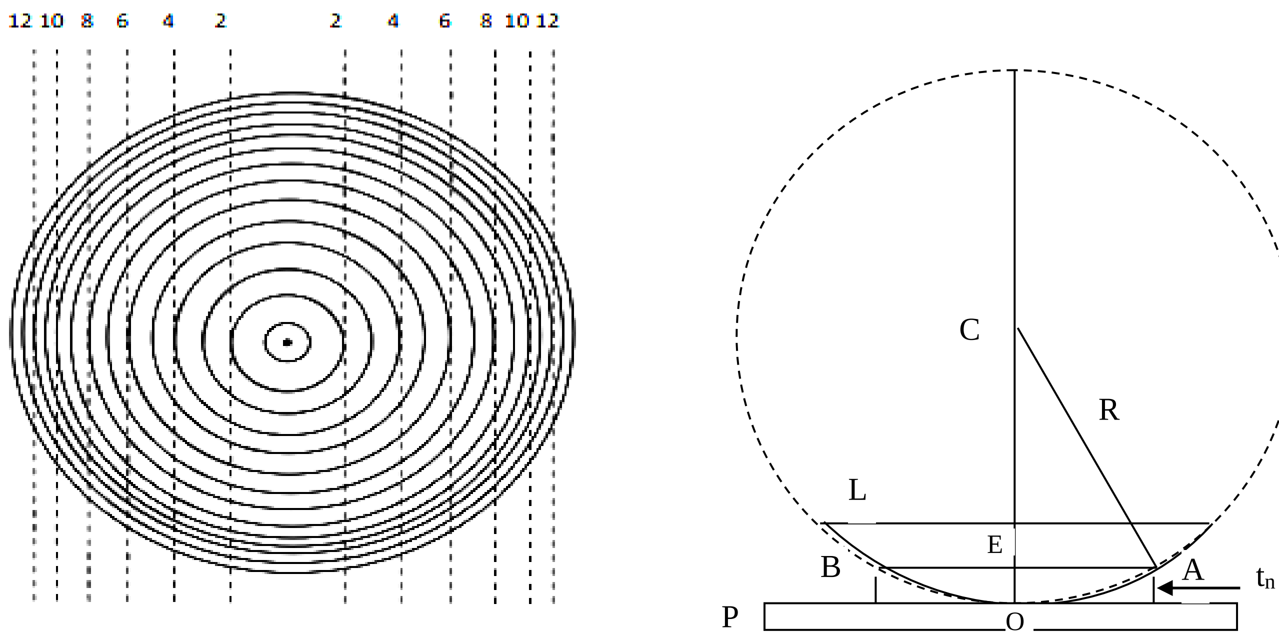


Fig. 2

2. Focus the eyepiece on the cross-wire and move the microscope in the vertical plane by means of rack and pin on arrangements till the rings are quite distinct. Adjustments are to be done till satisfactory fringe syste m of perfect circular shape with a dark spot at the centre is obtained.
3. 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.
4. The microscope is moved in the vertical direction by means of rack and pinion arrangement till the rings are seen distinctly.
5. The centre of the fringes is brought symmetrically below the cross wires by adjusting the position of the lens and the microscope.

6. 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.
7. 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.
8. The observations are not taken on the first two or three rings, which are wide enough.
9. The radius of curvature of the curved surface or the pIano-convex lens is determined using spherometer. The observations with the spherometer are first taken on the curved surface and then on the plane surface.
10. 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.

Observations:

Value of 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										

(B) Determination of height(h)

Pitch of screw x=………………cm

No. of division on the scale n=………………

Least count of spherometer (x/n) = ……….. cm

S.No.	Spectrometer Reading						h = b-a cm	Mean h cm
	Zero reading on plane surface(a)			Reading on curved surface (b)				
	M.S. cm	V.S.	Total reading (a) Cm	M.S. cm	V.S	Total reading (b) cm		
1.								
2.								
3.								
4.								
5.								

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 = ……….

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

λ=………..Å

Result: -

Mean wavelength of sodium light = ……….Å

Standard value = 5893 Å

Percentage error =(Standard Value - Measured Value/Standard Value)x100

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 focused 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. What is the basic principle of newton's rings experiment?

Ans : The basic principle of Newton's rings experiment is Interference phenomenon.

Q2. Define Interference phenomena?

Ans : The phenomenon of Newton's rings is an illustration of the interference of light waves reflected from the opposite surfaces of a thin film of variable thickness.

Q3. Why the rings are circular?

Ans : The path difference along the circle is constant that's why the rings are circular in this experiment.

Q4. What are Newton's Rings?

Ans : Alternate dark and bright rings with central dark spot are called newton's rings.

Q5. Why it is necessary for the light to fall normally on plano convex lens?

Ans : For interference.

Q6. What is constructive interference and destructive interference?

Ans : When two light waves interfere at each other such that the resultant intensity at a point increase due to the interference of two waves is called Constructive interference. If the resultant intensity is minimum then that is called Destructive Interference.

Q7. What is the purpose of glass plate incline at 45^0 in this experiment?

Ans : For normal incidence of light wave.

Q8. Why the Centre of the rings is dark?

Ans : Because the plano convex lens and the plane lens both are in contact and at that particular place the centre dark ring will appear.

Q9. Which light do u use in this experiment?

Ans : Monochromatic light. Example: Sodium light.

Q10. What will happen if we use White light in this experiment?

Ans : Colored fringes will form.

Q12. If u replace yellow light with green light, is there any difference in the formation of rings?

Ans : No ,because both are Monochromatic lights only.

Q13. 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 lenses and glass plate (3) the radius of curvature R of the lens.

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. 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.

Q16. Do you get rings in the transmitted light?

Ans: Yes, in this case the pattern of the rings is complementary of the reflected light.

Q17. 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.

Q18. Where are the rings formed?

Ans. The rings are formed in the air film between the curved surface of lens and glass plate.

Q19. 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.

Q20. 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.

Experiment No. : 02

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

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

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

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

Where λ = wavelength of light,

$(e + b)$ = grating element

θ = Angle of diffraction,

n = order of spectrum.

Diagram:

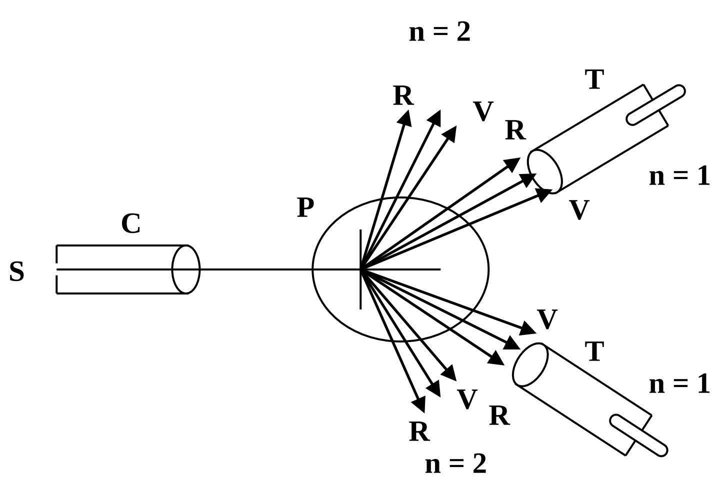


Fig. 1: Ray diagram of arrangement of diffraction grating experiment

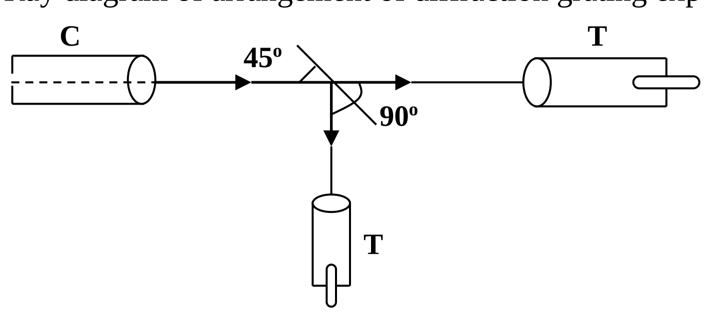


Fig. 2 : Measurement of angle

Procedure:

(A) Adjustment of spectrometer:

1. Adjustment of the telescope:

(i) 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.

(ii) 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.
2. 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'.
3. 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.
4. 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.
5. 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.
6. 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.

(C) 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 verniers 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 verniers V1 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 diffractionθ.
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), θ and n.

Observations:

(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 diffractionθ:

Least count of main scale x =………

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

Least count of Vernier scale = x / m

Observation Table:

(a) Order of spectrum 1:

S. No.	Colour of light	Vernier	Towards right of the central image (a)			Towards left of the central image (b)			2θ = a - b	θ	Mean θ
			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 1:

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

Calculations: -

(i) For violet colour

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

(ii) For green colour

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

(iii)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 entire 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.
7. Grating should be set normal to the incident light.

Viva-Voce:

Q1. 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.

Q.2 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.

Q.3 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.

Q.4 How many types of grating are there?

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

Q.5 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.

Q.6 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.

Q.7 Is the grating used in the laboratory a real grating?

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

Q.8 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 un-deviated and then only diffraction takes place at the ruled surface. In this case the angle measured will be true angle of diffraction

Q.9 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.

Q.10 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.

Q.11 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.

Q.12 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.

Q.13 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.

Q.14 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.

Q.15 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.

Q.16 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 increase in the same space.

Q.17 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.

Q.18 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.

Experiment-3

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

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

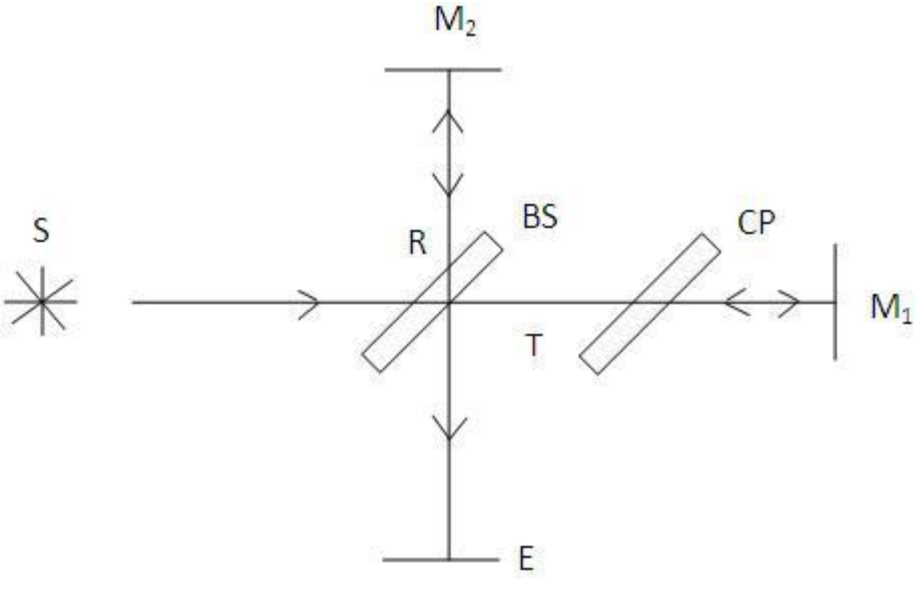


Fig. 1

Formula/ Theory:

Using the Michelson interferometer, the wavelength of light from a monochromatic source can be determined. If M_1 is moved forward or backward, circular fringes appear or disappear at the centre. The mirror is moved through a known distance d and the number N of fringes appearing or disappearing at the centre is counted. For one fringe to appear or disappear, the mirror must be moved through a distance of $\lambda/2$. Knowing this, we can write,

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

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

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.

Observation Table

S. No.	No. Of Fringes (N)	Distance (mm) d	Diffrence in Distance (mm) Δd
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.

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

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

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.

Is = Reverse saturation current

When PN junction is in the reverse bias with large voltage, the exponential term in eq. (1) becomes negligible.

Hence I=-Is

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

$$I_s = A_s \exp(-\frac{\Delta E_g}{kT}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where ΔE = Band gap in electron - volt.

A_s = Constant

Diode resistance at saturation

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

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

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

Graph between (10^3 / T) as abscissa and $\log_{10}\frac{V}{A_s}$ is as ordinate will be a straight line having a slop = 5.04 ΔE.

Hence band gap ΔE_g

$$\Delta E_g = \text{slope of the line} / 5.04 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$\Delta Eg = 0.198 \times$ slope of the line

Circuit Diagram:

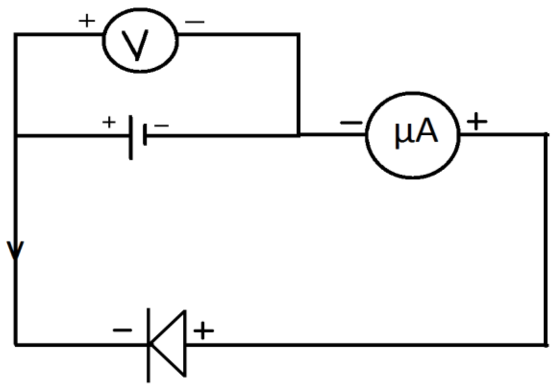


Figure:- 1.Circuit Diagram of Band Gap

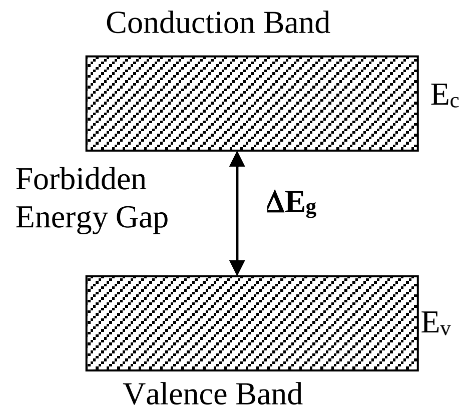


Figure:-2. Energy Band Diagram

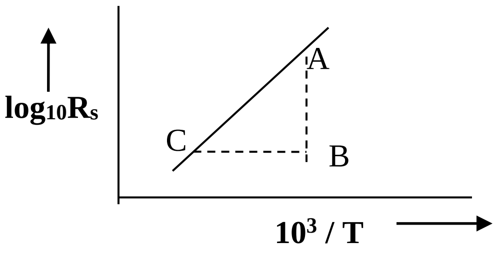
Procedure:

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 (μA)**			**Temperature of diode T**		**10^3 / T (K^{-1})**	**R_s =V/I_s**	**$\log_{10}R_s$ (μA)**
	↑	**↓**	**I_s (average)**	**in ^{0}C**	**in K**			
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9								
10								

Calculation:



From the graph,

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

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

$$= ....eV$$

Result:

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 diode?

Ans: The diode consists of two electrodes one is cathode and another is anode. The cathode emits electrons and the anode will attracts the emitted electrons when it is supplied by positive potential.

Q2. What is energy gap?

Ans : The gap between conduction band and the valency band is called Energy Gap. To move the electrons from the valency band to conduction band the supplied external voltage must be equal to energy gap.

Q3. What is valency band?

Ans: The range of energy which is possessed by valency electrons is known as valency band. Here the electrons which are situated at outer most orbits are called valency electrons. The valency band consists of valency electrons which are having highest energy.

Q4. What is conduction band?

Ans: The range of energies possessed by a conducting electrons is known as conduction band. The conduction electrons are responsible for the conduction of current in a conducting material. So, these electrons are called as conduction electrons.

Q5. How many types of solid materials are there and what are those materials?

Ans: Based on the energy gap the solid materials are classified into 3 types they are: conductors, insulators and semiconductors.

Q6. What are Semiconductors?

Ans: Those substances which have conductivity and resistivity properties in between conductors and insulators are called semiconductors. (ex: Si , Ge).Energy gap of these semiconductors lies between 0.5 to 1.1 eV.(Foe Ge it is 0.5 – 0.7eV).

Q7. How many types of semiconductors are there?

Ans: Two types of semiconductors are there (1) Intrinsic or pure semiconductors.(2) Extrinsic or impure semiconductors.

Q8. What do you meant by Fermi energy level?

Ans: The average energy of charge carriers is calculated by Fermi energy level. In pure semiconductors Fermi energy level is at the centre of the valency and conduction bands.

A. In P-type semiconductors (extrinsic/impure semiconductor) Fermi energy level is near to the valency band.

B. In N-type semiconductors (extrinsic/impure semiconductor) Fermi energy level is near to the

Q9. What is a band gap?

Ans. This is energy gap between the conduction and valence bands of a semiconductor.

Q10. 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.

Q11. 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.

Q12. 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.

Q13. What are intrinsic and extrinsic semiconductors?

Ans. A pure semiconductor 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.

Q14. What are N-type and P-type semiconductors?

Ans. Pure semiconductors are 4th 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.

Q15. 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.

Q16. 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.

Q17. What is the effect of impurities on the conductivity of semiconductors?

Ans. It increases the conductivity of the semiconductor.

Q18. What are the order of current in forward and reverse bias arrangement?

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

Q19. 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.

Q20. 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.

Experiment No.: 5

Object: To determine the height of water tank with the help of sextant.

Apparatus: A sextant, a measuring tape and chalk pieces of two different colors.

Formula:

$$H = \frac{x}{(\cot\theta_1 - \cot\theta_2)} + h'$$

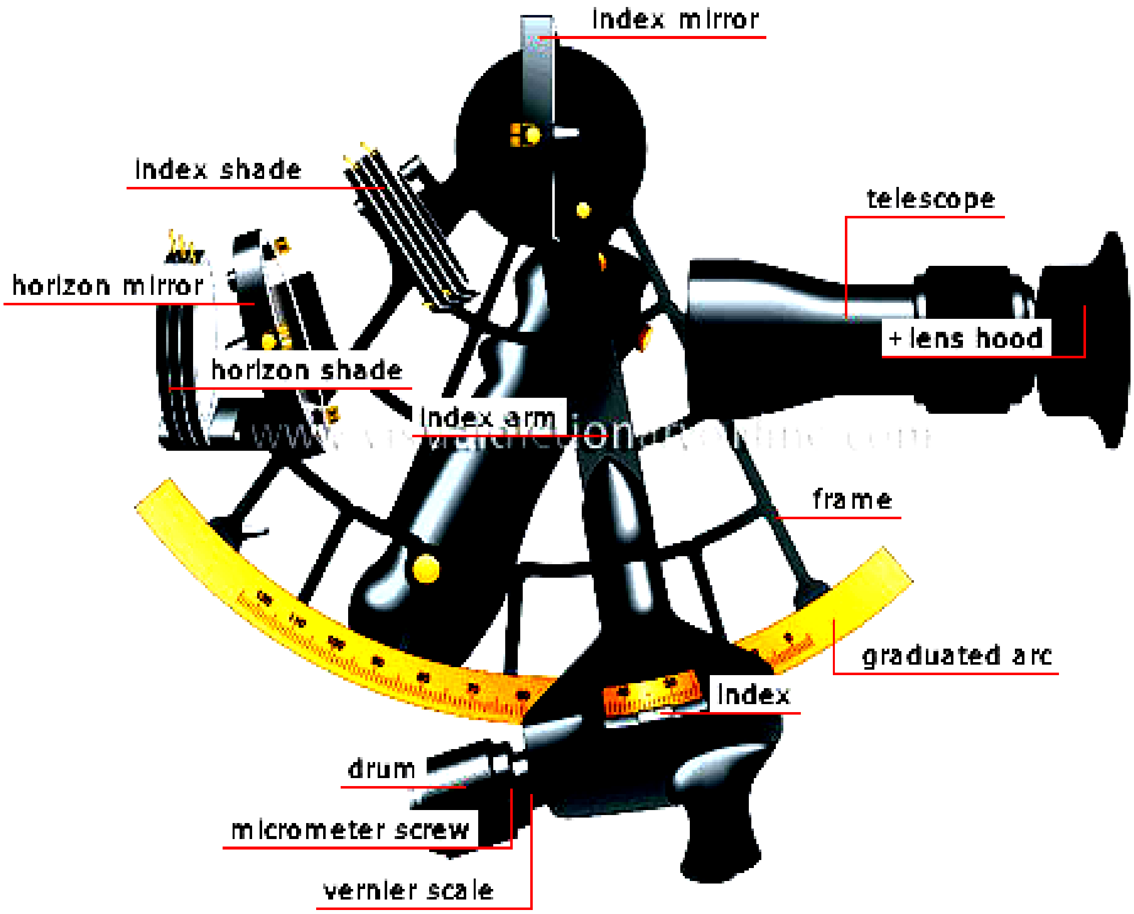
$$H = h + h'$$

Where θ_1, θ_2 $\longrightarrow$ the angels subtended by the top at the two positions of the sextant

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

h' $\longrightarrow$ the height of an object above the reference mark.

Diagram:



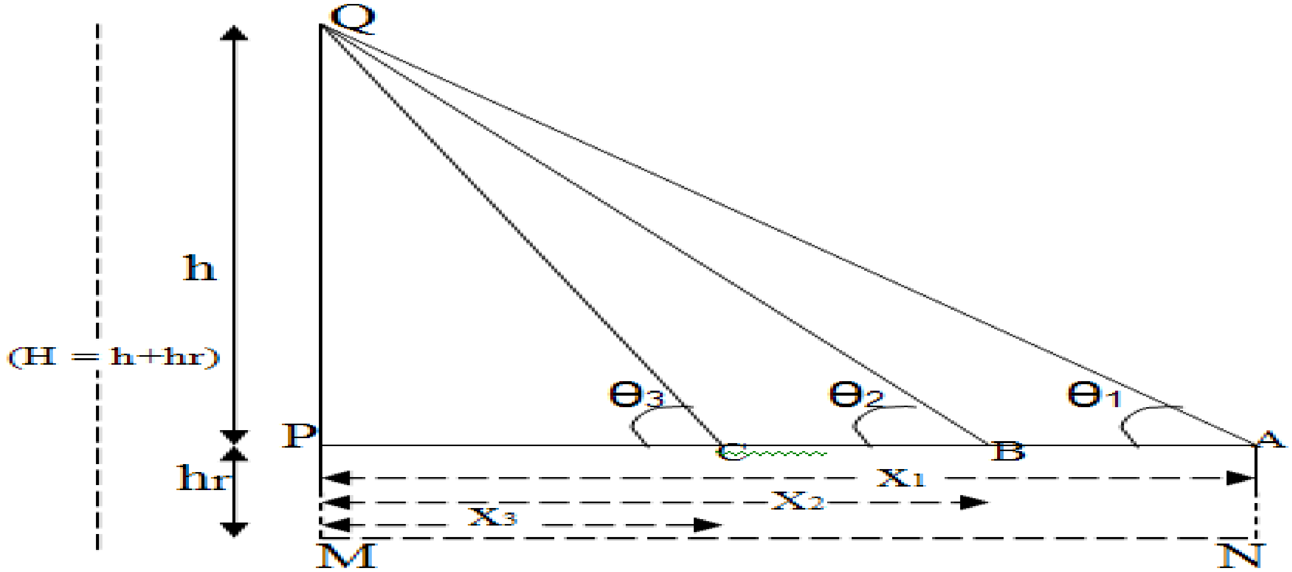


Fig-1

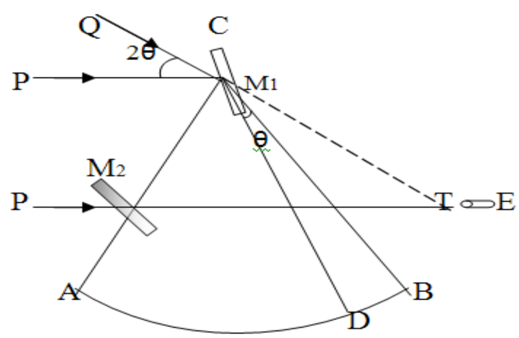


Fig-3

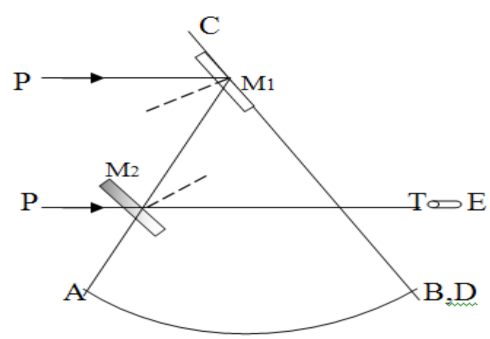


Fig-2

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:

(A) For least count of an instrument

- The smallest division on the main scale x = 1°
- The number of divisions on the circular scale(drum) is n= 60
- Thus the least count of circular scale = x/n = 1°/60 = 1/60*60’ = 1’
- No. of division on vernier = 5
- Thus the least count of vernier scale x’/n’ = 1’/5 = (1/300)° = 1/300*60 = 12”
- Total reading TR = MSR+CSR+VSR = MSR+(1/60)°*CSD+(1/300)°*VSD

Observation Table for angle of elevation:

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

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

(B) Height of the reference mark from the ground “Gr” = ………… m
(C) 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, x_1= ……… m; θ_1= ………

For point B, x_2= ……… m; θ_2= ………

For point C, x_3= ……… m; θ_3= ………

Now

$$h_1 = \frac{x_1 - x_2}{(\cot\theta_1 - \cot\theta_2)} = \ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ \text{m}$$

$$h_2 = \frac{x_2 - x_3}{(\cot\theta_2 - \cot\theta_3)} = \ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ \text{m}$$

$$h_3 = \frac{x_1 - x_3}{(\cot\theta_1 - \cot\theta_3)} = \ldots\ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots\ \text{m}$$

The mean value of $h = (h_1+h_2+h_3+h_4) / 5$ (in meter)

Then height of the object is $H = h + h'$ = ……… + ……… = ………m

$$\%Error = \frac{H' - H}{H'} \times 100 = \ldots\ldots\ldots = \%$$

Where H' ⟹ *Actual Height of object*

And H ⟹ *Observed height of object*

Result:

The height of the given object H = ………..

Actual height of an object H' = ………...

Percentage Error = ………... %

Precautions and Sources of Errors:

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.

Viva - Voce:

Q1. 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.

Q2. 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.

Q3. 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 especially when the measurements are made with the bright objects like the sun.

Q4. 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.

Q5. 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.

Q6. Can it measure the height of the building?

Ans. Yes, sure.

Q7. Can it measure the depth of well?

Ans. Yes, sure

Q8. Is zero correction error in a particular instrument?

Ans. No

Q9. How it can be used in navigation systems?

Ans. For measuring the altitudes of sun and moon.

Q10. How it helps in measuring the distances?

Ans. By finding latitude and longitudes.

Q11. How does it helps in finding terrestrial objects?

Ans. By determining the vertical and horizontal distances.

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-

$$w = \frac{\theta}{\delta_y} = \frac{\delta_v - \delta_r}{\delta_y} = \frac{\mu_v - \mu_r}{\mu_y - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

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 by

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

Where

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

Diagram:

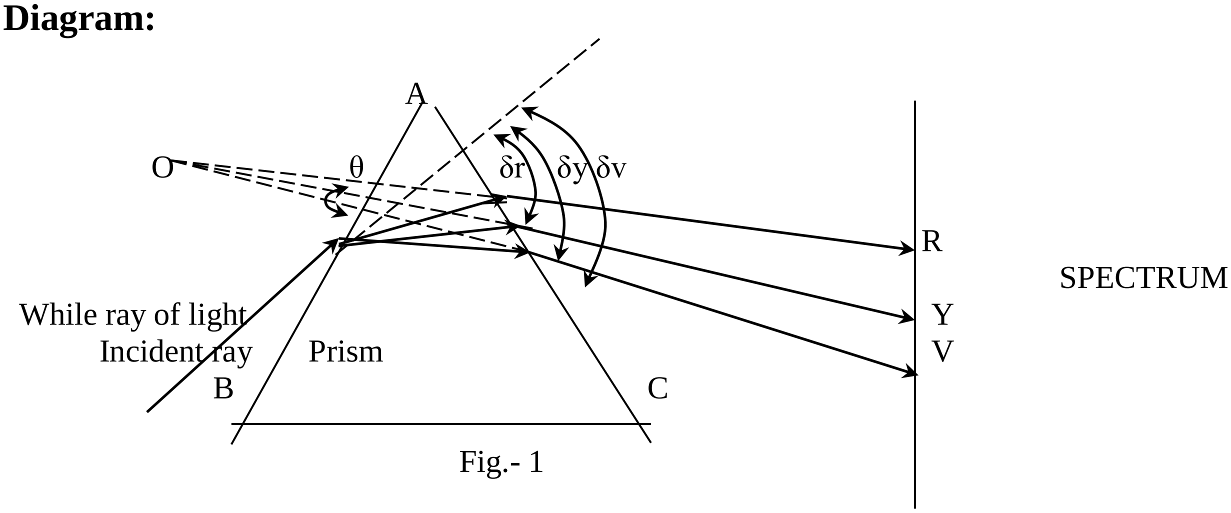


Fig.- 1

From Collimator

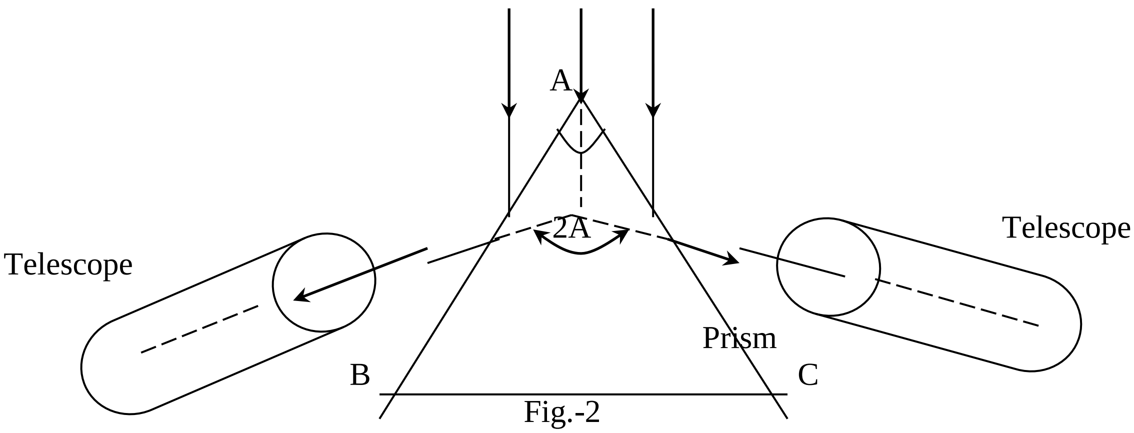


Fig.-2

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 form 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 in front of collimator as the cross wire coincide with image of slit. Note the readings of both verniers.

Observations and Observation Table:

One division of M.S. x = ………………………

No. of division of V.S. n = ………………………

Least count of V.S. x/n = …………………….

(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	VD	VSR	TR (P)	MSR	VD	VSR	TR (Q)		
1.	V1										
	V2										
2.	V1										
	V2										

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

S. No.	Colours	Scale	Reading in Minimum Deviation Image			Reading for Direct Image			δm= a-b	Mean δm
			MSR	VD	TR (a)	MSR	VD	TR (b)		
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

$$\mu_v = \frac{\sin\left(\frac{A+\delta_v}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\mu_r = \frac{\sin\left(\frac{A+\delta_r}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots$$

$$\mu_y = \frac{\sin\left(\frac{A+\delta_y}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(iii) Dispersive power of prism's material

$$w = \frac{\mu_v - \mu_r}{\mu_y - 1} = \ldots\ldots\ldots\ldots \text{OR } w = \ldots\ldots\ldots\ldots\ldots\ldots$$

(iv) Standard dispersive power of crown glass $w_{st} = 0.015$

$$\% \text{ Error} = \frac{w_{st} - w_{Observed}}{w_{st}} \times 100 = \ldots\ldots\%$$

Result:

The dispersive power of prism's material is =………

Percentage error = ………. %

Precautions:

1. The telescope should be focused for infinity and the collimator should be adjusted to give a paralleled beam of light.
2. The axis of telescope and collimator, and the plane of prism table should be horizontal.
3. The slit should be as narrow as possible.
4. The prism table should be leveled as that the maximum light must fall on the entire surface of prism.
5. At the time of observation, the telescope and the prism table should be clamped.
6. The telescope should be used on both verniers to note the readings.
7. Before observation, clean to prism and lens.
8. 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).

Q.10. 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 normal.

Experiment No.: 7

Object: To study the charging and discharging of a condenser and hence determine the same 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) The voltage charge across condenser during charging is given by:

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

$Q_c = Q_o\, [1- e^{-t/RC}]$

ii) The voltage across resistance during charging is given by:

$V_R = V_o e^{-t/RC}$ --------------------- (2)

iii) The current in the circuit at any time t is given by:

$I(t) = V_R/R = V_o/R\, e^{-t/RC} = I_o\, e^{-t/RC}$ ------------------- (3)

iv) The voltage Vc across condenser during discharging is given by:

$V_c = V_o\, e^{-t/RC}$ ------------------- (4)

v) The voltage VR across resistance during discharging is given by:

$V_R = V_o\, e^{-t/RC}$ ------------------- (5)

vi) The current (t) in the circuit at any time t is given by:

$I(t) = -V_R/R = -V_o/R\, e^{-t/RC} = -I_o\, e^{-t/RC}$ ---------------- (6)

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

(a) During charging at t = RC = T

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

$V_c(t) = V_o[1-1/2.718] = 0.63V_o$ -------------------- (7)

(b) During discharging at t = RC = T

$V_c = V_o e^{-t/RC} = V_o e^{-1} = V_o.1/2.718 = 0.37V_o$ ----------------- (8)

(c) Using equ. (3) We have

$I(t_2)/I(t_1) = e$

$Log_e I(t_2)-Log_e I(t_1) = -(t_2-t_1/T)$

$T = (t_2-t_1)/Log_e I(t_1)-Log_e I(t_2)$

$T = (t_2-t_1)/2.303\ [Log_{10}\ I(t_1)-Log_{10}\ I(t_2)]$ ----------------------- (9)

Where

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.

t = RC = T = time constant in second.

Circuit diagram:

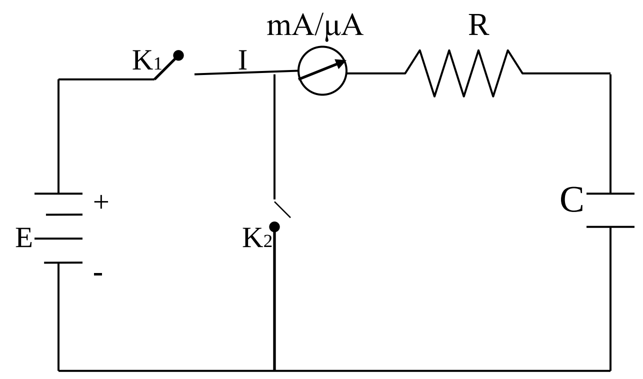


Fig.- 1 Circuit Diagram

Where

E = EMF of the battery; K1, K2 = One way key

R = Resistance in circuit; C = Condenser in circuit

RC = Circuit; I = Current in circuit

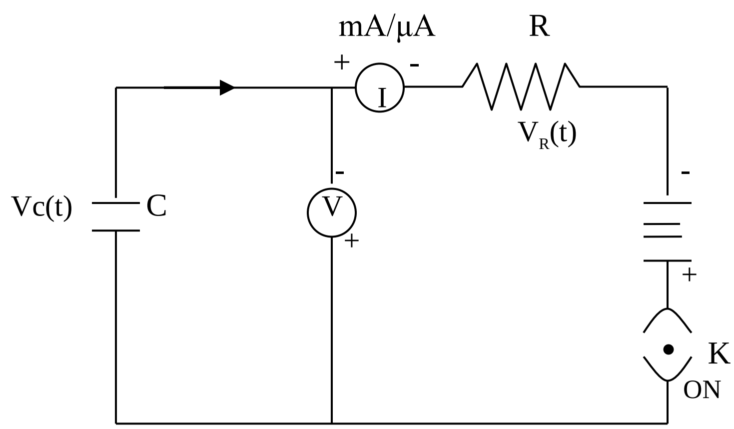


Fig.- 2 Charging (taking Voltage across capacitor)

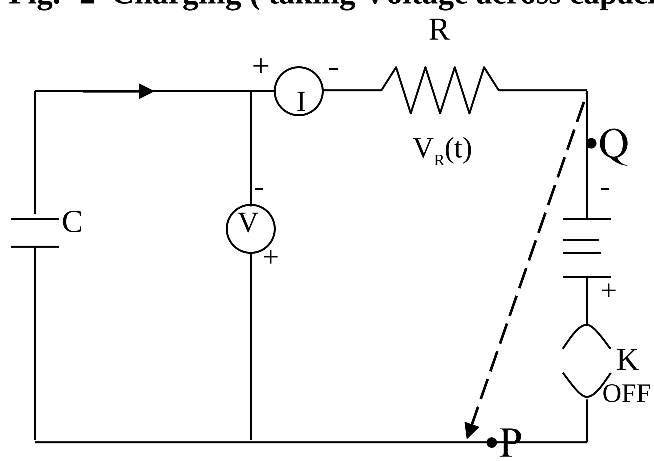


Fig.- 3 Discharging (taking Voltage across capacitor)

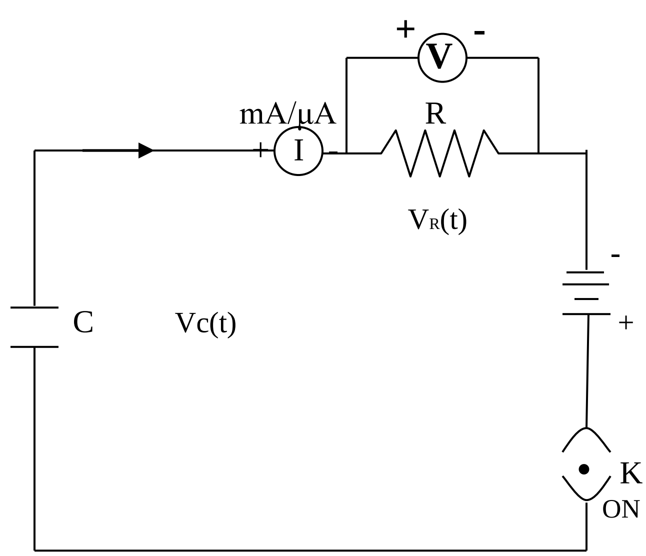


Fig.- 4 Charging (taking Voltage across resistor)

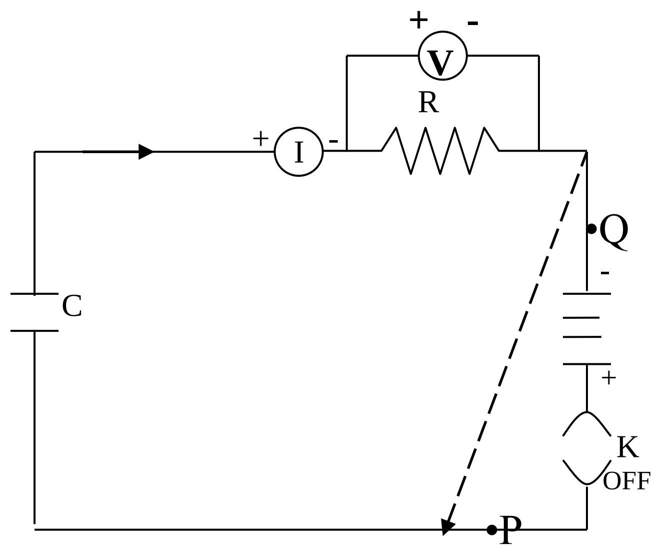


Fig.- 5 Discharging (taking Voltage across capacitor)

Procedure:

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.

Observation:

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

Values of V_0 = ……….. Volt

R = ………... ohm

C = ………… Farad

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

S. No.	During Charging		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				
11				
12				
13				

(B) Table for values of voltage across R and current across C in time t [Table for values of $V_R(t)$ and I(t) in time 't'.] :

S. No.	Charging $V_R(t)$ V/s t				Discharging $V_R(t)$ V/s t			
	Time t (Sec.)	$V_R(t)$ {Volts}	$I(t)=V_R(t)/R$ (Amp.)	Log_{10} I(t)	Time t (Sec.)	$V_R(t)$ {Volts}	$I(t)=V_R(t)/R$ (Amp.)	Log_{10} I(t)
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.

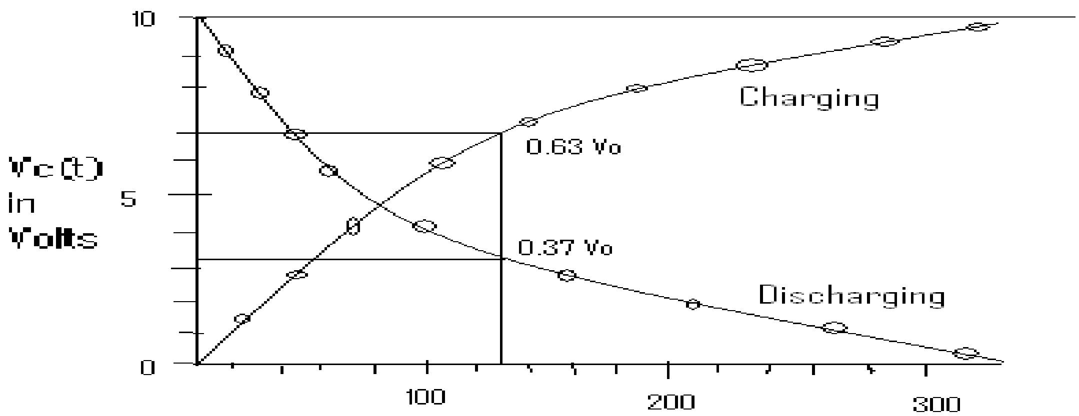


Fig.- 6 Variation in voltage for charging and discharging of Condenser.

(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.

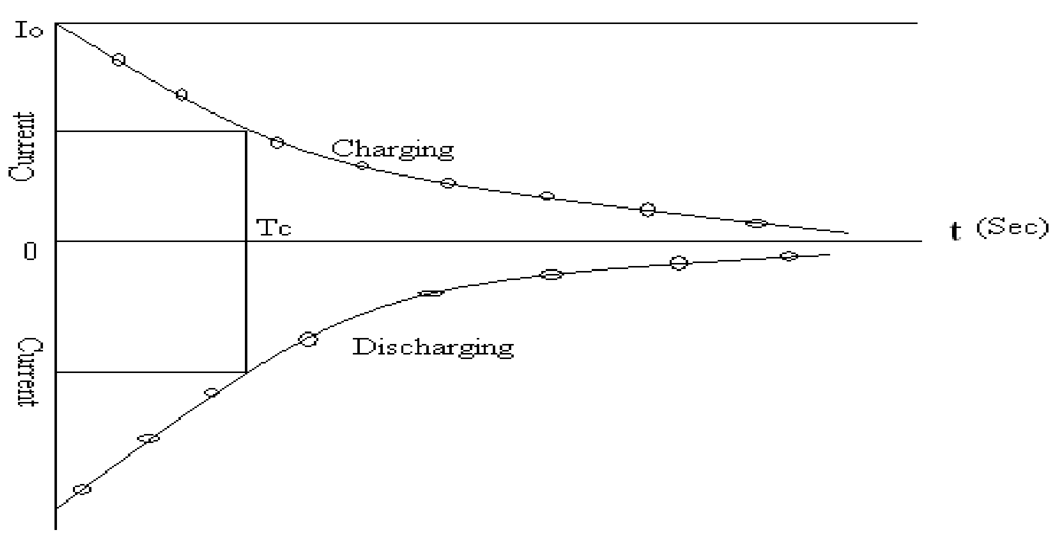


Fig.- 7 Variation in current for charging and discharging of a Condenser.

(iv) Lastly plot a graph Log_{10} I(t) and t and the time corresponding to Log_{10} I(t1) and Log_{10} $I(t_2)$ ie t_1 and t_2 should be noted as shown in fig.- 8.

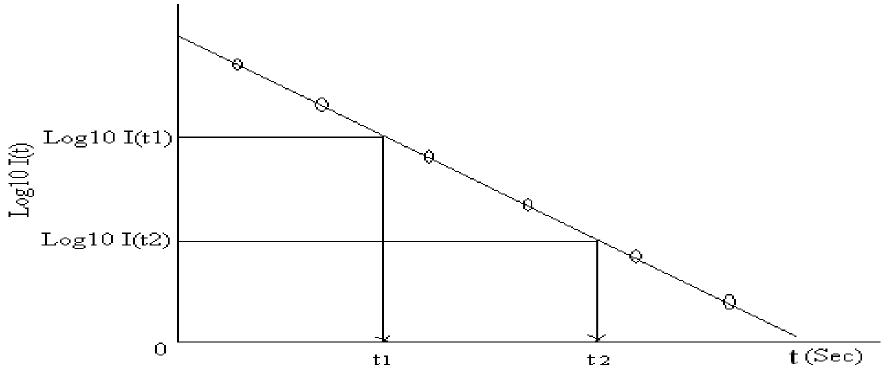


Fig.-8 Variation in Log_{10} I(t) and time (t).

Time constant will be given by

T_c= $(t_2-t_1)/2.303$ [Log_{10} I(t1)- Log_{10} $I(t_2)$]

By substituting the values of Log_{10} $I(t_1)$, Log_{10} $I(t_2)$, t_1 and t_2 from graph, one can able to calculates the experimental time constant Tc.

Hence experimentally calculated values of time constant Tc= RC.

From graph

i) From Vc(t) and t

Tc_1= $t_1+t_2/2$ = …………... Sec

ii) From I(t) and t

Tc_2= $t_1+t_2/2$ = …………... Sec

iii) From Log_{10} $I(t_1)$ and Log_{10} $I(t_2)$

Tc_3= $t_2-t_1/2.303$[Log_{10} $I(t_1)$- Log_{10} $I(t_2)$] = ………. = ………… Sec

iv) Average Tc= (Tc_1 +Tc_2 +Tc_3)/3 = ………… = …………..…. Sec

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

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

Calculation Table:

S. No.	Experimental value of Tc				Theoretical value of Tc (Sec)	% error
	From Vc(t)-t graph (Sec)	From I(t)- t graph (Sec)	From Log10 I(t1)- t graph (Sec)	Average Tc (Sec)		

Result:

S. No.	Experimental value of Tc				Theoretical value of Tc (Sec)	% error
	From Vc(t)-t graph (Sec)	From I(t)- t graph (Sec)	From Log10 I(t1)-t graph (Sec)	Average Tc (Sec)		

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. Mention one important application of RC circuit?

Ans. It is used to quench the discharge in nuclear detectors specially in given counter.

Q.10. Does any other current correspond to charging and discharging of a 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 ID = $(\varepsilon_0)d\phi/dt = (\varepsilon_0 A)dD/dt$.

Experiment No.: 8

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

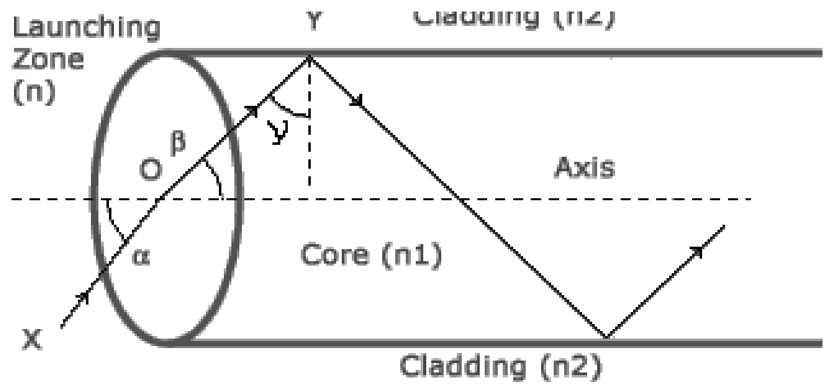
$$NA = \sqrt{n_1^2 - n_2^2}$$

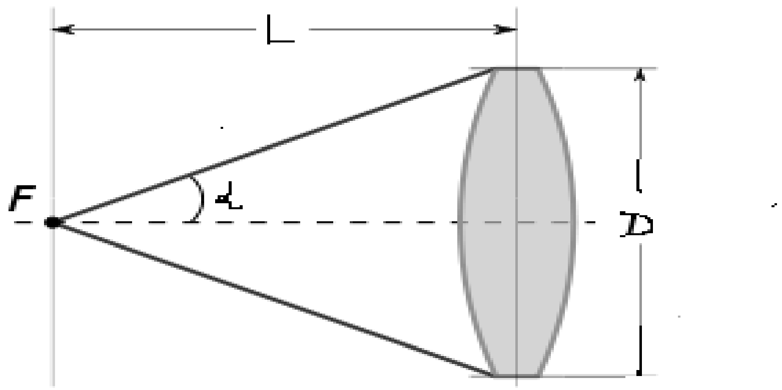
As n_0 = 1in air, NA= sinα

$$NA = \frac{D}{\sqrt{4f^2 + D^2}}$$

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:-

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.

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
(vii) Electric insulation

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

Experiment No.: 9

Object: To determine the coherence length and coherence time of laser using He – Ne laser.

Apparatus: Optical Bench, LASER Source, Optical Screen, Diffraction Grating.

Formula: The wave length λ of any spectral lines can be calculated by the formula:

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

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

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 1: Energy Level Diagram of He-Ne LASER

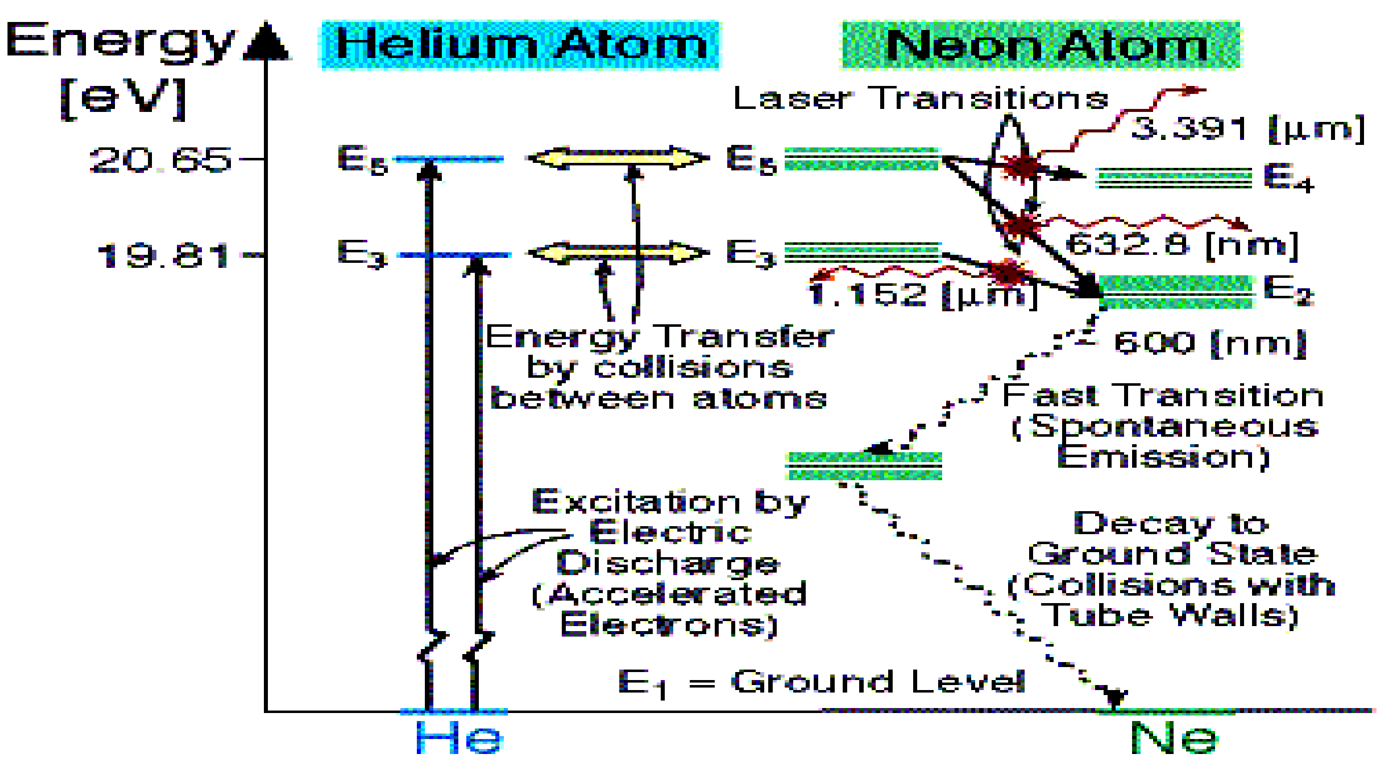
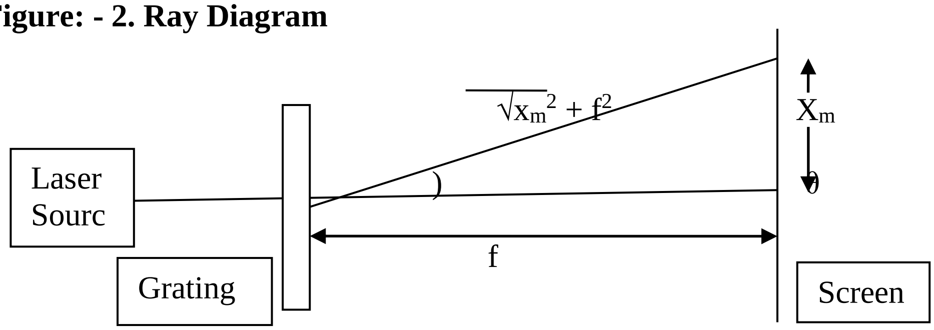


Figure: - 2. Ray Diagram



Procedure:

On the optical screen well defined spectrum is obtain. In the middle of it there is 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 θ = $[x_m/\sqrt{(x^2_m+f^2)}]$
			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 , 2nd and 3rd order of spectrum. Calculate mean wave length.

$\lambda = (\lambda_1 + \lambda_2 + \lambda_3)/3$ = ……..cm

= ………. Ǻ

Calculation of coherent length

$\Delta\lambda$ = 0.01 Å (given)

$\Delta l = \lambda^2/\Delta\lambda$,

Coherent Time $\tau = \Delta l/C$

Result: The wavelength of He-Ne LASER is λ = ……… Ǻ

Coherent length of Laser = ……. Ǻ

Coherent Time of Laser = ….. sec.

Standard value of λ = 6328 Ǻ

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.

Viva-Voce:

Q.1 What is laser?

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

Q.2 What is meant of laser?

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

Q.3 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

Q.4 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.

Q.5 Is He-Ne laser is four energy level laser system?

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

Q.6 Give an example of three level laser.

Ans. Ruby laser

Q.7 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.

Q.8 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".

Q.9 Mention the basic characteristics of laser light source.

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

Q.10 What do you mean by solid angle?

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

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

Q.11 What is wavelength of light emitted from He-Ne laser?

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

Q.12 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.

Q.13 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.

Q.14 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.

Q.15 Which is the active gas in He-Ne gas laser?

Ans. Ne gas

Q.16 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.).

Q.17 What type of pumping source we use in He-Ne gas laser?

Ans. Electric discharge.

Q.18 What is the role of diffraction grating in your experiment?

Ans. It diffraction the incident laser light

Q.19 How many orders do you achieve in your experiment?

Ans. 2 order.

Q.20 In which state stimulated emission takes place in He-Ne gas laser?

Ans. $E_6 \rightarrow E_3$

Experiment No.: 10

Object:

1. To determine the Hall voltage developed across the sample material.
2. To calculate the Hall coefficient and the carrier concentration of the sample material.

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

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

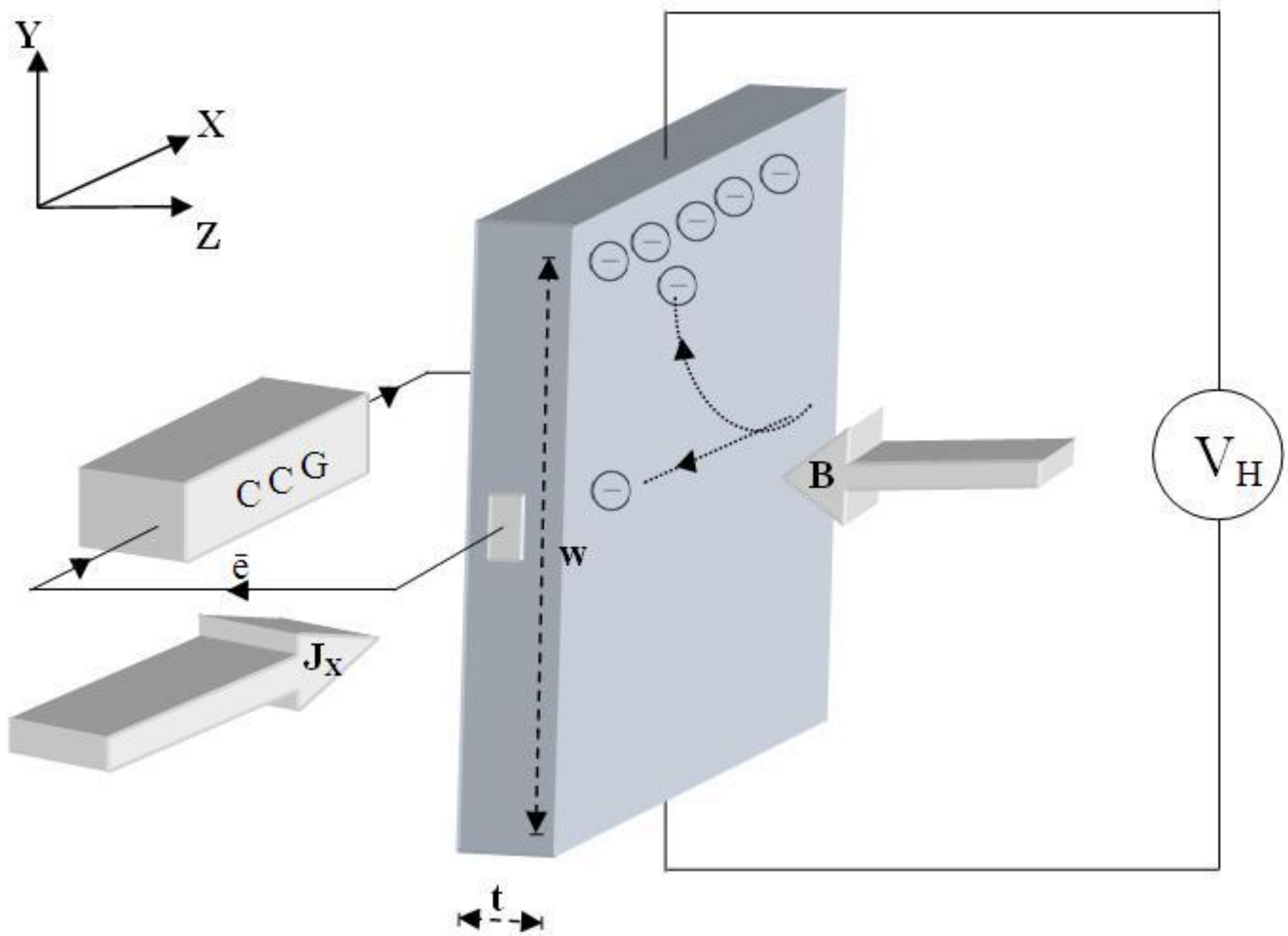


Fig. 1 Schematic representation of Hall Effect in a conductor.
CCG – Constant Current Generator, $\boldsymbol{J_X}$ – current density
$\bar{e}$ – electron, ***B*** – applied magnetic field
t – thickness, ***w*** – width
$\boldsymbol{V_H}$ – Hall voltage

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 $\boldsymbol{V_H}$ 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 force, $F_m = q(v x B)$ 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

$$eE = evB \tag{2}$$

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,

$$I = neAv \tag{3}$$

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,

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

$$V_H = R_H \frac{IB}{t} \tag{4}$$

by rearranging eq(4) we get

$$R_H = \frac{V_H * t}{I * B} \tag{5}$$

Where R_H is called the Hall coefficient.

$$R_H = 1/ne \tag{6}$$

<u>Procedure</u>:

- 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

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

Where R_H is the Hall coefficient

$$R_H=1/ne$$

And ***n*** is the carrier concentration

- Repeat the experiment with different magnetic file.

Observation Table:

Serial No:	Magnetic Field (Gauss)	Thickness (t) m	Hall current, mA	Hall Voltage mV	R_H
1					
2					
3					
4					
5					

Result

Hall coefficient of the material = ...

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

Precautions:

Personal

- 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.

Apparatus

- 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 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.