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LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE & Affiliated to JNTUK, Kakinada)

(Accredited by NAAC with "A" grade)

Jonnada (Village), Denkada (Mandal), Vizianagaram Dist – 535 005

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VISION & MISSION OF THE INSTITUTE

VISION

Producing globally competent and quality technocrats with human values for the holistic needs of industry and society

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Envisions mechanical engineers of highly competent and skilled professionals to meet the needs of the modern society.

MISSION

- Providing a conducive and inspiring learning environment to become competent engineers.
- Providing additional skills and training to meet the current and future needs of the Industry.
- Providing an unique environment towards entrepreneurship by fostering innovation, creativity, freedom and empowerment.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will have strong knowledge, skills and attitudes towards employment, higher studies and research.

PEO2: Graduates shall comprehend latest tools and techniques to analyze, design and develop novel systems and products for real life problems.

PEO3: Graduates shall have multidisciplinary approach, professional attitude, ethics, good communication, teamwork and engage in life-long learning to adapt the rapidly changing technologies.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop and implement sustainable mechanical and environmental systems.

PSO2: Qualify in national and international competitive examinations for successful higher studies and employment.

PROGRAM OUTCOMES (POs)

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 analyze 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 including prediction and modeling 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 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 give 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 a team, to manage projects and in multidisciplinary environments.

PO12: Life-Long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OBJECTIVES

1. To compute the radius of curvature of a given convex lens & thickness of given thin paper by forming the Newton rings & parallel fringes using the interference in thin air films.
2. To determine the wavelengths of various spectral lines in the polychromatic source (Hg source) and to determine the wavelength of Laser source by diffraction phenomenon.
3. To study the T-R characteristics of thermistor & to find the energy band gap of semiconductor by understanding & analyzing the variation of resistance with temperature in devices such as thermistor, semiconductors, etc.,
4. To calculate the rigidity modulus of the given wire & acceleration due to gravity at a given point by studying the modified simple harmonic oscillations using a Torsional and compound pendulums respectively.
5. To verify the laws vibrations of stretched string & to determine the velocity of sound in air by using the resonance phenomenon.
6. To study the V-I characteristics of Zener diode & to find the breakdown voltage of Zener diode.
7. To study the variation of intensity of magnetic field with distance along the axis of a circular coil carrying current.
8. To study the frequency response characteristics of LCR series circuit and to determine the resonance frequency.
9. To determine the numerical aperture, the acceptance angle & bending losses of the optical fiber.

COURSE OUTCOMES

1. Identify the working principles of laboratory experiments in optics, mechanics, electromagnetic and electronics.
2. Apply the working principles of laboratory experiments in optics, mechanics, electromagnetic and electronics and perform the experiments using required apparatus.
3. Compute the required parameter by suitable formula using experimental values (observed values) in mechanics, optics, electromagnetic and electronic experiments.
4. Analyze the experimental results through graphical interpretation.
5. Recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.
6. Demonstrate the working principles, procedures and applications.

COs – POs & PSOs MAPPING

SNO	DESCRIPTION	PO(1..12) MAPPING	PSO(1..2) MAPPING
C117.1	Identify the working principles of laboratory experiments in optics, mechanics, electromagnetic and electronics.	PO1, PO2, PO5, PO9	
C117.2	Apply the working principles of laboratory experiments in optics, mechanics, electromagnetic and electronics and perform the experiments using required apparatus.	PO1, PO2, PO5, PO9	
C117.3	Compute the required parameter by suitable formula using experimental values (observed values) in mechanics, optics, electromagnetic and electronic experiments.	PO1, PO2, PO9	
C117.4	Analyze the experimental results through graphical interpretation.	PO1, PO2, PO9	
C117.5	Recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.	PO1, PO2, PO9	
C117.6	Demonstrate the working principles, procedures and applications.	PO1, PO2, PO9	
COURSE OVERALL PO/PSO MAPPING: PO1, PO2, PO5, PO9			

COs – POs & PSOs LEVEL OF MAPPING & JUSTIFICATION

SNO	PO 1	P O2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	P O9	PO 10	PO1 1	PO1 2	PSO 1	PSO 2
C117.1	3	3			1				2					
C117.2	3	3			1				2					
C117.3	3	3							2					
C117.4	3	3							2					
C117.5	3	3							2					
C117.6	3	3							2					
C117*	3	3			1				2					

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

COs VS POs MAPPING JUSTIFICATION:

S.NO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
C117.1	PO1	3	The student can able to apply the knowledge of optics, mechanics, electromagnetism and electronics to identify the working principles of laboratory experiments.
	PO2	3	The student can able to identify the working principles of laboratory experiments.
	PO5	1	The student can able to use the Laser source as a modern tool for determining the wavelength of laser light.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to identify the working principles of laboratory experiments.
C117.2	PO1	3	The student can able to apply the knowledge of optics, mechanics, electromagnetism and electronics to identify the experimental procedure and to apply the working principles of laboratory experiments.
	PO2	3	The student can able to identify the procedure of laboratory experiments.
	PO5	1	The student can able to use the Laser source as a modern tool for determining the wavelength of laser light.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to identify the procedure of laboratory experiments.
C117.3	PO1	3	The student can able to apply the knowledge of optics, mechanics, electromagnetism and electronics to compute the required parameter by suitable formula using experimental values.
	PO2	3	The student can able to compute the required parameter by suitable formula using experimental values in mechanics, optics, electromagnetic and electronic experiments.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to compute the required parameter of laboratory experiments.
C117.4	PO1	3	The student can able to apply the knowledge of optics, mechanics, electromagnetism and electronics to analyze the experimental results through graphical interpretation.
	PO2	3	The student can able to analyze the experimental results through graphical interpretation.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to analyze the experimental results through graphical interpretation.

C117.5	PO1	3	The student can able to apply the knowledge of optics, mechanics, electromagnetism and electronics to recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.
	PO2	3	The student can able to identify the required precautions to carry out the experiment and handling the apparatus in the laboratory.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.
C117.6	PO1	3	The student can able to apply the knowledge of optics, mechanics, electromagnetism and electronics to demonstrate the working principles, procedures and applications of experiments through viva-voce.
	PO2	3	The student can able to demonstrate the working principles, procedures and applications of experiments through viva-voce.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to demonstrate the working principles, procedures and applications of experiments through viva-voce.
C117*	PO1, PO2, PO5, PO9	3,3,1,2	The student can able to acquire knowledge of basic experiments on Applied/Engineering Physics and apply these principles & knowledge in his/her engineering course.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

I B.Tech. MECH–II Semester

ENGINEERING/ APPLIED PHYSICS LAB
(Any 10 of the following listed experiments)

L	T	P	C
0	0	3	2

List of Experiments
(As Per R-16 Regulation of JNTUK, KAKINADA)

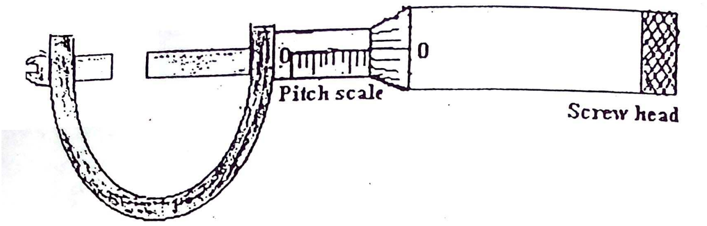
1. Determination of wavelength of a source-Diffraction Grating-Normal incidence
2. Newton's rings –Radius of Curvature of Plano Convex Lens.
3. Determination of thickness of a spacer using wedge film and parallel interference fringes.
4. Determination of Rigidity modulus of a material- Torsional Pendulum.
5. Determination of Acceleration due to Gravity and Radius of Gyration- Compound Pendulum.
6. Meld's experiment – Transverse and Longitudinal modes.
7. Verification of laws of stretched string – Sonometer.
8. Determination of velocity of sound – Volume resonator.
9. L C R Series Resonance Circuit
10. Study of I/V Characteristics of Semiconductor diode
11. I/V characteristics of Zener diode
12. Characteristics of Thermistor – Temperature Coefficients
13. Magnetic field along the axis of a current carrying coil – Stewart and Gee's apparatus.
14. Energy Band gap of a Semiconductor p - n junction.
15. Hall Effect in semiconductors.
16. Time constant of CR circuit.
17. Determination of wavelength of Laser source using Diffraction Grating.
18. Determination of Young's modulus by method of single Cantilever oscillations.
19. Determination of Lattice constant – lattice dimensions kit.
20. Determination of Planck's constant using photocell.
21. Determination of surface tension of liquid by capillary rise method.

Instructions for Students@ Applied / Engineering Physics Laboratory

- The objective of the laboratory is learning (application point of view). 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 & to experience the application based analytical thinking) and equally share the work with your partners.
- Be honest in recording and representing your data. Never make up readings or manipulate 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.
- Bring observation book cum manual and necessary graph papers for each of experiment. Learn to optimize on usage of graph papers.
- Graphs should be neatly drawn with pencil. Always label the graphs, the axes and display units. Please write the scale at the top-right most corner of the graph paper.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs.
- Come equipped with calculator, pen, scale, pencil, eraser, sharpener, etc.
- Get the signature from your Lab Faculty before leaving the lab on your observation book. And also submit your pending calculations & graph works within two days after completion of your lab.
- Do not fiddle idly with apparatus. Handle instruments with care. Report any breakage to the Lab-Technician/ Faculty.
- Return all the equipment at the end of your experiment.
- Bring your records at each lab session & submit it for the correction of previously completed experiments.

SCREW GAUGE

It is an instrument used for the measurement of very small lengths (such as the diameter of a wire and thickness of a disc) with greater accuracy than is possible with veriner calipers. The screw gauge consists of U-shaped metal frame which is attached to a hallow cylinder with a screw head. The screw head has a cap which is marked with 100 equal divisions. This is called Head scale. The hallow cylinder is marked in millimeters called Pitch scale. The distance advanced on the pitch scale when the screw head is turned through one complete revolution is called the pitch of the screw. Least count of the screw gauge is the distance advanced by the screw when the screw is turned through one division on the head scale.



L.C of the screw gauge = pitch of the screw/No of Head scale divisions.

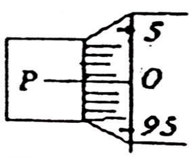
Pitch of the screw = Distance moved on the pitch scale for one rotation of the head.

The distance is divided by 5 gives the value of the pitch of the screw. Again the pitch of the screw is divided by the number of head scale divisions and the resulting value is the least count of the screw gauge.

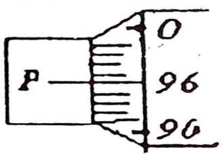
The screw head is turned until the two jaws touch each other. If the zero of the head scale exactly coincides with the zero of the pitch scale line (called index line) then there is no zero error and no correction is to be made to the head scale reading. If they do not coincide then the instrument is said to have zero error and a correction is to be applied. In fig (a) the zero of the head scale coincides with the pitch scale line and hence correction is zero. If the zero division of the head scale is above the pitch scale line then the error is negative and the correction is positive. In fig (b) the zero of the head scale is 4 divisions above the index line, hence the error is -4 and the correction is +4. Therefore 4 must be added to the head scale reading.

In fig(c) zero of the head scale is below index line the error is +6 and correction is -6 which means that 6 must subtracted from the head scale reading.

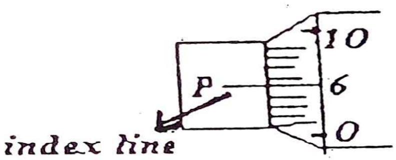
P is the index line on the pitch scale



Zero error 0
Correction 0
Fig (a)



Zero error – 4
Correction + 4
Fig (b)



Zero error + 6
Corrction – 6
Fig (c)

Place the given object between the two jaws of the screw gauge and the screw head is turned gently until the two jaws touch the object. Note down the pitch scale reading (PSR) and head scale division opposite to the pitch scale index line called head scale reading (HSR). Correct the head scale reading (CHSR) in case the correction is not zero. Then

Total reading = PSR + (CHSR x Least count)

The process is repeated at three different locations along the length of the wire and determines the average diameter of the wire or thickness of given object.

VERNIER CALIPERS

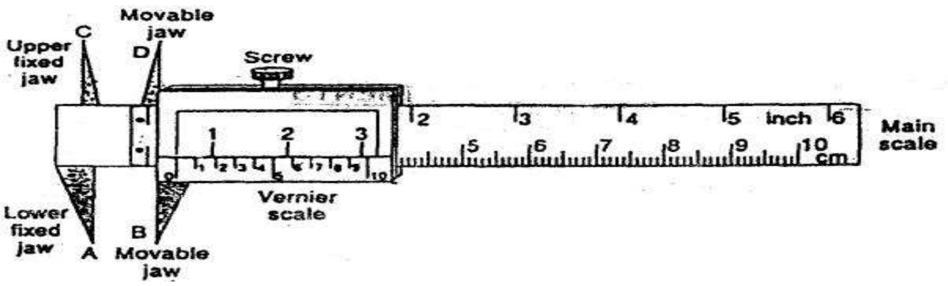
A scale is used to measure the length of an object. One end of the object is made to coincide with the zero of the scale, the other end of the object falls between the fifth and sixth divisions. This means that the length of the object is greater than 5 divisions and less than 6 divisions. So the length of the object is 5 divisions plus some fraction of a scale division. An accurate measurement of this fractional length can be made by means of veriner calipers and screw gauge.

A Veriner caliper is an instrument used for the measurement of small lengths such as diameter of a disc and diameter of a bob. A veriner calipers consists of a rectangular metal strip, graduated in centimeters, with a fixed jaw at one end. This is called main scale. A movable jaw with veriner attached to it slides along the main scale and can be fixed at any position with a screw. This is called veriner scale. The veriner scale is graduated in such a way that the length of 10 divisions on the veriner scale (VSD) is equal to length of 9 main scale divisions (MSD). Thus the length of 1 VSD = 9/10of the MSD. Then the difference between one MSD and one VSD is 1-9/10) MSD= 1/10 MSD, which is called the Least count of the veriner calipers. The least count of veriner calipers of an instrument is the smallest value that can be measured with that instrument.

1 MSD = 1/10 cm;   10VSD= 9 MSD or 1 VSD = 9/10 MSD

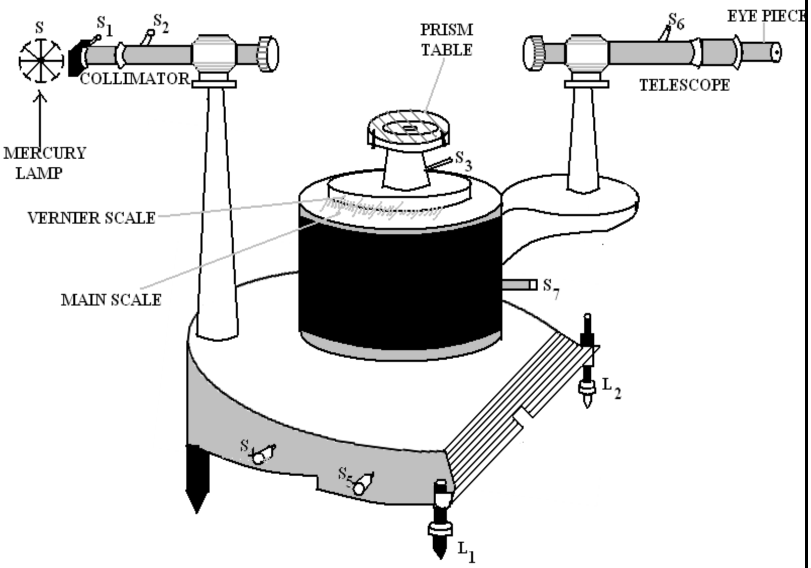
Least count of veriner calipers = 1MSD – 1 VSD = (1-9/10) MSD = 1/10 MSD

= (1/10) x 1/10 cm = 1/100 cm = 0.01 cm



Least count can also be expressed as 1 MSD/No. of veriner scale divisions.
Suppose the length of the object is to measure using veriner calipers. The object is placed between the fixed jaw and movable jaw. Suppose the zero of the veriner lies between 1.7cms and 1.8 cm. This means the length of the object is greater than 1.7 cm and less than 1.8 cm. The fractional part exceeding 1.7cm (called main scale reading MSR) can be determined from the veriner coincidence. Suppose the 4 division on the veriner exactly coincides with one of the main scale divisions. This veriner division which coincides with the main scale division is called veriner coincidence. So the fraction exceeding the 1.7cm is (4 MSD- 4 VSD). This fraction is equal to 4 (1MSD-1VSD) = 4xLeast count. Therefore the length of the object = MSR + (veriner coincidence x L.count)= 1.7 cm + 4 x 0.01 cm = 1.74 cm

SPECTRO METER



Align the spectrometer in order to correctly measure angles with the spectrometer, we must first align it. To do so, use the following steps:

a) **Telescope focus:** Do not put the prism onto the silver table yet. That will come later. Notice that there are two knobs associated with the telescope. They are located directly under the telescope barrel. One points along the barrel and one is perpendicular to it. The knob that is along the barrel will lock the telescope's position and will prevent it from rotating. When it is locked down in this way, you can use the other knob for a fine adjustment, to rotate it by very small amounts. If the telescope is not unlocked, turn the knob that is parallel to the barrel counterclockwise until you can freely rotate the telescope. Turn the telescope so that it is not pointing at the collimator but is instead aimed at something as far away from you in the room as possible. Now rotate the focus adjustment (**see diagram on page 12**) until you can see through the telescope clearly. You may notice that the image is upside down. This is normal. Just ensure that it is as clear and in focus as you can. ***After this adjustment, you should not adjust the focus of the telescope again***.

b) **Telescope alignment**: Now place a white light (desk lamp) in front of the slit on the end of the collimator (**in the diagram on page 12)**, the desk lamp goes where the "HG lamp" is pictured). Now rotate the telescope until it is pointed at the collimator. You should imagine a straight line going from the lamp through the collimator, and through the telescope. By looking through the telescope, you should be able to line up the crosshair with the slit in the far end of the collimator. By locking down the telescope and using the fine adjustment (the knob perpendicular to the one that you used to lock down the telescope) you should be able to do this very accurately.

   If you are unable to see the slit, it may be closed too tightly. You can widen and narrow the slit by rotating the adjuster on the collimator (it is located on the far end of the collimator, much like the focus for the telescope). This will adjust the slit width, but will not focus the slit. If the slit does not have very crisp edges when you look through the telescope, move the end of the collimator near the lamp in and out to focus it. If your slit is not vertical in the telescope, you can also rotate it so that it is. Once you have a nice thin, well-focused slit, with your crosshairs centered on it **and your telescope locked down**, you are now ready to align the scales to read the angle.

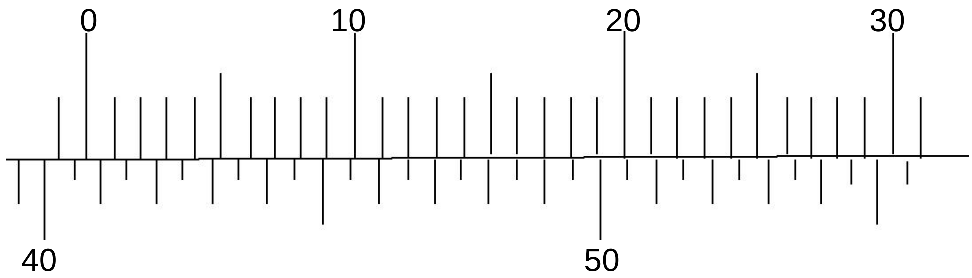
c) **Angle adjustment**: If you look below the set of knobs that control the telescope, you will see another pair of knobs that look identical to the ones for the telescope. These knobs perform the same functions (locking down and fine adjustment) for the black table itself. If you unlock the black table, you can rotate it. Notice that there are two windows in which you can read an angle. We want to rotate the table until one of the windows has 0 (zero) lined up with 0 (zero) or 360 (since a circle is 360 degrees, 360 is the same as 180. If at all possible, we should try to use set it so that this window is to the left of the telescope (as we are looking over the barrel toward the lamp) because this will make reading our angle easiest. (Please have a look at the diagram on page 5) On some scopes there is a small magnifier attached to the black table over one window, and this would also be advantageous to use. Once you have aligned them, you will ***lock down the black table and will not rotate it again***. From now on, we will ***only rotate the telescope.***

d) **Prism placement**: Now you should place the prism in the center of the silver table. Recall that light is bent toward the base of the prism, so it should be placed on the silver table so that the gray plastic part makes a "C" shape if you were to look at it from the telescope side of the apparatus. Now, without moving the telescope, move your head to the left (about to where the telescope is rotated to in the diagram on page 5) and look into the prism. You will have to put your head down at the height of the telescope/collimator. Now rotate the silver table clockwise until you can see a nice rainbow like spectrum “inside” the prism. (You should notice that the rainbow is inside of a black circle. You are seeing the light coming out of the collimator and bent through the prism.) If it does not look like a very nice, bright, well formed rainbow, you probably do not have your head in the right place; move further left and try to rotate the silver table back and forth. Once you have found it, unlock the telescope (**not the black table**) and rotate it **to the left** where you were looking. Now look through the telescope, and you should be able to find the rainbow. We are now in about the right place to find our spectrum with the mercury vapor lamp and to adjust for the minimum angle of deviation.

e) **Minimum angle of deviation**: Now, remove the white light and replace it with the mercury vapor lamp. You will want to move the lamp until it is aligned with the slit. To do this, look through the telescope and move the lamp back and forth until it is nice and bright in the telescope. **Instead of a complete rainbow, you should now see only certain bands of colors**. If your bands do not look nice and sharp, you may have to adjust your slit focus or width. Some lines are better seen if you tighten the slit. (The lamp should be very close to the slit.) Move the telescope back and forth until you get the cross hair lined up on the **green band**. Now look back to the diagram on page 12. We want to make the angle as small as possible. To do this, rotate the silver table back and forth just a little bit. You should be able to get the green line to move **to the right**. Now realign the crosshair on the green line and rotate the silver table a little bit again. Then realign the crosshair on the green line. You should repeat this process until no matter which way you rotate the silver table, the green line goes to the left, not the right. When this occurs, and the green line is as far as you can get it to go to the right, you are at the minimum angle of deviation. This angle should be around 51 or 52 degrees for the green line. If it is not, you may not have aligned the scales correctly, please repeat steps c, d, and e from above. (Record it below). Every time that you do a different color, you will have to repeat this process.

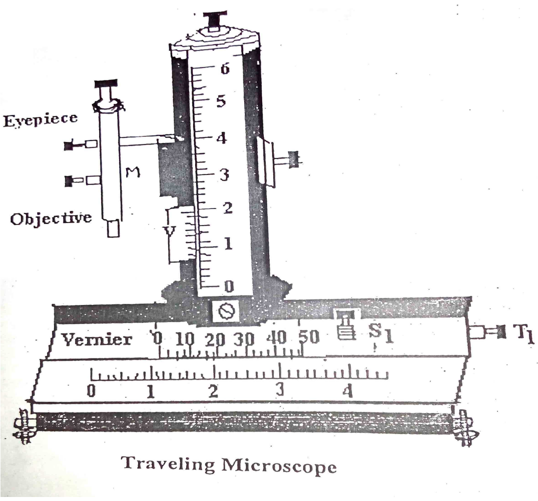
PROCEDURE: Become familiar with the spectrometer identify each component: the black table, the prism table, the collimator, and the telescope (see figure above). Note the clamping screws and the fine adjustment screws for the telescope and the black table. Note the clamping screw for the prism table. Note how to adjust the slit focusing in the collimator tube. Note how the slit width can be adjusted and how the slit orientation can be rotated

Practice reading the angle from a precise protractor scale on the rim of the black table. Use the Veriner scale with the little magnifying glass to read the angle to the nearest arc minute. (1 arc min = 1' = 1/ 60 degree.) **The following is an example**:



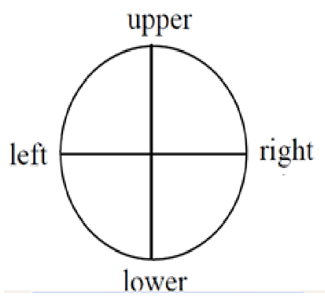
In this example, the zero line of the Vernier scale (the upper scale) is between 40° 30' and 41°, so the angle is somewhere between 40° 30' and 41°. The Vernier scale tells exactly where in between. Look along the Vernier for the line that exactly lines up with the line below it. In this case, it's the 17' line. So the angle is 40° 47', which we get by adding 17' to 40° 30'. Before using this angle in equation (2), we must convert it to decimal degrees: 40 + (47/60) degrees = 40.78°.

A Travelling Microscope



A travelling microscope is used to determine small distance to an accuracy of **0.001 cm**. The measurement principle is based on the principle of Vernier. In a typical travelling microscope, the main scale divisions are of magnitude **1/20 cm = 0.05 cm (0.5 mm)** each and the Vernier scale contains 50 divisions. This makes the Least Count to be **0.05/50 = 0.001 cm.**

Determination of diameter: For determination of diameter of the capillary along the horizontal direction. Mount the capillary tube in horizontal direction in a stand with the help of a rubber cork to place and hold the capillary tube. Rotate the microscope so that it is horizontal and in line with the tip of the capillary tube. Now looking through the microscope, turn the focusing screw to get a clear image of the capillary tube. Now adjust the microscope in such a way that the vertical crosswire coincides with the left end of the capillary tube. Take the reading in the horizontal scale, look the zero of the veriner, and find out the division on the main scale just before the zero mark. Note it as the MSR. Now look carefully at the Vernier. Any one of the fifty lines will come exactly in line with one of the lines of the main scale. That division on the **Vernier** is the Vernier scale reading. Note it down in the observation table. Now move the telescope horizontally to focus on the right end of the capillary tube. Again take the reading as before. Repeat the experiment by moving the telescope vertically coinciding the horizontal crosswire with top and bottom and now the readings are taken on the vertical scale. From the observations you will get two values of diameter, one for vertical and one for the horizontal.



Total reading = Main scale reading + Vernier coincidence x Least count

OBSERVATIONS: Least count of the traveling microscope = 0.001 cm

BACK – LASH EROR:

This error occurs when instruments like screw gauge, speedometer and travelling microscope are used, which work on screw-nut principle. Due to wear and tear of the screw or imperfect fitting, some space will be left between the screw and nut for its operation. If the screw is rotated for a certain angle of rotation in the forward direction and afterwards in the backward direction, then the screw will not move for a little motion of the head of the screw (or the misfits in the nut through which it moves). This error is called back-lash error. In order to avoid this error, the screw must always be moved in the same direction. This is to be remembered whenever we use any instrument using / involving screw motion.

Experiment No:
Date:

EXPERIMENT NO – 1

VOLUME RESONATOR

Aim: To Determine of velocity of sound in air at room temperature using Volume resonator

Apparatus: Aspirator bottle, beaker, measuring jar, tuning forks, Venier calipers, rubber hammer, meter scale.

Working Principle: It works on the principle of resonance. When air column vibrates with natural frequency of tuning fork, loud sound is heard due to increase in amplitude. The natural frequency **n** of vibrations of the air cavity is given by

$$n = \frac{V_t}{2\pi}\sqrt{\frac{A}{V\,L}}$$

Or

$$n^2 V = \frac{V_t^2\,A}{4\,\pi^2\,L} = \text{Constant}$$

Formula: The velocity of sound in air is

$$V_t = 2\pi n\sqrt{\frac{(V+e)L}{A}}$$

Where V_t is the velocity of sound at a temperature t,
n is the frequency,
A is the cross sectional area of the neck,
L is length of the neck,
V is the volume of the vibrating air up to the neck of the bottle,
and e is the end correction.

Since V, A and L are constants, the volume V of the air cavity is inversely proportional to the square of the frequency n of the note producing resonance in it. Therefore,

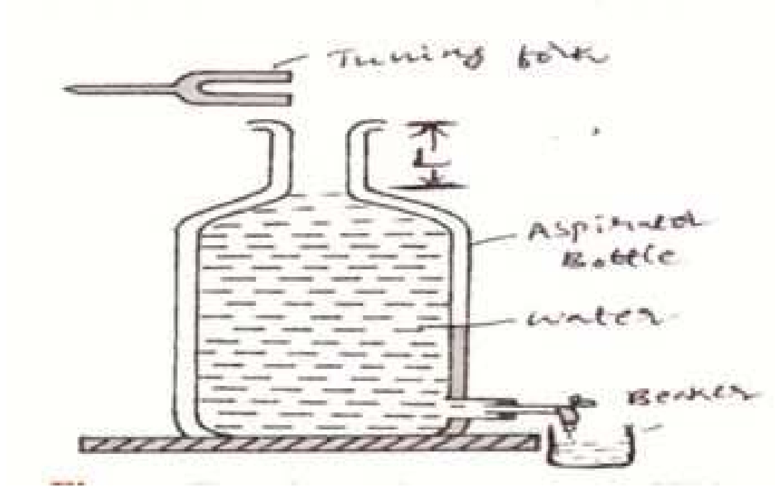
$$V \propto 1/n^2$$

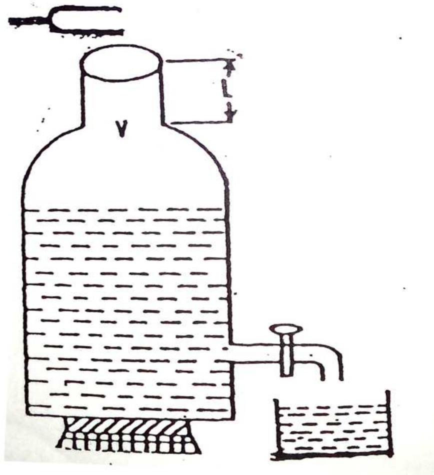
Or $$n^2 (V+e) = \text{constant}$$

Description:

The volume resonator consists of an aspirator bottle filled with water having a small neck and some outlet (opening) at its bottom. A bottle from which water is drawn through a narrow tube is called an aspirator bottle. The outlet is fitted with a one-holed rubber stopper into which a short glass tube is inserted. A rubber tube with a pinch cock is connected to the glass tube. Water can be drawn from the bottle into a measuring jar by opening pinch cock.

Experimental Diagram:





THEORY: Excited tuning fork kept at the neck of the bottle vibrates forcibly air column present above the surface of water. Water run down slowly is collected into a measuring jar. Longitudinal stationary waves are formed in air. As water is run down, at some instance, a booming sound is produced due to resonance. Here frequency of vibrating air column becomes equal to the frequency of the tuning fork.

PROCEDURE: The aspirator bottle is completely filled with water. A tuning fork of known frequency ‘n’ is excited and kept just above the neck of the bottle. Water in the bottle is slowly run down and collected in the measuring jar by opening the pinch cock. When volume of air inside the bottle reaches a particular value, loud sound is heard due to resonance. Then pinch cock is closed and volume ‘v’ of water collected is measured directly by the jar.

It is in fact equal to the volume of air present in the bottle. 3 more such readings are taken with different tuning forks and values are noted in the table. Length of the neck of the bottle is measured with a scale and its radius ‘r’ is measured by vernier calipers.

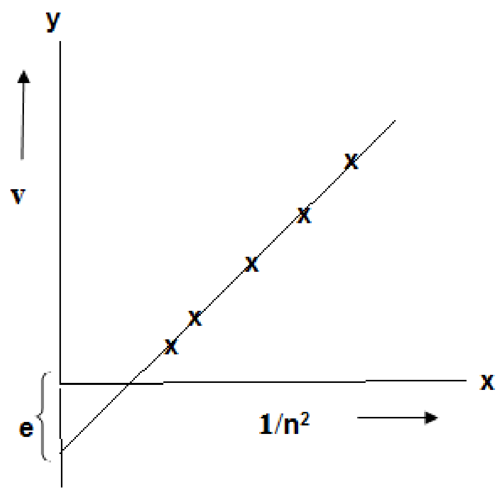
Observations:

S.No	Frequency n Hz	Volume of the resonating air column V(cc)			n^2	$1/n^2$	$(V+e) \times n^2$ = constant
		Trial 1	Trial 2	Mean			
1							
2							
3							
4							
5							
6							

Graph:

The actual volume of the air will be **(V+e)** instead of V where e is called as an end correction which is approximately equal to the volume of the air above the neck. The end correction is obtained by drawing a plot between **$1/n^2$** on x-axis and V on y-axis, which is a straight line with the negative intercept on y-axis. This intercept gives end correction **(e)**

$$(V+e)\, n^2 = \text{constant}$$



Knowing **V+e** from the graph the velocity of sound in air **(V_t)** at room temperature t is calculated using the equation

$$V_t = 2\pi n \sqrt{\frac{(V+e)L}{A}}$$

The velocity of the air at a particular temperature can be evaluated using the expression

$$V_0 = V_t\left(1 - \frac{t}{546}\right)$$

V_0 is the velocity of air at 0^0 C, **V_t** is the velocity of air at **t^0** C and t is the room temperature.

Calculations:

Applications:

1. Helmholtz resonators are used in architectural acoustics to reduce undesirable low frequency sounds by building a resonator tuned to the problem frequency, thereby eliminating it.
2. Helmholtz resonators are also used to build acoustic liners for reducing the noise of aircraft engines.
3. This method is used in silencers of car exhaust systems.
4. In stringed instruments such as the guitar and violin, the resonance curve of the instrument has the Helmholtz resonance as one of it speaks, along with other peaks coming from resonances of the vibration of the wood.

Precautions:

1. The exited tuning fork should not touch the aspirator bottle.
2. The water should be drawn slowly and uniformly.
3. The exited tuning fork should be kept horizontally above the neck of the bottle.

Result: The velocity of the sound at room temperature is V_t = cm/sec.

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Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

Viva Questions

1. **Define the wave. What are the factors which affects the wave?**
   A wave is a disturbance that moves along a medium from one end to the other. The factors which affect the wave are wavelength, frequency, velocity and mass density of the wave.
2. **Define transverse and longitudinal waves?**
   For transverse waves the displacement of the medium is perpendicular to the direction of propagation of the wave
   In the longitudinal waves the displacement of the medium is parallel to the propagation of the wave
3. **What is node and anti node?**
   A node is a point along a standing wave where the waves have minimum amplitude. For instance, in a vibrating guitar strings are nodes. The opposite of a node is an anti-node, a point where the amplitude of the standing wave is a maximum. These occur midway b/w the nodes.
4. **Define and explain about the resonance?**
   Resonance or sympathetic vibration may occur when an object is exposed to forced vibrations. If the frequency of these "forced" vibrations matches the object's "natural frequency" the object may begin to vibrate or, if it is already vibrating, a dramatic increase in the amplitude of these vibrations may occur. When either of these happens it is a called resonance or sympathetic vibration.
5. **Explain the difference b/w the forced vibration and natural vibration.**
   Forced vibration: When a periodic disturbing force keeps the body in vibration throughout its entire period of motion, such vibration is said to be a forced vibration. The frequency of vibration of the body is same as the frequency of the applied force.
   Natural vibration: In free vibration the body at first is given an initial displacement and the force is withdrawn. The body starts vibrating and continues the motion of its own accord. No external force acts on the body further to keep it in motion. The frequency of free vibration is known as free or natural frequency.
6. **Give an example of mechanical wave?**
   Water waves and sound waves are mechanical waves.
7. **How the resonance takes place in this experiment?**
   When the frequency of the vibrating tuning fork is equal to the natural frequency of the Vibrating air column in the aspirator bottle then the resonance takes place.

Experiment No:
Date:

EXPERIMENT NO – 2

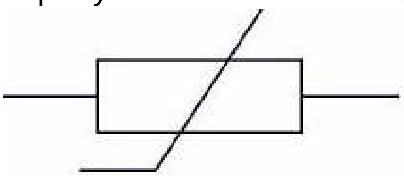
THERMISTOR

AIM: To determine the temperature coefficient of resistance of a given Thermister

APPARATUS

A Thermister, thermometer, a heating arrangement to heat the Thermister, constant current power supply, galvanometer, milli meter and volt meter

WORKING PRINCIPLE: ***Thermally Varying Resistance:*** The basic the electrical resistance of the device changes drastically when the temperature is varied. These devices are called thermistor because of their thermally sensitive property of resistance. These materials have a negative temperature coefficient of resistance.



Thermistor Symbol

Formula:

The temperature coefficient of resistance of Thermister is

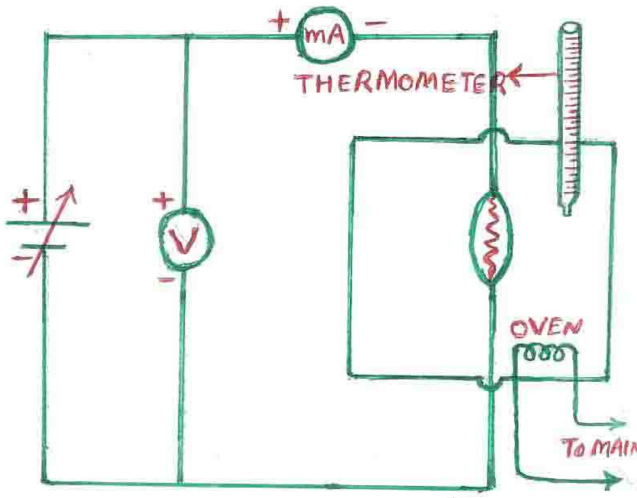
$$\alpha = \frac{R_2 - R_1}{R_1 T_2 - R_2 T_1} \ /^0C$$

Where R_1 and R_2 are the resistances of thermistor and T_1 and T_2 are temperatures

THEORY:

Thermistors are semiconductor devices. The basic property is the electrical resistance of the device changes drastically when the temperature is varied. These devices are called thermistor because of their thermally sensitive property of resistance. Thermister materials are mainly ceramic compounds having semiconductor properties. They are made up of oxides of Mn, Ni, Fe and Co and blended in suitable proportion and compressed in to desired shapes from powders and heat treated to re crystallize them, Suitable combination of these oxide materials are used to obtain the necessary range of resistance. Conduction is controlled by the concentration of the oxygen in the semiconductors. N-type oxide semiconductors are produced when the metal oxides are compounded with deficiency of oxygen.

Circuit diagram:



Because of this process there will be excess ionized metal atoms in the lattice. P-type semiconductors are produced when there is excess of oxygen, which results in deficiency of ionized metal atoms in the lattice. 'α' is called the temperature coefficient of resistance for a given material.

It is positive for metallic elements as their resistance increases with temperature. Hence the materials have a positive temperature coefficient of materials. On the other hand α is negative for carbon and semiconductors because their resistance which decreases with increasing temperature. These materials have a negative temperature coefficient of resistance.

FORMULAE:

The variation of resistance (R) of a thermistor with temperature (T) is given by,

$$R = A\, e^{\frac{B}{T}} \quad \text{---------} \quad (1)$$

where 'A' and 'B' are constants, which are to be experimentally determined,' R' is the resistance of the thermistor and 'T' is the temperature.

Taking logarithm on both sides, we get

$$\log_{10}R = \log_{10}A + \left(\frac{B}{2.303}\right)\frac{1}{T} \qquad (2)$$

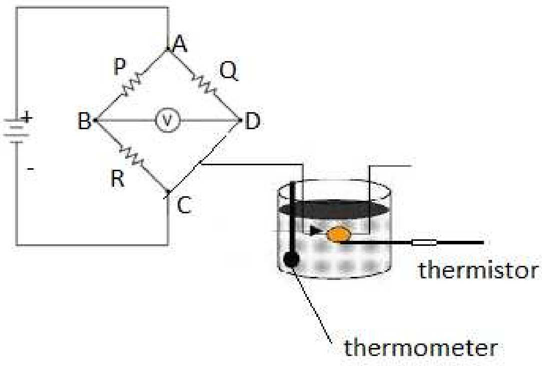
Now the temperature coefficient of resistance 'α' of the thermistor is given by,

$$\alpha = \frac{1}{R}\frac{dR}{dT} = -\frac{B}{T^2} \qquad (3)$$

Evidently, α is negative (as expected) and is also temperature dependent.

The temperature coefficient of thermistor materials is many orders of magnitude greater than that of metals. From (2),

Experimental diagram



$$\text{Log}_{10}R = \log_{10}A + \left(\frac{B}{2.303 x 10^3}\right)\frac{10^3}{T} \qquad (4)$$

This is in the form y = m*x* + c where the slope **m =** $\frac{B}{2.303x10^3}$ (5)

Taking the value of B from the above equation (5), the activation energy can be determined as follows

$$E_g/2k = B \quad \text{or} \quad E_g = 2KB \qquad (6)$$

The temperature resistance characteristics of the thermistor exhibits an exponential type of behavior and it is given by the relation

$$R = R_0 \exp\left[B\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$

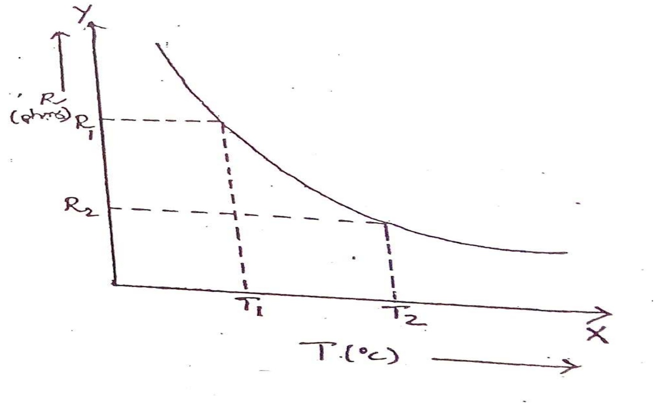
If we differentiate this equation we get,

$$\frac{\Delta R}{\Delta T} = R_0 \exp\left[B\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]\frac{-B}{T^2}$$

But $\frac{1}{R}\frac{\Delta R}{\Delta T} = \alpha$, where $\alpha = \frac{-B}{T^2}$

GRAPH:

A plot drawn between log R on y-axis and $10^3/T$ on x-axis gives a straight line and slope of this line is equal to $B/2.303x10^3$.By measuring the slope of the graph we can determine the value of B.



The intercept (OP) along the y-axis as shown in the model graph gives the value of log A from which the value of ‘A’ is calculated.

From the graph temperature coefficient of resistance ‘α’ can be calculated using the formula

$$\alpha = \frac{R_2 - R_1}{R_1T_2 - R_2T_1} \ /^0C$$

Where R_1 and R_2 are the resistances of the thermistor at the temperatures T_1 and T_2 respectively.

PROCEDURE:

1. Connect the +5V power supply to power supply socket and galvanometer socket
2. Also connect the variable resistance (0 to 1000 Ω) to variable resistance socket and thermistor terminal to thermistor socket which are given on heater.
3. Put up the thermistor to heater where the thermistor keeps up option
4. Switch on the kit and set the galvanometer to zero by variable resistance. Switch on the heater
5. As soon as the temperature increases i.e. 30^0C, 35^0C, 40^0C, 45^0C, 50^0C, 55^0C, 60^0C, 65^0C, 70^0C and 75^0C the value of resistance is found by multimeter. (Suppose the temperature is 40^oC, now the galvanometer shows some deflection now decrease it to zero by variable resistance and take reading of resistance by multimeter. This is the reading of R at 40^oC. Similar take readings for different temperatures).
6. Note down the readings & Plot the graph between R Vs T(K).

OBSERVATIONS: **Input Voltage V_i =**

SNo	Temperature t (^{0}C)	Current (I) mA	Temperature T = t + 273 (K)	$\frac{1000}{T}$ (K^{-1})	Resistance R KΩ	Log R
1	30^0					
2	35^0					
3	40^0					
4	45^0					
5	50^0					
6	55^0					
7	60^0					
8	65^0					
9	70^0					
10	75^0					

APPLICATIONS:

1. Thermistor can be used as current-limiting devices for circuit protection, as replacements for fuses. Current through the device causes a small amount of resistive heating. If the current is large enough to generate more heat than the device can lose to its surroundings, the device heats up, causing its resistance to increase, and therefore causing even more heating. This creates a self-reinforcing effect that drives the resistance upwards, reducing the current and voltage available to the device.
2. Thermistors are used for Self regulating heaters, Liquid level sensing, Motor starting.
3. Thermistors are used as resistance thermometers in low-temperature measurements of the order of 10 K.
4. Thermistors are regularly used in automotive applications. For example, they monitor things like coolant temperature and/or oil temperature inside the engine and provide data to the ECU(Engine Control Unit).
5. Thermistors are also commonly used in modern digital thermostats and to monitor the temperature of battery packs while charging.

PRECAUTIONS:

1. The thermistor and thermometer are kept at the same level in the oil bath.
2. The temperature of the thermistor should not be allowed to go beyond 80^0 C.

CALCULATIONS:

RESULT: The temperature coefficient of resistance of the given Thermister is =

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

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VIVA QUESTIONS

1. **What is a thermistor?**
   Thermistor is a semiconductor material usually prepared from metal oxides whose electric resistance changes drastically for even minute changes in temperature.

2. **What is positive temperature coefficient of resistance?**
   A positive temperature coefficient (PTC) refers to materials that experience an increase in electrical resistance when their temperature is raised. e.g. all conductors

3. **What is negative temperature coefficient of resistance?**
   A negative temperature coefficient (NTC) refers to materials that experience a decrease in electrical resistance when their temperature is raised. e.g. semiconductors

4 **What is the difference of semiconductor diode and thermistor?**
In a semiconductor the carrier concentration depends on temperature but the carrier concentration is temperature independent in case of thermistor. The variation of electrical resistance in thermistor with temperature is due to only the thermal activation of charge carriers with increase of temperature.

5 **What is activation energy?**
The quantity of energy required for the electric conduction to take place in a thermistor is called as the activation energy.

EXPERIMENT NO-3

TORSIONAL PENDULUM

Aim: To determine the rigidity Modulus of the given wire by dynamical method.

Apparatus: Torsional pendulum, stop watch, screw gauge, Venier calipers, scale.

Working Principle: Torsional pendulum is an ***angular form the linear simple harmonic oscillator*** in which the elasticity is associated with twisting a suspension wire. In Torsional pendulum the mass rotates around its center point and twists the suspending wire. This is called Torsional pendulum with torsion referring to the twisting motion.

Formula: The Rigidity modulus of the given wire is

$$\eta = \frac{8\pi I}{a^4} \times \frac{l}{T^2}$$

Where, η is the rigidity modulus,

a is the radius of the given wire,

I is the moment of inertia

l is the length of the pendulum from the fixed point

T is time period.

Theory: A heavy cylindrical disc suspended from one end of a fine wire whose upper end is fixed constitutes a Torsional pendulum. The disc is turned in its old plane to twist the wire, so that on being released, it executes Torsional vibrations about the wire as axis.

Experimental Diagram:

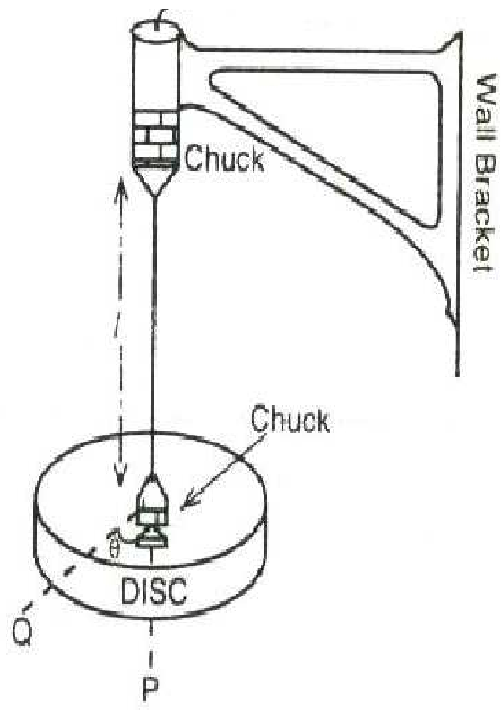


Figure : *Torsional Pendulum*

Let θ be the angle through which the wire is twisted.

Then the restoring couple set up in it is equal to $\frac{(\pi.n.a^4.\theta)}{2l} = c\theta$ Where $\frac{(\pi.a^4.n)}{2l} = c$ ------ (1)

is the twisting couple per unit (radian) twist of the wire.

This produces an angular acceleration (dw/dt) in the disc

Therefore if "I" is the moment of inertia of the disc about the wire we have I. $\frac{dw}{dt} = -c.\theta$ $\quad \frac{dw}{dt} = -\left(\frac{c}{I}\right)\theta$

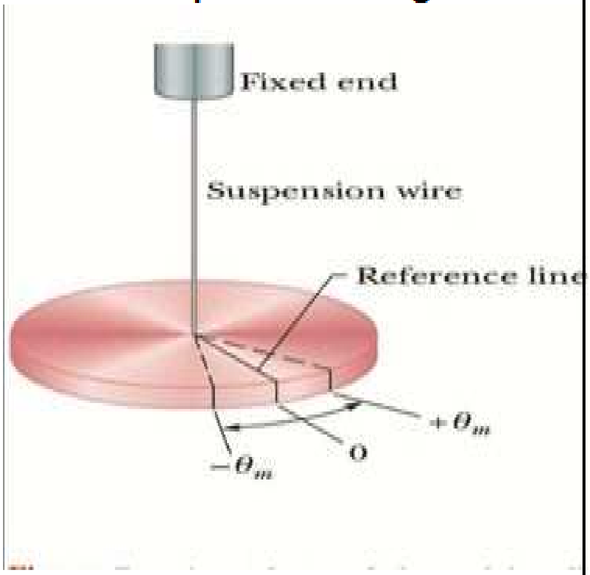
i.e the angular acceleration $(\frac{dw}{dt})$ of the angular displacement(θ). Therefore its motion is simple harmonic hence time period is given by T= $2\pi\sqrt{\frac{I}{c}}$ ---- (2)

From (1) (2) $\eta = \frac{8\pi I}{a^4} \times \frac{l}{T^2}$

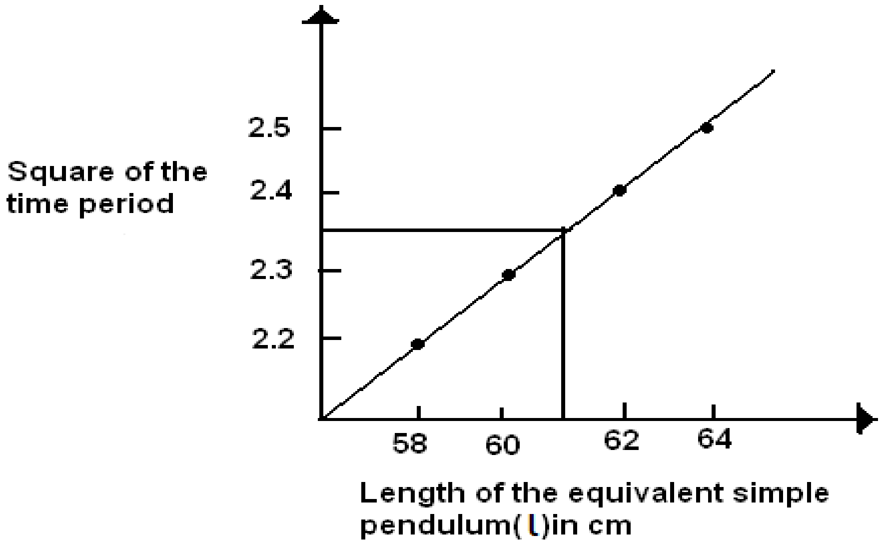
In case of a circular disc whose geometric axes coincide with the axis of rotation. The moment of inertia "I" is given by I= $\frac{(MR^2)}{2}$ Where M is the mass of disc and "R" is the radius of the disc.

$$\eta = \frac{8\pi}{a^4} \times \frac{(MR^2)}{2} \times \text{Slope} \quad \text{dynes/cm}^2$$

Experimental Diagram:



Graph: Plot a curve for l *Vs* T^2 and calculate the slope.



Determination of the Period of Oscillation 'T':

S.No	Length of the Wire l (cm)	Time for 10 (or 3) oscillation (t)			Time Per one oscillation T= (t/3)		$\frac{l}{T^2}$
		Trial1	Trail2	Mean(t)	T	T^2	
1	20						
2	25						
3	30						
4	35						
5	40						
6	45						
7	50						
8	55						

To determine the radius of the disc:

S. No	Main scale reading(a)	Vernier Coincidence	Vernier Reading (b=L.C x V.C)	Total Reading (a + b)cm
1				
2				
3				

To determine the radius of the wire:

S. No	P.S.R (a)	H.S.R	H.S.C	H.S.R (b=L.C x H.S.C)	Total (a+b) (mm)
1					
2					
3					

Applications:

1. To study the strength of materials.
2. To find the tensile strength of a wire.
3. To find MI for the girders and metal sheets.

Objectives:

1. Determine (η) for a given wire.
2. Find the relation between L and T^2 from graph.
3. Find the relation between material of a wire and period of oscillation.

Calculations:

Precautions:

1. while using vernier calipers see that the readings must be taken without any parallax error
2. Measure the thickness of wire using screw gauge.
3. Note the disc should be rotated along with its own axis.

Result: The rigidity modulus of the given wire using dynamical method is

η = dynes/cm^2

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

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Viva Questions

1. **Define the different types of modulii of Elasticity?**
   There are three modulii in use.
   (i) Young modulus: The ratio of longitudinal stress to longitudinal stress to longitudinal strain, within the elastic limits is called young's modulus of the material. its units its N/m^2 .
   (ii) Bulk modulus: When a uniform pressure is applied over the whole surface of a body, it produces a uniform compression. The compression is proportional to the pressure, and the ratio and the ratio of pressure to the volume strain is called bulk modulus. it is measured in N/m^2.
   (iii) Rigidity Modulus: The Rigidity Modulus describes an objects pendency to shear (deformation of shape at constant volume) When acted upon by opposing forces.
2. **Define stress and strain and state their units?**
   The magnitude of the attractive or repulsive Forces between molecules of a body per unit Area is called stress. It is measured in N/m^2. The change of shape or the fractional change Of size of a body by a given set of forces of Couples is called strain. Strain has no unit.
3. **List the different stages of elastic properties of Matter?**
   When a load continuously increased in case Of wire, it reaches different elastic stages Like: **(i)** elastic limit **(ii)** permanent set **(iii)** breaking stress **(iv)**yield point
4. **State Hooke's law and define modulus of elasticity?**
   The stress is proportional to the strain wit in the elastic limits is called Hooke's law. The ratio of any stress to the strain is called modulus of elasticity. It is measured in N/m$^{2.}$
5. **What is Poisson's ratio? What is its unit?**
   Within elastic limits there is a complete proportionality between the lateral strain and the Longitudinal strain is called poison's ratio. It has no units.
6. **What is a cantilever?**
   When one end of horizontal beam is fixed and the other end is free it is called a cantilever.
7. **How is bending of a beam related to young's modulus?**
   When a beam is bent by an applied couple, its longitudinal filaments are lengthened on the convex side and shortened on the concave and thus which the beam often to bending will depend up on young's modulus for the material

Experiment No:
Date:

EXPERIMENT NO – 4

COMPOUND PENDULUM

AIM: To determine the acceleration due to gravity 'g' and radius of gyration using a compound pendulum.

APPARATUS: Compound pendulum with suitable support for its suspension, stop-clock and a scale.

WORKING PRINCIPLE: ***Modified Simple Harmonic Motion:*** Any rigid body mounted upon a horizontal axis so as to vibrate under the force of gravity is a compound pendulum. The motion of such a body is an angular vibration about the axis of suspension is called Angular SHM or M SHM.

FORMULA: Acceleration due to gravity at a given place is.

$$g = 4\Pi^2 \left(\frac{l}{T^2}\right) cm/s^2$$

Where,

g = Acceleration due to gravity at a place in cm/s^2

l =Distance between the point of suspension and point of oscillation in cm

T = Time period of oscillation in seconds

THEORY: The point at which the steel bar is suspended is called the centre of suspension, (Points) while the other extreme point (Point 0) is called the centre of oscillation. These two points are interchangeable. The distance between the point of suspension and the point of oscillation gives the length of equivalent pendulum with the same time period. There will be many such pair of points i.e., the point of suspension and the point of oscillation, and 'T' is the corresponding time period, then we have

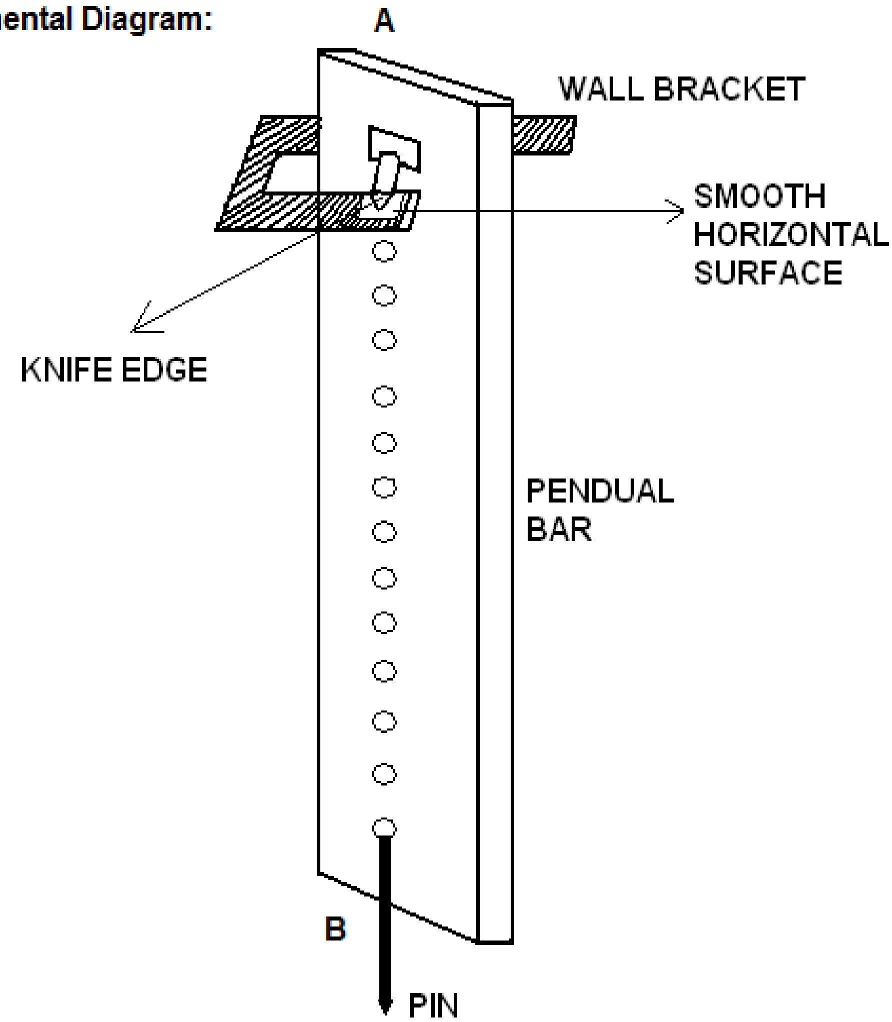
$$g = 4\Pi^2 \left(\frac{l}{T^2}\right) cm/s^2$$

PROCEDURE:

One end(A end) of the steel bar is suspended thorough the hole(S) as shown and allowed to oscillate(30 oscillations) and the time taken for 30 oscillations is noted (trail 1).The oscillations set up should be confined to vertical plane only. The experiment is repeated for the same point of suspensions and again the time taken for 30 oscillations is noted(Trail 2).The average time of these two trials is noted and then the time period T(i.e. time taken for one oscillation) is noted.

The bar is now suspended through the next hole and the experiment is repeated each time noting the time taken for 30 oscillations and the time period. The experiment is continued by suspending the bar through the successive holes and the time period is recorded. As we approach the centre of the bar, i.e., centre of gravity of the bar, the time period would increase considerably.

Experimental Diagram:



Now the pendulum is reversed i.e., B end is made to suspend through the hole and is allowed to oscillate as before (30 oscillations) and the time period is noted. It is to be noted that even after reversal, the distance of point of suspension is to be measured from the same end i.e., from same end A. The observations are recorded in the tabular form as shown.

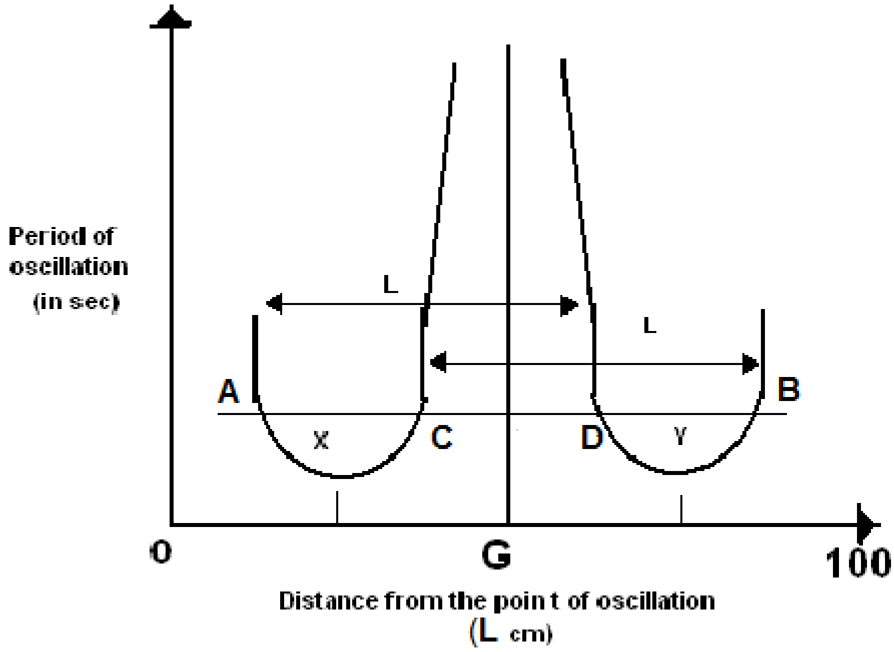
A graph is drawn with the distance of the point of oscillation from one end (A end) on the X-axis and the period of oscillation on the Y-axis. The graph consists of two symmetrical curves corresponding to the two halves of the bar. The bar is taken out and is balanced on a knife edge (the centre point) and the centre of gravity (G) of the bar is determined. The distance is from the A end of the bar to the centre of gravity is noted (50 cm) and is marked on the graph paper as G. It is to be noted that the ordinate through G is the line about which the two curves are symmetrical.

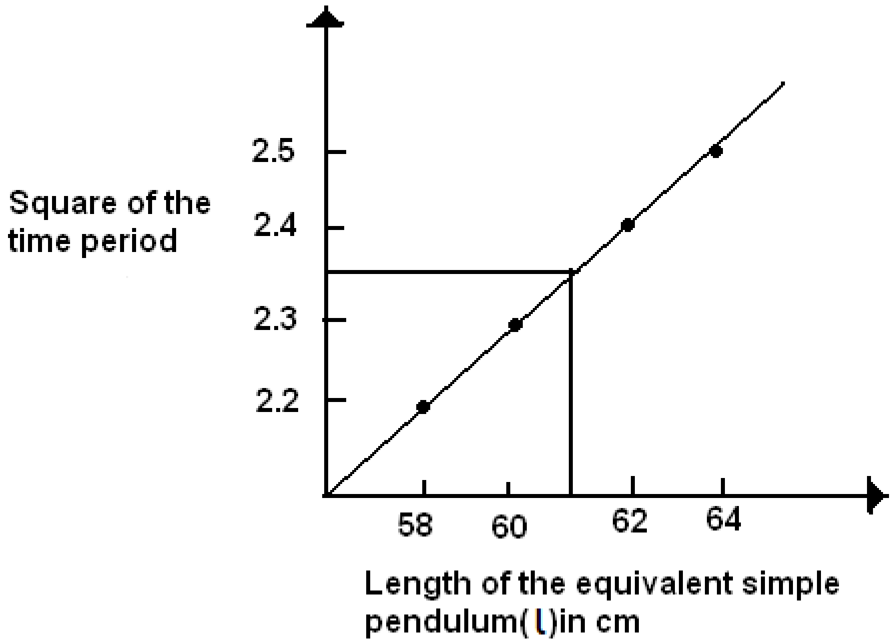
On the graph paper, a line ABCD is drawn parallel to x-axis intersecting the two curves at four points A, B, C, and D. It is to be noted that AC will be equal to BD. Each being equal to the length of the equivalent pendulum (*l*), corresponding to the time period (T).This value of l and t are substituted in the equation $g = 4\Pi^2 (\frac{l}{T^2})\, cm/s^2$ and the 'g' value at that place is obtained.

Table to determine the period of oscillation T of the compound pendulum

S.No	Distance of the point of suspension measured from one end of the bar(A-end only) (L in cm)	Time taken for 10 (or 5) oscillations (Sec)			Period of oscillation T (Sec)
		Trail 1	Trail 2	Mean	
1	5				
2	10				
3	15				
4	20				
5	25				
6	30				
7	35				
8	40				
9	45				
10	95				
11	90				
12	85				
13	80				
14	75				
15	70				
16	65				
17	60				
18	55				

Graph:





The radius of gyration k of the pendulum about an axis through its centre of gravity perpendicular to the broad face of the bar is obtained from the graph as:

$$K = \frac{XY}{2}$$

The moment of inertia (I_g) of the bar about an axis through its centre of gravity and perpendicular to the broad face is given by:

$$I_g = MK^2$$

Where, M is the mass of the bar.

The moment of inertia (I_g) of the bar about any other parallel axis at a distance'd' from the center of gravity is given by:

$$I = I_g + Md^2$$

$$= M(k^2 + d^2)$$

Table for to find the values of l, T^2 from the graph and to determine 'g'

S.No	Time Period	T^2	Length of the equivalent simple pendulum			l/T^2 Cm/sec^2
			AD	BC	$l = \frac{AD+BC}{2}\ cm^2$	
1						
2						
3						

Applications:

1. It is used in developing the experiments to measure the moments of inertia of hockey sticks, golf clubs, Frisbees, etc.
2. It is used in the analysis of compound pendulum rocket suspension modeling.
3. Examples of the application of compound pendulum theory to the practical measurements of the moments of inertia of human beings, farm tractors and sailing boats.
4. It is also used in CPJC (Compound Pendulum Jaw Crusher). CPJC is a kind of commonly crusher and is used in broken missions of the metallurgy, mining, chemicals, building materials, industries, as well as highway and railway construction.

CALCULATIONS:

PRECAUTIONS:

1. The knife edge should perfectly rest on the smooth horizontal surface.
2. The knife-edge should be horizontal and the pendulum should oscillate in a vertical plane.
3. Amplitude of oscillations must be small.
4. The time should be noted when the oscillations are regular.
5. The graph drawn should be a free-hand curve.

Result: Acceleration due to gravity g at a given place =

Radius of gyration K =

Signature of Faculty with date & Remark

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

Viva Questions

1. **What is acceleration due to gravity?**
   The acceleration due to gravity is the acceleration of a body due to the influence of the pull of gravity alone, usually denoted by ‘g’.
2. **What is simple harmonic motion?**
   Simple harmonic motion is a type of periodic motion where the restoring force is directly proportional to the displacement.
3. **What is compound pendulum?**
   Pendulum consists of an actual object allowed rotating freely around a horizontal axis.
4. **What is the ‘g’ value at the pole and at the equator?**
   At the equator and at the sea level its value of g is about 9.78m/s^2 and at the poles it is 9.83 m/s^2.
5. **What is the equivalent length of a simple Pendulum?**
   For these pendulums the appropriate equivalent length is the distance from the pivot point to a point in the pendulum called the center of Oscillation.
6. **What is meant by center of gravity?**
   It’s the geometric center of the sphere, for other shapes or for objects where the density is Not the same throughout, it’s more complicated.
7. **What are units and dimensions of g?**
   The units of g are m/s^2 and the dimensions is Length/time^2
8. **What is radius of gyration?**
   Radius of gyration or gyrations refers to the distribution of the components of an object around an axis. In terms of moment of inertia, it is the perpendicular distance from the axis of rotation to a point mass (of mass, m) that gives an equivalent inertia to the original object(s) of mass, (m).

EXPERIMENT NO – 5

ENERGY GAP OF THE SEMICONDUCTOR

Aim

To determine the energy band gap of the given semiconductor using p-n junction diode.

Apparatus

Semiconductor diode, dc power supply, Thermometer, Oven, Ammeter and Voltmeter.

Introduction

A semiconducting material is comprised of valence band and conduction band separated by a narrow energy difference of nearly 1eV. The conduction band is almost empty while the valence band is nearly full. This narrow energy gap is called as the forbidden energy gap or the energy band gap. There are two types of semiconductors. They are intrinsic (or) pure semiconductors and extrinsic (or) impure semiconductors. The electrical conductivity of a pure semiconductor can be drastically varied by addition of minute impurities. Extrinsic semiconductors are formed by adding impurity (doping) to pure semiconductors. The n-type semiconductor is formed by doping trivalent impurity (e.g. Ga^{3+}) to pure semiconductor while the p-type semiconductor is formed by doping a pentavalent impurity (As^{5+}). The p-type semiconductors are electron deficient while the n-type are excess in electrons.

WORKING PRINCIPLE:

The electrical conductivity of a germanium or silicon test piece is measured as a function of temperature. The energy gap is determined from the measured values.

Formulae:

The temperature dependence of reverse saturation current I_S in p-n junction diode is given by,

$$I_S = A\, e^{\frac{-E_g}{\eta KT}} \qquad (1)$$

where, A is the constant, E_g is the band energy gap of the semiconductor in eV, K in Boltzmann constant in 8.625×10^{-5} eV/K, T is the absolute temperature and η =1 for Ge and η = 2 for Si.
for instance in case of Ge,

$$I_S = A\, e^{\frac{-E_g}{KT}} \qquad (2)$$

On taking logarithm to base 10 on both sides, we get,

$$\log I_S = \log A - 0.4303 \left(\frac{E_g}{KT}\right)$$

$$\log I_S = \log_{10} A - 5036 \left(\frac{E_g}{T}\right) \qquad (3)$$

In the operating range of diodes, the temperature dependence of I_S is mainly determined by the second term of Eq. (3) even though A is temperature dependent.

Hence, a graph with $\frac{1}{T}$ on x-axis T in K and $\log_{10} I_S$ on Y-axis will be a straight line having a slope of magnitude m = 5.036 × E_g. From this the energy band gap of the p-n junction diode is calculated to be

$$E_g = |m|/5.036 \text{ eV} \qquad (4)$$

Where m-slope of the straight line from graph

Description: The arrow head of p-n junction diode 'D' represents the anode (of p region) and the vertical line represents the cathode (n region). As shown in figure (1). When diode is reverse biased i.e. p-region is connected to negative terminal of the battery and n-region is connected via the ammeter to the positive terminal of battery, the current flowing through the diode is negligibly small in rage of μA and is called as reverse saturation current.

Circuit Diagram:

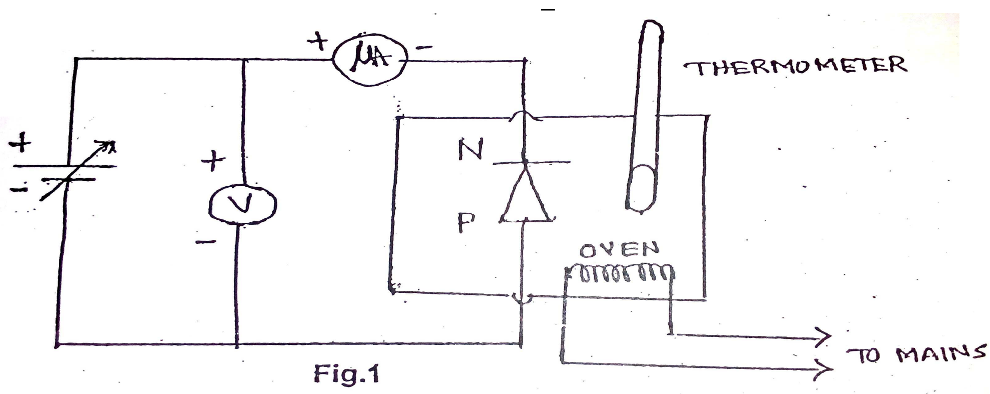
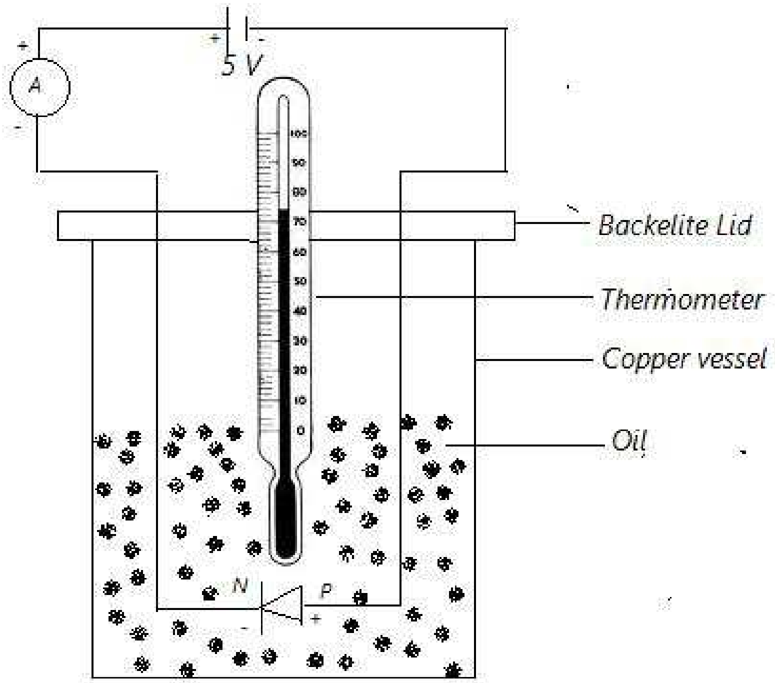


Fig.1

Experimental Diagram:



In our experiment we study the effect of temperature on the reverse saturation current in the diode and there from estimate the energy band gap of the semiconductor material.

Procedure

The connections are made as shown in the figure (1). A small reverse bias voltage is applied across the diode by adjusting the potentiometer 'P'. The applied voltage is recorded using a voltmeter and the corresponding reverse saturation current (I_S) is noted using a micro-ammeter.

The reverse bias voltage is maintained constant throughout the experiment. During heating cycle, the oven is switched on and the temperature of the diode increases slowly. Now, the reverse saturation current values

$((I_S)_{increase})$ are noted together with the corresponding temperatures in Conversely in the cooling cycle, the oven is switched off and system is cooled. Now, the reverse saturation current values $((I_S)_{decrease})$ corresponding to the temperature range of 70°C to 30°C are tabulated in steps of 5°C respectively.

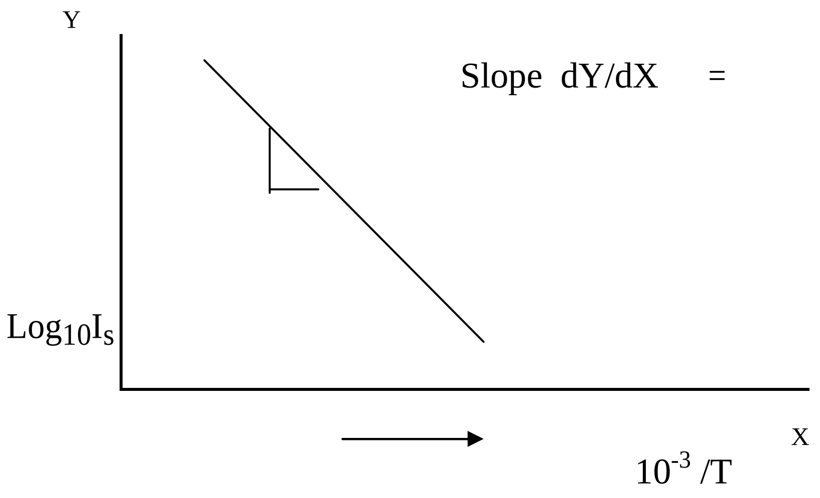
At any temperature, the average value of reverse saturation current will be considered. **$I_S = ((I_S)_{increase} + (I_S)_{decrease}) / 2$.**

Readings are tabulated in the table and graph is between $\frac{1}{T} \times 10^3$ on x- axis T in K and $\log_{10} I_S$ on Y- axis is drawn and slope is found and E_g is calculated.

Observations:

S.No	Temperature		Reverse Saturation Current (I) in μA			$Log_{10} (I_S)$	$1/TX10^{-3}$ K^{-1}
	Temp in t °C	Temp T (K)	Current(I_H) Heating	Current (I_C) Cooling	$I_S = (I_H + I_C) /2$		

Graph: Draw the graph between 1/T versus log (I_s), straight line passing through positive 'X' axis. Find mod of the slope of the straight line



CALCULATIONS:

From graph slope of the line dy/dx =

E_g = slope/ 5.04 = ____________ eV

Standard value for Ge = 0.72 eV
Standard value for Si = 1.1 eV

Precautions:

1. Do not operate above 90^{o}C.
2. Temperatures are to be determined accurately.
3. Observations should be taken not only as the temperature rise but also when it cools.
4. The current flow should not be too high, if the current is high then the internal heating of the device will occur. This will cause actual temperature of the junction to be higher then the measured value. This will produce non-linearity in the curve.

Result: The Energy band gap of semiconductor is $\mathbf{E_g}$ = ---------------- eV.

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

VIVA QUESTIONS

1. **What is a p-type semiconductor?**
   Semiconductor formed by adding trivalent impurities in which the majority carriers are holes is called as a p-type semiconductor

2. **What is an n-type semiconductor?**
   Semiconductor formed by adding pentavalent impurities in which the majority carriers are electrons are called as a n-type semiconductor.

3. **What is doping?**
   The process of changing the performance of a semiconductor by introducing a small number of suitable replacement atoms as impurities into the semiconductor lattice is called as doping.

4. **Due to what phenomenon does the reverse saturation current arise?**
   The reverse saturation current arise in a junction diode due to the diffusion of minority charge carriers.(Electrons in p-region & holes in n-region are respective minority charge carriers.)

5. **Why should the reverse bias be kept below the breakdown voltage?**
   Then only the reverse saturation current remains constant.

6. **Why does the reverse saturation current depend on temperature?**
   This is because the reverse saturation current is due to diffusion of minority charge carriers which are thermally generated. The diffusion is also temperature dependent. Hence the reverse saturation current is highly sensitive to temperature.

7. **What is diffusion?**
   The motion of charge carriers takes place when there is a non uniform distribution of charged particles. This process is called as diffusion.

8. **Why reverse bias current is called as reverse saturation current?**
   Because the reverse current becomes saturated quickly with the increase in the reverse bias.

9. **What are the values of band gap for metals, semiconductors and insulators?**
   For metals= 0eV, Semiconductors= 0.5 -3 eV and for insulators greater than 3 eV.

10. **Which type of semiconductor is used in the given apparatus?**
    Germanium (Ge)

11. **Which type of transformer is used in this experiment and what is it?**
    Step down transformer. It is a device, which converts high voltage currents to low voltage currents.

EXPERIMENT NO - 6

NEWTON'S RINGS

AIM: To determine the radius of curvature of given Plano-convex lens by Newton's rings method

APPARATUS: A Plano-convex lens, piece of thick glass plate, thin glass plate, sodium vapour lamp, traveling micro scope and black sheet.

WORKING PRINCIPLE: ***Interference of Light:*** The light reflected from the upper and lower surfaces of thin air film formed in between the lower surface of convex lens and upper surface of glass plate.

FORMULA: The Newton's rings experiment is an example of interference of light by division of amplitude in reflected light according to the theory of Newton's rings, the diameter of the m^{th} dark ring is given by $D_m=2\sqrt{m\lambda R}$ where m=,1,2.. etc and diameter of the n^{th} dark ring is $D_n=2\sqrt{n\lambda R}$ where n=0,1,2.. etc

Therefore, $D_m^2-D_n^2=4m\lambda R-4n\lambda R$ or

$$R=\frac{D_m^2-D_n^2}{4\lambda(m-n)}cm$$

Where,

R is the radius of curvature of the lens in constant with the glass plate (cm)
D_m and D_n are the diameters of the m^{th} and n^{th} dark rings respectively (cm)
m, n are the number of chosen rings
λ is the wavelength of the monochromatic source of light(sodium light)
(λ=5893 A^0 =5893 X 10^{-8} cm)

Concentric ring system is formed because the path difference between the two interfering light rays is constant radially or the locus of all points having the same air gap is a circle.

The values of D_m and D_n are small and are measured accurately with the traveling microscope. It can be seen from the formula that the diameter of the ring increases with the radius of curvature R. Therefore it is desirable to select a suitable convex lens of long focal length for forming rings. The diameter of the bright fringes is proportional to the square root of the natural numbers.

D_n (bright) = $\sqrt{(2n-1)\lambda R}$

D_n (dark) = $2\sqrt{n\lambda R}$

ARRANGEMENT OF APPARATUS:

Clean the surface of the convex lens and thick glass plate P_1.With lens paper. Keep the glass plate on a black paper laid on the platform of the traveling microscope. Place the convex lens of large radius of curvature on the glass plate with its spherical surface in contact with the glass plate. Direct a parallel beam of light from a sodium lamp on to a thin glass plate P_2 kept inclined at 45^o to the horizontal as shown in fig. The beam of light is reflected on to the lens by the glass plate P_2.

As a result of interference between the light rays reflected from the lower surface of the convex lens and the top surface of the thick glass plate P_1, a concentric ring system (Newton's rings) with alternate dark

and bright rings having a black spot at the center, will be seen through the microscope. In other words the light reflected from the top and bottom surfaces of the air film superimpose giving rise to interface fringes in the form of alternate bright and dark concentric rings, called Newton's rings.

Ray Diagram

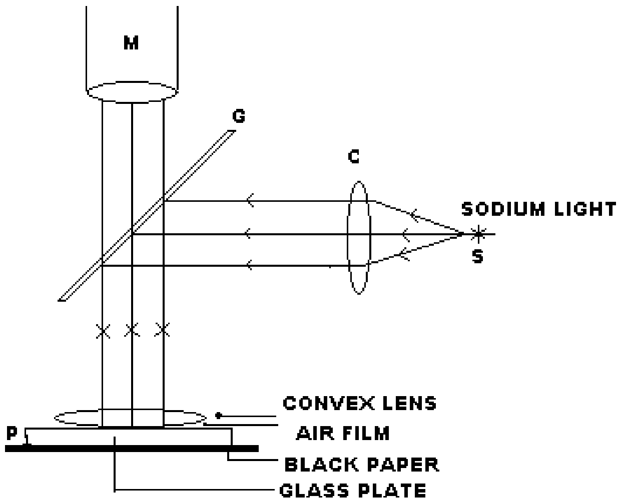


Fig: Experimental arrangement to observe Newton's Rings

Adjust the microscope until the rings are in sharp focus. Improve the definition of the rings by slightly adjusting the reflecting glass plate P_2 with respect to the sodium light. Sometimes due to the presence of the dust particles between the lens and the thick glass plate the central spot may be bright. In such a case clean the surface of the lens and glass plate to get a dark spot at the center.

PROCEDURE:

Determine the least count of the traveling microscope and record it in your observation book. Scribble with pen on a piece of white paper and place it on the glass plate and focus the microscope such that the writing on the white paper is clearly visible. Bring the point of intersection of the cross-wire to the center of the ring system and if necessary turn the cross-wires such that one of them is perpendicular to the line of travel of the microscope. This wire can be set tangential to any ring while making measurement. Starting from the center of the ring system move the microscope, say to the left across the field of view counting the numbers of the rings.

After passing beyond the 20^{th} dark ring tangential to it, note the main scale reading and vernier coincidence on the horizontal scale using a reading lens. Similarly note the readings with the cross wire set successively on the 20^{th}, 18^{th}, 16th, 14th… up to 20^{th} dark ring on the right side. Readings should be taken with the microscope moving in the same direction to avoid errors due to back-slash. Record the observations in the table given below. Note that as the microscope is moved from 20^{th} dark ring on the left to the 20^{th} dark ring on the right the microscope decreases continuously.

OBSERVATIONS:

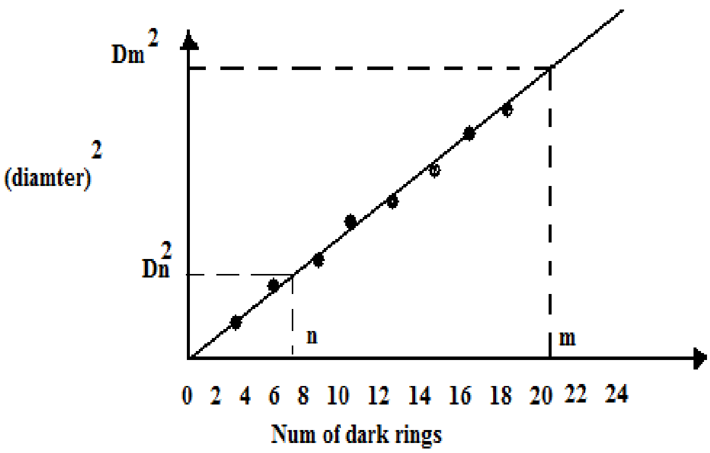
$$\text{Least count of the microscope} = \frac{\text{Value of one } M.S.D}{\text{Total Number of vernier scale divisions}}$$

TABLE:

No. Of Rings	Microscope Readings						Diameter D= (a ~ b) Cm	(Diameter)^2 D^2 cm^2
	Left			Right				
	MSR cm	VC	Total M.S.R+(V.C XL.C) (a) cm	MSR Cm	VC	Total M.S.R+(V.C XL.C) (b) cm		
20								
18								
16								
14								
12								
10								
8								
6								
4								
2								

Graph:

Draw a graph with number of dark rings on the X-axis and the square of the diameter of the rings on Y-axis. A straight line passing through the origin will be obtained. From the graph ,note down the values of D_m^2 and D_n^2 corresponding to m^{th} (say 5 or 7) by substituting these values in above equation the radius of curvature of the given lens can be found.



Applications:

1. Interference is used in Interference Auto Compensators in measurement engineering.
2. Interference is used in CWDM (Coarse Wavelength Division Multiplexing) system, which can have many diverse applications than the existing passive fiber optics.
3. Interference in thin films concept is used in non-reflecting coatings in engineering applications.
4. Laser light optical interference is used in MFM (Magnetic Force Microscopy).

CALCULATIONS:

From Graph:

m = n =

Dm^2 = Dn^2 =

$$R = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} cm$$

RESULT: Radius of curvature of the given convex lens is R=

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Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

Viva Questions

1. What do you mean by interference of light?
The modification in the distribution of light energy due to the superposition of two or more waves of light is called interference of light.

2. What are the conditions for sustained interference?

(a) The light waves superposing at appoint must have the same wavelength or same frequency.
(b) The amplitude of superposing light waves should be equal or almost equal.
(c) The waves superposing should either have the same phase or constant phase difference.
(d) Light sources must be very narrow and very close to each other.

3. Explain the term coherent sources?
Any two sources of light continuously emitting light waves have zero or constant phase difference are called coherent sources.

4. How Newton's rings are formed?
When a monochromatic light falls normally on Plano convex lens and glass plate set, the light reflected by the lower surface of the lens and the upper surface of the glass plate superpose to produce interference pattern. This circular interference pattern is called Newton's rings.

5. Why the central ring is dark?
The path difference is introduced b/w the two rays as a result of the phase change of $\lambda/2$ for ray reflects from glass plate and no phase change for the ray reflects from plano convex lens. The central ring is dark because the two interfering rays have a path difference (1/2) in spite of the fact that the thickness is zero.

6. How to obtain central bright spot in Newton's rings?
By interpose a film of refractive index less than that of the material of the plate. Then the path difference b/w the two rays becomes central bright spot.

7. On what factors does the diameter of the ring depend?
It depends on the wave length of the light and the radius of the curvature of the plano-convex lens.

8. What are the applications of Newton's rings?
It is used to:
(i) Determine wavelength of unknown light source.
(ii) To determine radius of curvature of given lens.
(iii) Refractive index of the given liquid.

9. Why the center of the rings is dark?
Because the Plano convex lens and the plane glass plate both are in contact and at that particular place the center ring will appear dark.

10. Why the Newton's rings are circular?
The thin air film formed in between the glass plate and the convex lens is having zero thickness at the point of contact of lens and glass plate. Its thickness is symmetrically increasing on both sides of the point of contact. Hence the obtained fringes having dark spot at the center followed by alternate bright and dark circular fringes. These are called Newton's rings. The path difference along the circle is constant that's why the rings are circular in this experiment.

11. What is meant by radius of curvature?
If we extend the curved path of the convex lens to make a sphere, then the radius of such an extended sphere is called Radius of curvature.

Experiment No:
Date:

EXPERIMENT NO-7

SONOMETER

Aim: To verify the laws of transverse vibrations of a stretched string using Sonometer.

Apparatus: Sonometer, tuning forks of known frequency, rubber block, slotted weights, paper riders (small V shaped paper bits).

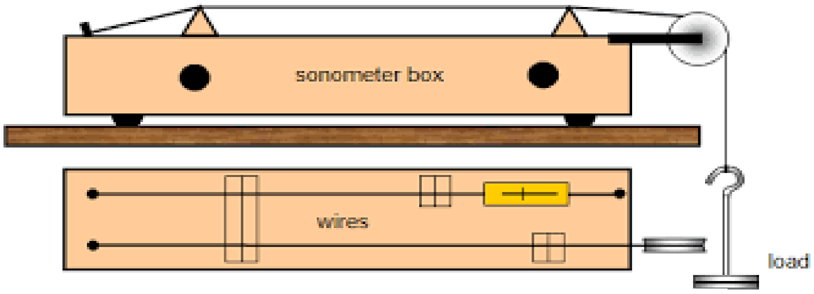
Working Principle: ***Resonance:*** Resonance takes place when the frequency of the external body/tuning fork is equal to the natural frequency of the segment of the wire (vibrating air column in between the bridges inside the Sonometer).

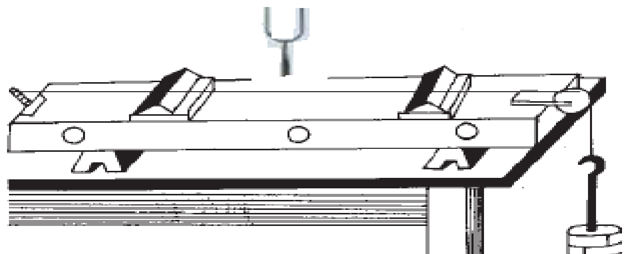
Formula: The frequency of transverse wave is

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

Where T is tension,
l is the length of the vibrating loop and
m is the mass per unit length of the wire i.e., linear density.

Experimental Diagram:





Sonometer

PROCEDURE:

A wave that travels from a point into an infinite medium and never returns to the origin is called a progressive wave. If the particles of the medium vibrate parallel to the direction of propagation of the wave then the wave is called longitudinal wave. If the particles of the medium vibrate perpendicular to the direction of propagation of the wave then the wave is called transverse wave.

If the applied frequency is equal to the natural frequency of the body, then the body vibrates with maximum amplitude and the phenomenon is called resonance. When two simple harmonic waves of the same amplitude and frequency travelling in opposite directions in a straight line superimpose then the resultant wave obtained is called as stationary wave.

A stretched string vibrating in a single loop when plucked at the middle due to formation of stationary waves with nodes at the end and antinodes at the middle is said to be vibrating with the fundamental frequency.

The fundamental frequency is given by $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$

From the above relation, the laws of transverse vibration of stretched strings may be stated as:

1. The frequency (n) of the stretched string is inversely proportional to its length, where tension T and linear density m are kept constant.

   n l = constant, where T and m are constants

2. The frequency of the stretched string is proportional to the square root of the tension T, linear density m and length l are kept constant

   √T/ l = constant, where n and m are constants.

3. With the constant frequency(n) of the stretched string, the length l is inversely proportional to the square root of the linear density m, where tension T and length n are kept constant

   l√m = constant, where T and n are constants

Verification of I Law:

The sonometer wire is kept under tension by a suitable load, say 2 kg. A small paper rider is place on the wire between the movable bridges. The stem of an excited tuning fork of known frequency (*n*) is placed on the sonometer box. By adjusting the positions of the bridge gently, the length of the vibrating segment is changed till the paper rider flutters violently and is thrown off. The length of string between the movable bridges, '*l*' gives the resonating length.

Keeping the tension constant the experiment is repeated with the tuning forks of different frequencies and corresponding vibrating lengths of the wire are found out as before. The values are tabulated and the product '*nl*' is found to be a constant verifying the first law.

T = dyne/ cm^2. String =

S.No.	Frequency (n) Hz	Length of the vibrating segment		Mean length $l = (l_1 + l_2)/2$	n x l = constant
		Trail 1 l_1 cm	Trail 2 l_2 cm		

Verification of II Law:

The Sonometer wire is kept under tension by a load of *1 kg*. Using a tuning fork of known frequency, the resonating length (*l*) is found out as explained earlier. By increasing the load in steps of 0.5 kg, the corresponding resonating lengths are found out for the same fork. The tension of the wire T is calculated in each case using the relation $T = mg$ where g is the acceleration duet to gravity.

n = Hz. String =

S.No	Tension T= mg	Length of the vibrating segment		Mean length	√T	√T/ l = constant
		Trail 1 l_1 cm	Trail 2 l_2 cm	$l = (l_1 + l_2)/2$		

Verification of III law:

To verify the 3rd law, resonating lengths are determined for two different wires of material brass and steel, using the same tuning fork and same load applied to the wire. Using the value of density ρ of the material of the wire, according to the relation $m = \pi \rho d^4/4$.

n = Hz. T = dyne/ cm^2.

S.No	Material of the wire	Length of the vibrating segment		Mean length	$l\sqrt{m}$ = constant
		Trail 1 l_1 cm	Trail 2 l_2 cm	$l = (l_1 + l_2)/2$	
	Iron				
	Copper				
	Brass				

Density of Iron is 7.86 gm/cc

Density of Copper is 8.9 gm/cc

Density of Brass is 8.5 gm/cc

To determine the radius of the Iron wire:

Correction =   Least Count = pitch of the screw/ N =

S.No	P.S.R. a (cm)	Head scale Reading		Diameter of the wire d= a + (n x L.C)
		Observed	Corrected (n)	
1				
2				
3				
4				

To determine the radius of the Copper wire:

Correction =   Least count = pitch of the screw/ N =

S.No	P.S.R. a (cm)	Head scale Reading		Diameter of the wire d= a + (n x L.C)
		Observed	Corrected (n)	
1				
2				
3				
4				

To determine the radius of the Brass wire:

Correction =   Least count = pitch of the screw/ N =

S.No	P.S.R. a (cm)	Head scale Reading		Diameter of the wire d= a + (n x L.C)
		Observed	Corrected (n)	
1				
2				
3				
4				

Calculations:

Applications:

1. Sonometer is used in Acoustics of buildings.
2. Sonometer is used to know the natural frequency of a vibrating wire.
3. Sonometer is used to find the frequency of unknown tuning fork.
4. It is commonly used in Melde's experiment.
5. Sonometer is a very ancient device used to study the factors influencing the frequency of oscillation of a vibrating string or wire.

Precautions:

1. The wire should be uniform throughout. It should be straight and free from kinks.
2. The pulley should be free from friction.
3. The mass applied on string should be freely suspended, otherwise tension will be varied.
4. The excited tuning fork should be placed vertically with its shank pressed on the sonometer box.

Result: The three laws of transverse vibrations of stretched strings are verified.

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

Signature of Faculty with date & Remark

Viva Questions

1. **What is the principle involved in the Sonometer experiment?**
   A Sonometer is a device; it works based on the principle of Resonance
.
2. **Which type of waves is produced in Sonometer experiment?**
   Stationary transverse waves.

3. **What are the transverse waves?**
   A transverse wave is a moving wave that consists of oscillations occurring perpendicular (or right angled) to the direction of energy transfer or wave propagation.

4. **How the resonance takes place in this experiment?**
   When the frequency of the vibrating tuning fork is equal to the natural frequency of the vibrating air column in between the bridges of the stretched string then the resonance takes place.

5. **What is resonance?**
   In physics, resonance is the tendency of a system to oscillate with greater amplitude at some frequencies than at others. Frequencies at which the response amplitude is a relative maximum are known as the systems resonant frequencies, or resonance frequencies.

Experiment No:
Date:

EXPERIMENT No - 8

STEWART AND GEE'S METHOD

AIM

To study the variation of the intensity of magnetic field along the axis of a circular coil carrying current using Stewart and Gee's type of tangent galvanometer.

APPARATUS

Stewart and Gee's type of tangent galvanometer, battery, commutator, ammeter (0 to 2 amps), rheostat, plug key and connecting wires.

WORKING PRINCIPLE: ***Biot savart law*** is basic law of electricity and magnetism. It states that magnetic field produced due to small conductor of length dl carrying current I at point at distance r is

$$dB = (\mu_0/4\pi)\ I\ dl\ \sin\theta/r^2$$

RIGHT HAND THUMB RULE : If we grasp the conductor in the palm of right hand, so that thumb points in the direction of flow of current, then the direction in which finger curl gives the magnetic lines.

MAXWELL CORK -SCREW LAW: If a right handed cork screw is rotated so that it moves in the direction of flow of currents through the conductor, then the direction of rotation of the screw give the direction of magnetic field lines.

FORMULA: The Magnetic field induction is

$$B = \frac{2\pi n i a^2}{10(x^2+a^2)^{\frac{3}{2}}} \quad \text{(Theoretical)} \qquad (1)$$

Where
n - Number of turns of the coil
i - Current flowing through the coil
a - Radius of the coil
x - Distance of the magnetic needle from the center of the coil

$$B = H \tan\theta \quad \text{(Experimental)} \qquad (2)$$

Where
H - Horizontal component of the earth magnetic field.
θ - Average angle of deflection of the magnetic needle.

DESCRIPTION

1. Magnetic compass box:

The magnetic compass box consists of a very small magnetic needle pivoted on a sharp support at the center of a circular scale. An aluminum pointer is rigidly fixed perpendicular to the centre of the magnetic needle.

The circular scale is graduated in degrees and divided into four equal quadrants. Each quadrant is graduated from 0^0 to 90^0 so that diametrically opposite points indicate the same reading. A circular plane mirror is fixed just below the pointer which enables to take the readings of the pointer without error due to parallax. The needle, the aluminum pointer and the circular scale are enclosed in a circular brass box with a glass top to protect the needle from the wind and dust.

2. Stewart and gee's type of tangent galvanometer

Stewart and Gee's type tangent galvanometer consists of a non-magnetic circular frame C (Wooden / brass) of about 20 cm in diameter. The frame C is rigidly fixed at the middle of a horizontal wooden base B with its plane vertical. Three sets of thick insulated copper wire having different turns (5, 50 and 500) are wrapped on the circular frame. One end of all the coils is connected to the extreme left terminal T_1 and the other free ends of the coil are connected to the terminals T_2, T_3, and T_4 provided at the base of the instrument. The circular frame is large enough to keep a magnetic compass box to be moved along the axis of circular coil.

The magnetic compass box is placed on a platform P which is capable of sliding horizontally at right angles to the plane of the circular coil on a rectangular nonmagnetic metal frame F supported on four uprights. A scale S which is graduated in cm is engraved on one side of the metal frame F (about 110 cm long) by means of which the distance of the magnetic needle from the centre of the coil can be read with the index I marked on the sliding platform P. The zero of the scale is fixed at the centre and the scale increases on both sides. Here, the centre of the magnetic needle always lies on the axis of the circular coil for all positions of the magnetic compass box (Fig.1)

Experimental Diagram:

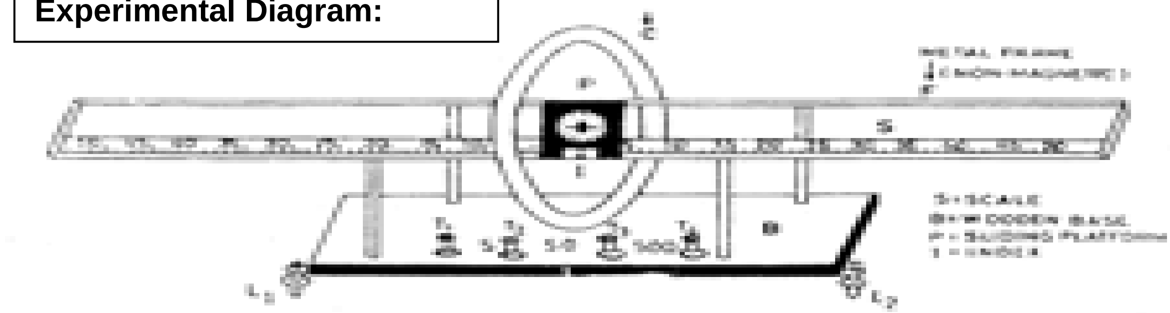


Figure-1

PROCEDURE

1. To set the circular coil in magnetic meridian (Tan A position)

Level the wooden base B so that it is perfectly horizontal by means o f the leveling screws L_1 and L_2. Place the magnetic compass box on the sliding platform P and keep it at the centre of the coil (reference mark on the platform P should coincide with the zero division on the scale S) In the absence of the external magnetic field, the vertical plane of the circular coil must be along the magnetic meridian. When current is passed through the circular coil, the magnetic field produced will be along the axis of the coil. To study the variation of magnetic field along the axis of the circular coil the following procedure should be adopted. Rotate the wooden base B in the horizontal plane until the arms of the base are parallel to the aluminum pointer in the magnetic compass box (i.e .arms are ease and west direction) and the magnetic needle is parallel to the vertical plane of the circular coil. In this position, the coil, magnetic needle and its image all lie in the same vertical plane. Now, without disturbing the coil, rotate the magnetic compass box until the ends of the aluminum pointer reads $0^0 – 0^0$ on both sides of the circular scale of the deflection magnetometer.

2. **To determine the angle of deflection θ of the magnetic needle**

Connect the terminals T_1 and T_3 (n = 50) to the two opposite terminals of a commutator. A battery B, rheostat R, ammeter A and plug key K are to be connected in series with the other two opposite terminals of the commutator Close he key K. Adjust the rheostat till the aluminum pointer shows a deflection of about 60 ^{0}. Note the deflections θ_1 and θ_2 against the ends of the aluminum

Pointer on the circular scale and keeping the ammeter reading constant, throughout the experiment. Now, reverse the direction of current through the coil, by means of the commutator and again note the deflections θ_3 and θ_4. If the mean deflections of the aluminum pointer before and after reversing the direct of the current are equal, it ensures that the vertical plane of the coil lies exactly in the magnetic meridian. If the mean deflections of the aluminum pointer before and after reversing the direction of current are differ by more than 3^0, it reveals that the coil is not set exactly in the magnetic meridian. Then, slightly turn the base B of the apparatus till the deflections before and after reversal of the direction of current through the coil are equal.

Now, open the key, move the platform towards east along the scale and place it at a distance x (say 2 cm) from the center of the coil. Close the key and note the deflections before and after reversal of the current. Find the mean of the four readings, which gives the mean deflection θ. Repeat the experiment by placing the platform at various distances (say 4 cm, 6cm, 8cm, 10cm, 12cm and 14cm) until the value of θ lies between 60^0 and 20^0. Move the platform towards west from the centre of the coil and note the readings for the same distances as was done on east. At each position, find the mean deflection θ_w.

Circuit Diagram:

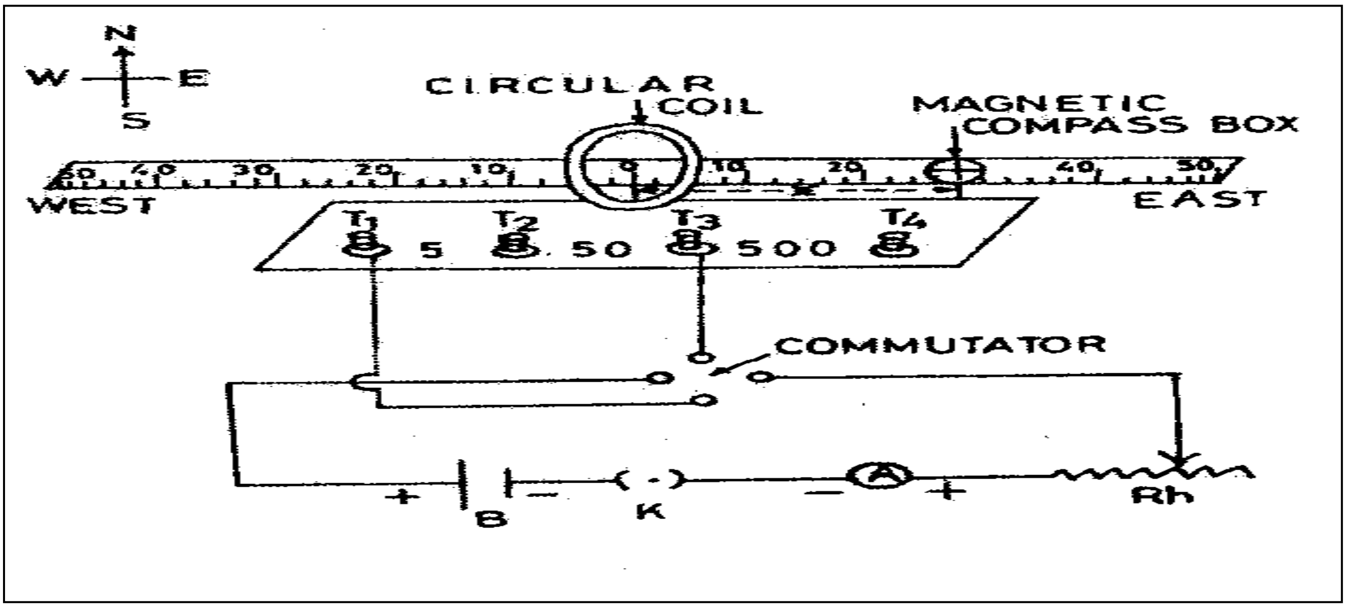


Figure-2

Observations:

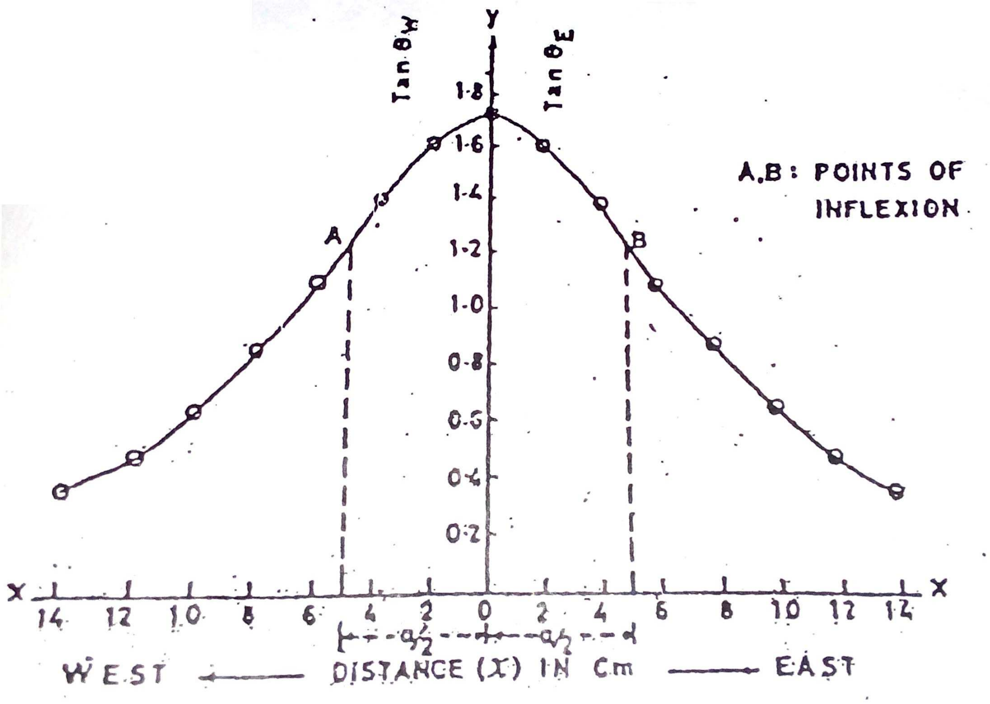
GRAPH:

Plot a graph with distance x along the X-axis with origin taking at the centre extending to east and west and the corresponding value of Tan θ along the Y –axis. A symmetrical curve of the shape as shown in the will be obtained. Mark the points of inflection A and B, where the slope of the curve changes its curvature suddenly on the two branches of the curve. The distance between the two points of inflection gives the radius of the coil.

![lendi logo]

Distance of the magnetic needle from the centre of the coil [x] in (cm)	Deflections of the magnetic needle												Tan θ = (Tan θ_E +Tan θ_W)/2	B= H Tan θ	$B=\frac{2\pi nia^2}{10(x^2+a^2)^{3/2}}$
	East side of the coil						West side of the coil								
	θ_1	θ_2	θ_3	θ_4	Mean θ_E	Tan θ_E	θ_1	θ_2	θ_3	θ_4	Mean θ_W	Tan θ_W			
X = 0															
X = 2															
X = 4															
X = 6															
X = 8															
X = 10															
X = 12															

CALCULATIONS:


Tan θ_W
Tan θ_E
Y
1·8
1·6
1·4
1·2
1·0
0·8
0·6
0·4
0·2
A
B
A,B : POINTS OF INFLEXION
X
14 12 10 8 6 4 2 0 2 4 6 8 10 12 14
a/2
WEST
DISTANCE (X) IN Cm
EAST

APPLICATIONS

i) To find the value of H at a given place.
ii) To detect the presence of electromagnetic fields.
iii) To calibrate an Ammeter

Objectives

i) To study the relation between Intensity and field.
ii) To study the effect of the number of turns on the field.

Precautions

i) The ends of the connecting wires should be cleaned well with a piece of sand paper and the connections should be tight.
ii) Magnets, magnetic substances or current carrying conductors should be kept away from the vicinity of the apparatus.
iii) The plane of the coil should be set in the magnetic meridian properly; otherwise the deflection magnetic needle does not obey the tangent law.
iv) Deflections should be noted without parallax between the aluminum pointer and its image.

RESULT

Magnetic field computed by two expressions [(1) -> theoretical] and [(2) ->experimental] are found to be nearly equal and field is symmetrically distributed on both sides of the coil.

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

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VIVA QUESTIONS

1. Define magnetic field?
The space surrounding a magnet in which its influence is felt is called its magnetic field.

2. Define magnetic meridian?
Vertical plane containing the magnetic axis of a freely suspended magnet is called magnetic meridian.

3. What is meant by intensity of magnetic field?
The intensity of magnetic field at a point is defined as the force acting on a unit North Pole placed at that point and is independent of the medium.

4. What is the direction of magnetic field at the centre of the coil?
The direction of the magnetic field at the centre of the coil is i) along the axis of the coil and perpendicular to the plane of the coil. ii) Perpendicular to the horizontal component of the earth's magnetic field, H as well.

5. How does the magnetic field vary along the axis of the coil?
The variation of the magnetic field along the axis of the circular coil is as shown in the graph. The point at which the slope of the curve changes its sign form concavity to convexity towards the origin is called point of inflexion. There are two such points on the curve. The distance between these points on the two sides of the symmetrical curve gives the radius of the coil.

Experiment No:
Date:

EXPERIMENT No - 9

DIFRACTION GRATING

AIM: To determine the wavelength of prominent lines of mercury spectrum by plane diffraction grating in normal incidence position.

APPARATUS: Spectrometer, Mercury lamp, Spirit level, Plane diffraction grating and reading lens.

WORKING PRINCIPLE: ***Diffraction of Light:*** Bending of the light rays at the transparent spaces between the equidistant parallel lines on the grating plate is the responsible for diffraction pattern and the grating spectrum.

FORMULA: If N is the number of lines per cm of the grating, then the width of the slit d=1/N. When light is incident normally on plane grating and if θ is the angle that the diffracted ray makes with the normal then the path difference between two rays passing through successive slits is 'd sinθ' for maximum of the diffracted beam **d sinθ = nλ.**

Therefore the wavelength λ of light incident normally on the grating is

$$\lambda = \frac{\text{Sin }\theta}{\text{n N}} A^0$$

Where,

θ is the angle of diffraction,

N is the number of lines per cm on the grating **(15000 LPI = 5905.511 lines/cm)**

n is the order of the spectrum

PROCEDURE:

i. Find the least count of the spectrometer:

Least count= Value of one M.S.D / No of Veriner scale divisions.

ii. Preliminary adjustments of the spectrometer:

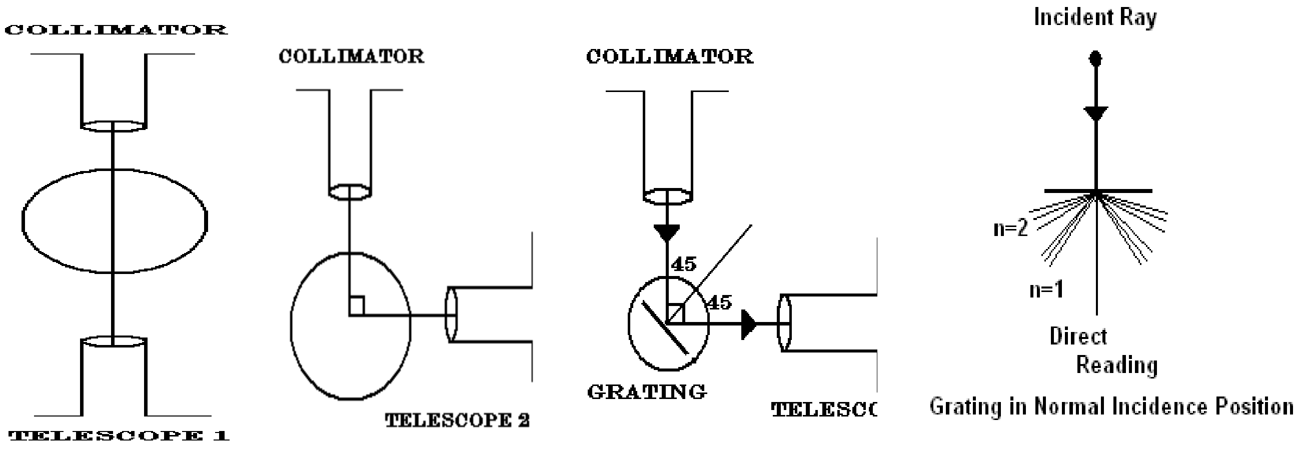
Turn the telescope towards a white surface. Move the eye-piece in or out until the cross wires are seen distinctly. Now focus the telescope to a distant object and by the turning the pinion screw adjusts the distance of the eye-piece from the object until the distant object is clearly seen in the plane of the cross-wires. Now the telescope is adjusted to receive the parallel rays.

The slit of the collimator is illuminated with mercury light and the telescope is brought in line with the collimator. Set the slit of the collimator vertical. Observing through the telescope, the width of the slit and the distance of the slit from the collimator lens are adjusted until a clear image of the slit with well-defined edges is formed in the plane of the cross-wires.

iii. To set the grating in normal incidence position:

Turn the telescope exactly in line with the collimator and observe the image of the slit. Clamp the veriner table to the prism table. Adjust the position of the telescope so that the vertical cross-wire exactly coincides with the image of the slit and note down the direct reading on both the verniers (Fig 1).Release the telescope and rotate it exactly through 90^o from the direct reading position and fix it. At this position the axis of the collimator and telescope are perpendicular to each other (Fig 2).

Ray Diagram



Mount the grating on the prism table such that the ruled surfaces the collimator. Then release the prism table and looking through the telescope. Rotate the prism table slowly until the reflected image of the slit from the grating exactly coincides with the vertical cross-wire. Keeping the prism table and telescope fixed, release the veriner table and rotate it exactly though 45^o towards the collimator such that the ruled surface of the grating is towards the collimator. Release the telescope and bring it in line with the collimator .Now the grating is said to be in normal incidence position and the light rays from the collimator will be incident on the grating surface perpendicularly. (Fig 3)

iv. Diffracted lines of mercury spectrum:

Now turn the telescope to each the diffracted spectral lines of the mercury spectrum on one side, say to the left. Starting from the extreme left coincide the vertical cross-wire with yellow-2 and note the reading. Similarly note the readings for all lines on the right side of the direct position (Fig 3).The difference between the readings corresponding to any line on left side (L) and right side (R) gives twice the angle of diffraction(2θ) for that line. Half the difference in the readings corresponding to any line gives the angle of diffraction (θ) for that line in the first order spectrum. Tabulate your results as shown in table.

Ray Diagram

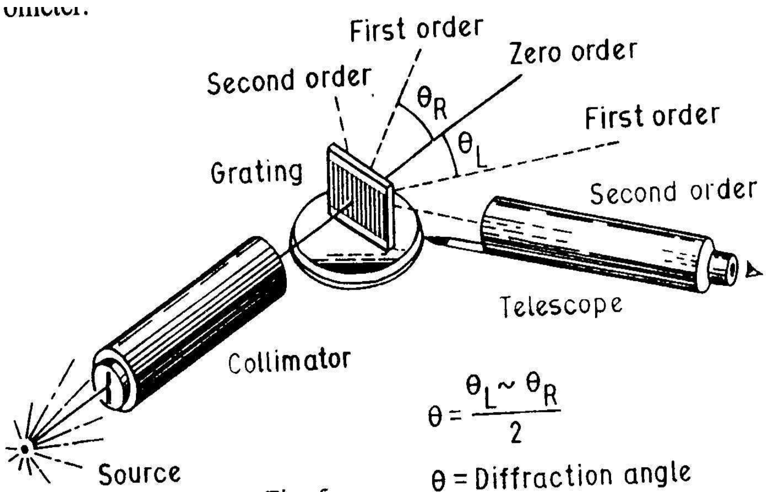


Fig. 5

OBSERVATIONS:

Note down the number of lines per inch marked on the grating and calculate the number of lines N per cm by using the formula

No. of lines per inch/2.54 (N) = 15000 / 2.54 = lines/cm

Order of the spectrum (n) =

L.C of the spectrometer = Value of one M.S.D /total No of Vernier scale divisions

=

Order of the spectrum (n)	Colour of the line	Telescope Reading						Angle of Diffraction θ = (L ~ R)/ 2	$\lambda = \frac{\text{Sin }\theta}{\text{n N}} A^0$
		Left (L)			Right (R)				
		MSR	VC	Total Reading= MSR+(VC X LC) (L)	MSR	VC	Total Reading= MSR+(VC X LC) (R)		
1	Violet								
1	Blue								
1	Bluish Green								
1	Green								
1	Yellow								
1	Red								

CALCULATIONS:

$$\lambda v = \frac{\text{Sin } \theta v}{\text{n N}} A^0 =$$

$$\lambda b = \frac{\text{Sin } \theta b}{\text{n N}} A^0 =$$

$$\lambda bg = \frac{\text{Sin } \theta bg}{\text{n N}} A^0 =$$

$$\lambda g = \frac{\text{Sin } \theta g}{\text{n N}} A^0 =$$

$$\lambda y = \frac{\text{Sin } \theta y}{\text{n N}} A^0 =$$

$$\lambda r = \frac{\text{Sin } \theta r}{\text{n N}} A^0 =$$

Applications:

1. Diffraction of light plays a dominant role in limiting the resolving power of cameras, binoculars, telescopes, microscopes and the eyes.
2. Diffraction gratings are used in the production of holograms.
3. Diffraction gratings are used in the laser shows which are popularly used in opening and closing ceremonies of film fare awards, IPL and Olympic games, etc.
4. Spectra produced by diffraction gratings are extremely useful in applications from studying the structure of atoms and molecules to investigating the composition of stars.
5. Diffraction grating is an immensely useful tool for the separation of the spectral lines associated with atomic transitions
6. Diffraction grating leads to application for measuring atomic spectra in both laboratory instruments and telescopes.
7. The hologram on a credit card and the closely spaced tracks of a CD or DVD act as a diffraction grating for producing a separation of the colors of white light.
8. Diffraction grating is used in ICPAES (Inductively Coupled Plasma Auger Electron Spectroscopy).

RESULT: The wavelengths of prominent lines in the mercury spectrum are determined by using diffraction grating in normal incidence position.

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Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

Viva Questions

1. **What is diffraction grating?**
   A plate of glass or metal ruled with very close parallel lines, producing a spectrum by diffraction grating and interference of light.
2. **What are the essential parts of the spectrometer?**
   The essential parts of the spectrometer are Eye-piece, telescope, objective lens, prism table, collimator, slit.
3. **How many types of spectra are available?**
   The familiar spectrum colors are easy to remember with the mnemonic"VIBGYOR" for Red, Orange, Yellow, Green, Blue, Indigo, and Violet. Different light sources have different amounts of these colors.
4. **What is dispersive power of grating?**
   Dispersive power is defined as the rate of change of angle of diffraction with the change of wavelength in a particular order of spectrum.
5. **Define grating element?**
   The distance b/w two adjacent slits is known as granting element/its value is obtained by dividing the length of grating by total number of lines ruled on the grating.
   $d=L/N$
   L=length of the grating
   N=number of lines ruled on the grating
6. **What is plane transmission diffraction grating?**
   A plane transmission diffraction grating is an optically plane parallel glass plate on which equidistant, extremely close grooves are made by ruling with a diamond point.
7. **In our experiment, what class of diffraction occur and how?**
   Fraunhoffer class of diffraction occurs. Since the spectrometer is focused for parallel rays, the source and the image are effectively at infinite distances from the grating.
8. **What type of diffraction occurs in this experiment?**
   Fraunhoffer diffraction
9. **What are maximum numbers of possible orders with the given grating?**
   Three (n=3).
10. **Among the three possible orders which order you are observing?**
    First order (n=1)

Experiment No:
Date:

EXPERIMENT No-10

WEDGE METHOD

AIM: To measure the diameter of a given thin wire (*or* thickness of given thin paper) using interference patterns formed by an extended source, at the air wedge between two glass plates.

Apparatus: Glass plate, thin wire, beam splitter, light source, traveling microscope etc.

Working Principle: ***Interference of Light:*** The light reflected from the upper and lower surfaces of thin air film formed in between the lower surface of top glass plate and upper surface of the bottom glass plate.

Formula: The Thickness of the glass plate is **$t = \lambda l/2\beta$**

Where t is thickness of the glass plate

β is the mean fringe width

l is the distance between the inner edge of the paper (or hair) & the point of contact of glass plates in cm.

Theory:

Interference effects are observed in a region of space where two or more coherent waves are superimposed. Depending on the phase difference, the effect of superposition is to produce variation in intensities which vary from a maximum of $(a_1 + a_2)^2$ to a minimum of $(a_1 - a_2)^2$ where a_1 and a_2 are amplitude of individual waves. For the interference effects to be observed, the two waves should be coherent. Interference patterns can be observed due to reflected waves from the top and bottom surfaces of a thin film medium. Because of the extended source, the fringes are localized at or near the wedge.

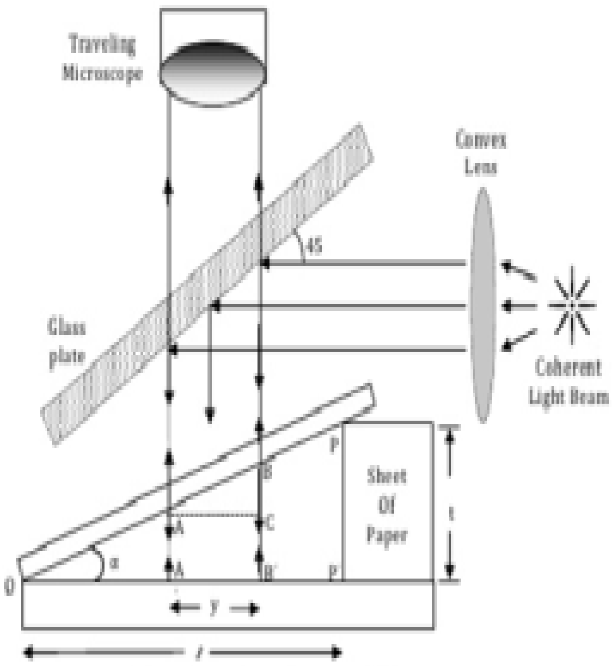
Ray Diagram

Fig. Shows the cross sectional view of the two flat glass plates kept on each other and separated by a wire at the rightmost end. There is a thin air film between the two glass plates due to the paper kept at the right end.

The path difference between the two ray's r_1 and r_2 is $2t \cos r$, where't' is the air thickness as shown in the figure.

The condition for dark band is,

$$2t\cos r = m\lambda$$



If the incident ray is close to normal, $2t = m\lambda$ ………………(1)

For $m = N$, the maximum order of the dark band the path difference will be maximum and this correspond to the position where the wire is kept . Moreover, here the fringes are equal thickness fringes. So eqn (1) can be written as

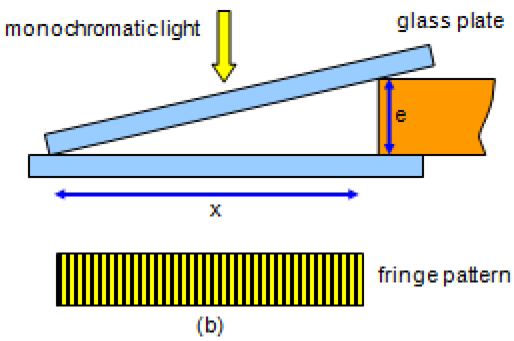
$$2d = N\lambda \text{ ……………………… (2)}$$

The length 'l' shown in the figure can be written as

$$l = N\beta \text{ ………………… (3)}$$

where β is the fringe width. From eq (2) and (3),

$$\mathbf{t = \lambda l/2\beta} \text{ -------------------------(4)}$$



Procedure:

- Place the two optically flat glass plates one over the other, so that they touch each other at the left end and are separated at the right end by the given thin wire. The length of the wire should be perpendicular to the length of the glass plate.
- Place this assembly on the platform of the microscope such that the length of the glass plate is parallel to the horizontal traverse of the microscope.
- Illuminate the assembly by sodium light. Adjust the glass plate G, such that incident light is almost normal to the glass plate wire assembly.
- Focus the microscope to observe the interference patterns
- Measure the horizontal positions of the dark bands in the order of say, m, m+5, m+10,......... by traversing the microscope horizontally.
- Determine the length 'L' with the help of microscope.
- Plot a graph of horizontal positions versus order of dark band. Find out the mean fringe width β from the table and calculate the thickness of the given wire.

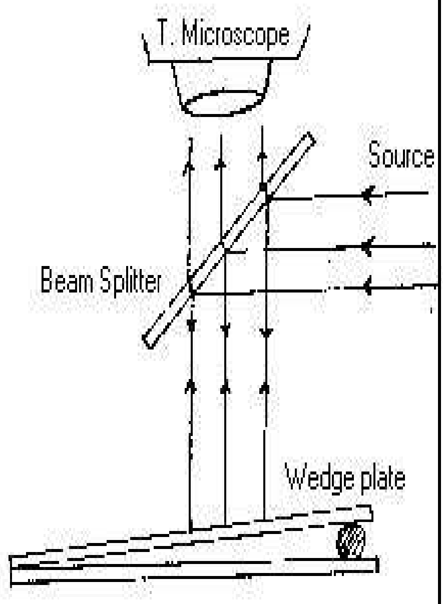
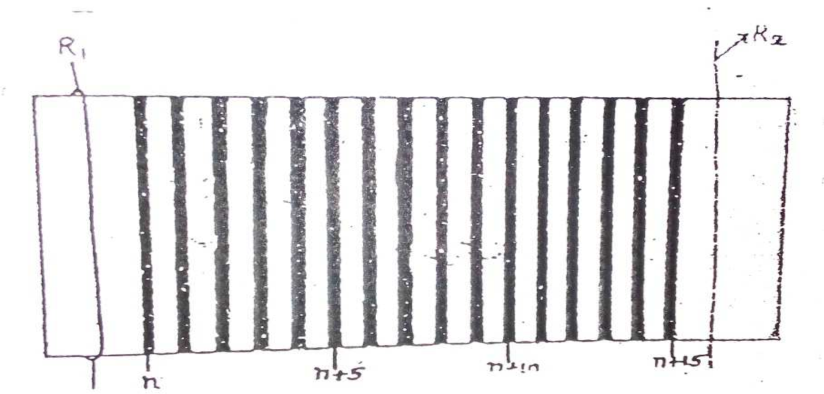


Fig. 2 Experimental setup



Formation of alternate bright and dark fringes

Observations:

To determine fringe width β:

S.No.	Order of Fringe	M.S.R. (a) cm	V.C (n)	Total reading = a + nx L.c	Width of 5 fringes cm	Width of one fringe cm
1	0^{th}					
2	5^{th}					
3	10^{th}					
4	15^{th}					
5	20^{th}					
6	25^{th}					
7	30^{th}					
8	35^{th}					
9	40^{th}					
10	45^{th}					
11	50^{th}					
12	55^{th}					
13	60^{th}					

To determine the length of the air wedge (l):

Microscope readings						
At the point of contact of the two glass plates			At the position of hair or paper			$l = R_1 \sim R_2$
M.S.R a cm	V.C N	R_1= a+ nxL.C Cm	M.S.R a cm	V.C N	R_2= a+ nxL.C cm	

Calculations:

Precautions:

1. While using microscope to measure fringe width etc., it is moved in one direction only from left to right or right to left, so that back lash error is avoided.
2. To achieve good accuracy in the measurements of beta and l, measurements are repeated thrice.

Applications:

1. Because of its extremely thin air-gap, the air-wedge interferometer was successfully applied in experiments with femto-second high-power lasers.
2. The air-wedge shearing interferometer is similar to the classical shearing interferometer but is micrometers thick, can operate with virtually any light source even with non-coherent white light, has an adjustable angular beam split, and uses standard inexpensive optical elements.
3. Design described in this article eliminates this obstruction and makes the air-wedge interferometer effective for practical applications with a visualization field interferometer
4. The air-wedge interferogram from even this very short coherence length laser beam exhibits clear, high-contrast interference lines.

Result: Thickness of the given thin paper (or wire) t = … … … … … …cm.

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

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Viva Questions

1. Is there is any energy loss in interference phenomenon?
No, there is only redistribution of energy i.e., energy from dark places is shifted to bright places.

2. What are interference fringes?
They are alternately bright and dark patches of light obtained in the region of superposition of two wave trains of light.

3. What is the shape of the fringes in wedge shaped film?
The fringes in wedge shaped film are straight line fringes.

4. What type of source is required in division of amplitude?
In division of amplitude a board source is required so that the whole firm may be viewed together.

5. Define air wedge?
Wedge shaped (V shaped) air film is formed between two plane surfaces inclined at small angle. When the film is illuminated by monochromatic light, alternate dark and bright fringes lines equidistant from one another is formed parallel to the thin edge of the wedge are obtained.

6. What is meant by fringe width?
Fringe width is defined as the separation b/w two consecutive maxima or minima.

7. What is meant by maxima and minima?
MAXIMA: The positions of maximum intensity are called maxima.
MINIMA: The positions of minimum intensity are called minima.

8. What is monochromatic wavelength of light?
The light having only one wavelength is called monochromatic wavelength of light.

9. What is wave length?
Wavelength is defined as the distance b/w any two points with the same phase, such as b/w crests, or troughs, or corresponding zero crossings as shown.

10. On which factor, the contrast in fringes in interference pattern depends?
The contrast in fringes in any interference pattern depends on intensity ratio of source.

11. What is locus of fringe?
A fringe is a locus of constant phase.

12. What is the use of intersecting 45^0 angled glass plate?
The use of intersecting 45^0 angled glass plate is important so the light will be split up into two components. ie reflected from the plate is normal (or) right angled (90^0)

Experiment No: **Date:**

EXPERIMENT No-11

LASER BEAM DIFFRACTION

AIM: To determine the wavelength of laser beam using n-parallel slits i.e., diffraction grating.

APPARATUS: Laser light source, N-parallel slits (Diffraction grating), Screen and a Meter scale.

FORMULA: The wavelength λ of laser light is given by

$$\lambda = \frac{\text{Sin}\,\theta}{\text{n N}} A^0$$

Where, θ is the angle of diffraction, **N** is the number of lines per cm on the grating, **n** is the order of the spectrum

The slit width W of the single slit is given by

$$W = \lambda \; Dn \;/\; d$$

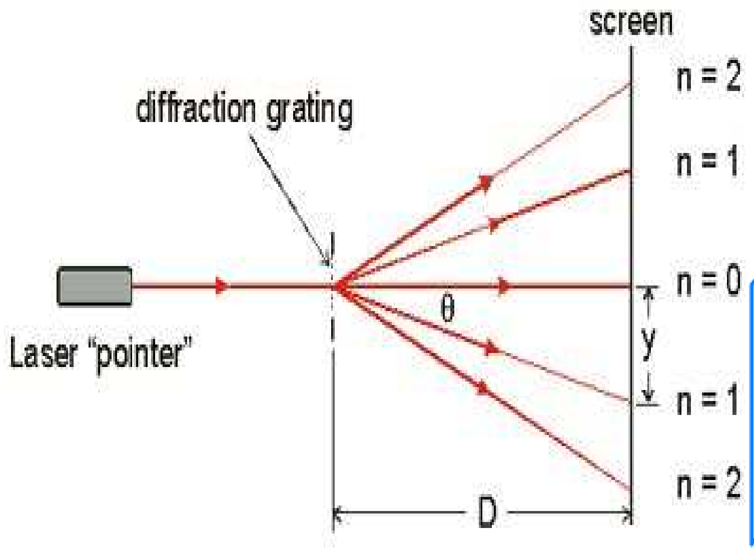
Where, λ is the wavelength of laser light, **D** is the distance between the slits and the screen, **d** is the distance on the screen from the center of the pattern (central maximum) to the **n**th maximum.

WORKING PRINCIPLE: ***Diffraction of Light:*** Bending of the light rays at the transparent spaces between the equidistant parallel lines on the grating plate is the responsible for diffraction pattern and the grating spectrum.

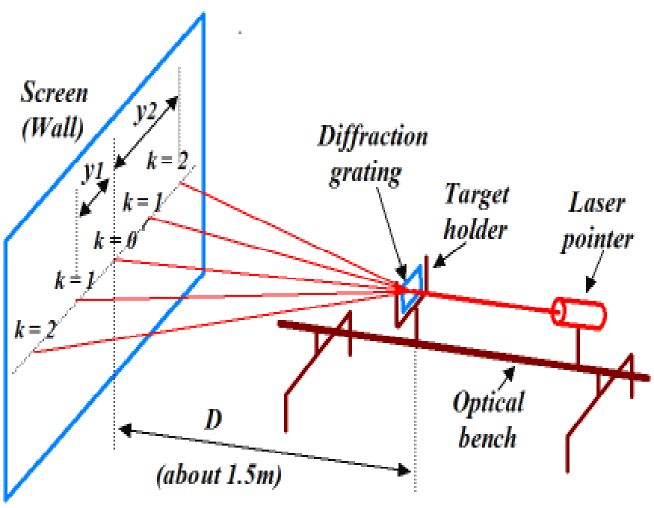
THEORY:

He-Ne Laser, Ga-As or Semiconductor Laser is generally used as laser source in this experiment. When a laser beam of wavelength λ is allowed to fall on the single slit or diffraction grating placed at a distance D from the screen, the incident laser beam bends at the corners of the slit and produces diffraction pattern on the screen. The diffraction pattern consists of a broad central maximum with narrow secondary maxima and minima on either side of the central maximum as shown in the ray diagram.

Ray Diagram



Experimental Diagram:



PROCEDURE:

Laser source is mounted on a stand. Slit or Diffraction grating is kept at a convenient distance with the lines being vertical at the same height as the source. A screen is placed in front of the slit or grating and the images are formed on the white wall. The distance of the first order image from the direct image is measured on left side as well as right side. The mean of the distance (d) is found. The distance (D) from the grating to the screen is measured (d/D) gives TanΘ. The wavelength of the light is given by **λ = Sin(Θ)**/Nn Where N=number of lines per unit length on the grating. n=order of the spectrum. The experiment is repeated for first, second and third order spectrums. The readings are tabulated as follows.

Table to determine the wavelength λ of laser light and slit width W

S.No	Order of the spectrum (**n**)	Distance of screen from the grating **D** (in cm)	Distance of the slit image from direct slit (central maximum) **d** (in cm)			**θ= Tan^{-1} (d/D)**	**Sinθ**	$\lambda=\frac{\sin\theta}{nN}A^0$	$W=\lambda Dn/d$ (in cm)
			Left d1	Right d2	Mean d=(d1+d2)/2				

PRECAUTIONS:

1. Do not look directly into the laser beam under any circumstance.
2. Do not put or shine the laser toward anyone.
3. The source, screen and slit or grating should be at the same height.
4. Readings should be taken without parallax error.
5. Diffraction pattern (minima) should be marked with fine pencil carefully.

RESULT:

The wavelength of the given laser source **λ =** **A^0**
And slit width W = mm

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Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2, PO5 & PO9** are attained.

Applications:

1. Diffraction gratings are used in the production of holograms.
2. Diffraction gratings are used in the laser shows which are popularly used in opening and closing ceremonies of film fare awards, IPL and Olympic games, etc.
3. Spectra produced by diffraction gratings are extremely useful in applications from studying the structure of atoms and molecules to investigating the composition of stars.

Experiment No:
Date:

EXPERIMENT No - 12

ZENER DIODE CHARACTERISTICS

AIM: To study V-I characteristics of the Zener diode and to determine its breakdown voltage.

APPRATUS: Power supply, Milli ammeter, Voltmeter, Zener diode, Resistor.

WORKING PRINCIPLE: It works based on the principle of breakdown voltage(the minimum reverse voltage to make the diode conduct in reverse bias) in the reverse biased (voltage) region.

THEORY

Diodes which have adequate power-dissipating capabilities to operate in the breakdown region are commonly called Zener diodes. These devices are employed as voltage regulators.

The location of the Zener region can be controlled by varying the doping levels. An increase in the doping produces an increase in the number of added impurities. Further, this will decrease the Zener potential. Zener diodes are available in the Zener potential range of 1.8 V to 200 V with power rating up to 50 W. Silicon is usually preferred in the manufacturing of Zener diodes because of its higher temperature and current handling capabilities.

The symbol of the Zener diode is represented in figure1 given below.

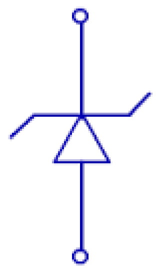


Figure1

AVALANCHE BREAKDOWN

The thermally generated electrons and holes acquire sufficient energy from the applied potential to produce new carriers by removing the valance electrons from their bonds. These new carriers in turn produce additional carriers again through the process of disrupting bonds. This cumulative process is referred as avalanche breakdown, Avalanche multiplication involves when the reference voltage is above breakdown voltage. The temperature co-efficient is positive (% change in reference voltage per centigrade degree change in diode temperature). A junction with broad depletion layer, and therefore low field intensity will break down by the avalanche mechanism.

ZENER BREAKDOWN

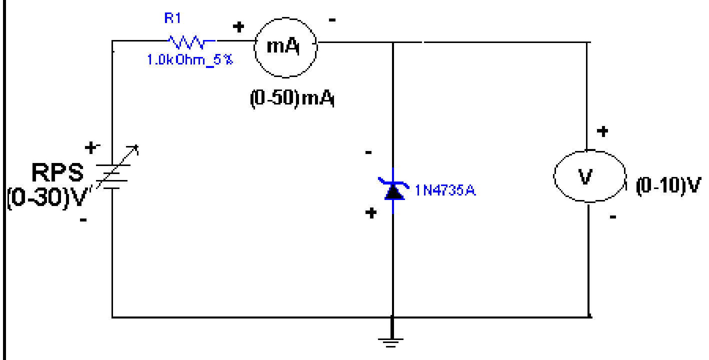
This process initiates breakdown through a direct rupture of the bonds because of the existence of strong electric field. Zener breakdown involves when the reference voltage is below breakdown voltage. The temperature co-efficient is negative. A junction having a narrow depletion layer width and high field intensity will breakdown by the Zener mechanism.
The dynamic resistance of the Zener diode is given by

$$r_z = \Delta V_Z / \Delta I_z$$

Where V_Z is called the Zener voltage or the break down voltage
I_z is the Zener current.

PROCEDURE: FORWARD BIAS:

Circuit Diagram:



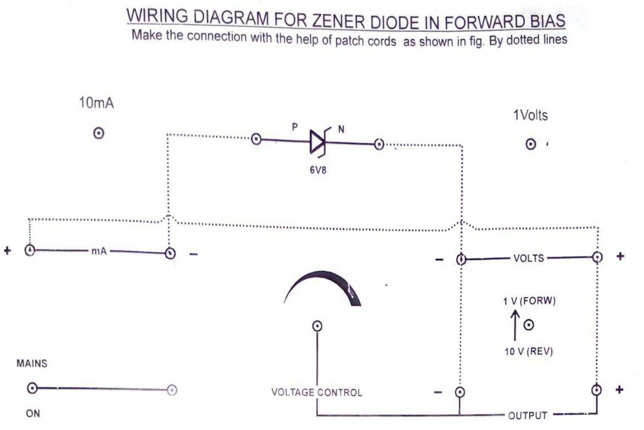
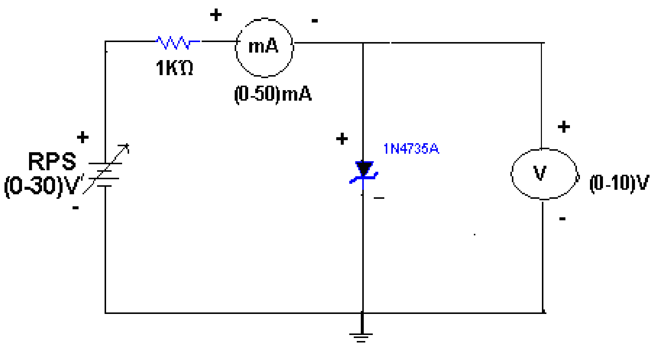
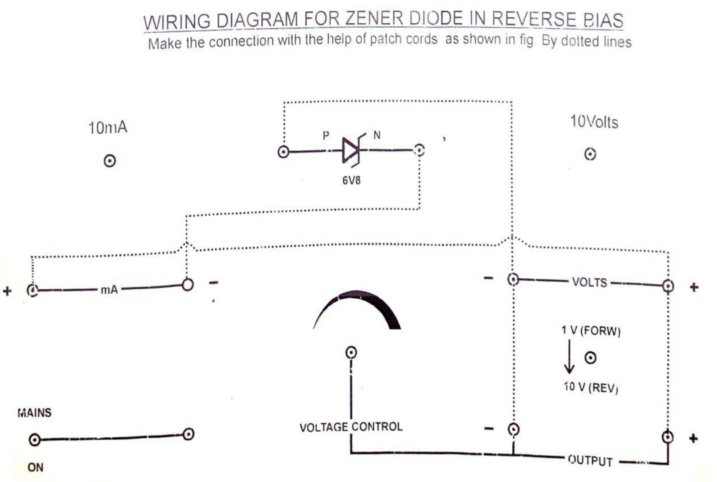


Figure-2

1. Connect the circuit as shown in figure2.
2. Vary the supply voltage gradually, starting from zero. Increase the supply voltage and note the voltmeter reading (V), for each 0.1V step in V, note the corresponding forward current (I) till V becomes 0.8 V. Should not exceed 10mA.
3. Tabulate the results and draw the V-I characteristics under forward characteristics.





REVERSEBIAS:

Circuit Diagram:

Figure-3

1. Connect the circuit as shown in figure3.
2. Increase the supply voltage suitably, and note down the corresponding I_z values.
3. Tabulate the results and draw the V-I characteristics under reverse bias characteristics.

OBSERVATIONS:

Forward bias

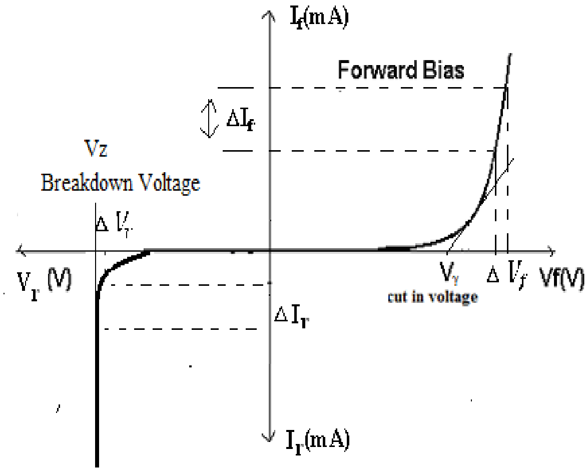
S.No.	V (volts)	I (mA)

Reverse bias

S.No.	V (volts)	I (mA)

GRAPH:

A graph is drawn with voltage on x-axis and current on y-axis for both forward and reverse bias conditions. Note that different scales have to be used in the forward and reverse bias.



CALCUATIONS:

PRECAUTIONS

1. The maximum voltage of the Zener diode should not exceed the breakdown voltage and if it happens then the diode will be permanently damaged.
2. The Zener diode should always be operated in reverse bias.
3. While approaching the cut off voltage, the increment of voltage should be in steps of 0.02V.

APPLICATIONS

1. Zener diodes are widely used as voltage regulators.

2. Zener diodes are also used in surge protectors to limit transient voltage spikes.

RESULT: The Zener breakdown voltage $\mathbf{V_z}$ =

The dynamic resistance of the Zener diode is given by, $r_Z = \frac{\Delta V_Z}{\Delta I_Z}$

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

VIVA QUESTIONS

1. Compare diode and Zener diode.

A Zener diode is a type of diode that permits current not only in the forward direction like a normal diode, but also in the reverse direction if the voltage is larger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage".

A conventional solid-state diode will not allow significant current if it is reverse biased below its reverse breakdown voltage. When the reverse bias breakdown voltage is exceeded, a conventional diode is subject to high current due to avalanche breakdown then the diode will be permanently damaged.

2. Zener diode is always operated in reverse bias. Why?

Zener diodes are designed to be operated in reverse-bias mode, providing a relatively low, stable breakdown, or *Zener* voltage at which they being to conduct substantial reverse current and hence it can be used as a stabilizer.

3. How a Zener diode can stabilize the voltage across load?

The voltage across the diode (it's Zener Voltage, Vz) remains nearly constant even with large changes in current through the diode caused by variations in the supply voltage or load. This ability to control itself can be used to regulate or stabilize a voltage source against supply or load variations. The diode will continue to regulate until the diode current falls below the minimum Iz value in the reverse breakdown region.

4. Why Zener diode highly doped?

The Zener diode's operation depends on the heavy doping of its p-n junction allowing electrons to tunnel from the valence band of the p-type material to the conduction band of the n-type material. In the atomic scale, this tunneling corresponds to the transport of valence band electrons into the empty conduction band states; as a result of the reduced barrier between these bands and high electric fields that are induced due to the relatively high levels of doping on both sides. The breakdown voltage can be controlled quite accurately in the doping process.

Experiment No:
Date:

EXPERIMENT No- 13

LCR SERIES RESONANCE CIRCUIT

AIM: To study the frequency response of L.C.R series circuit & to determine the resonant frequency it

APPARATUS:

Inductor, Capacitor, Resistor, Function generator, A.C milli Ammeter and connecting wires

WORKING PRINCIPLE: In the series LCR circuit, an inductor (L), capacitor(C) and Resistance(R) are connected in series with a variable frequency sinusoidal emf source and the voltage across the resistance is measured. As the frequency is varied, the current in the circuit and hence the voltage across R becomes maximum at the resonance frequency $f_{0.}$ In the parallel LCR circuit there is a minimum of the current at the resonance frequency $f_{0.}$

THEORY

Capacitors and inductors both are used to store energy. In capacitor the energy is stored in electric fields and in inductor the energy is stored in magnetic fields. When a capacitor and an inductor are combined in a single circuit, the energy can be traded back and forth between them at any given time. This leads to electrical oscillations which have important applications in field of electronics, for example the tuner in a radio of electron, the tuner in a radio receiver etc.

LCR SERIES RESONANCE:

An A.C circuit containing inductance, capacitance and resistance is represented in **Figure1.** Let a sinusoidal emf **E = E₀ Sin** ωt act in circuit L.C.R the current produced is also in sinusoidal fashion.

According to Ohm's law,

$$L\frac{dI}{dt} + \frac{Q}{C} + RI = E_0 \text{ Sin } \omega t$$

Where, Q is the instantaneous charge on the plates of the capacitor, ω is the angular frequency of oscillations and I is the instantaneous current.

The peak value of the current is given by, $I_0 = \frac{E_0}{\sqrt{R^2+(\omega L-\frac{1}{\omega C})^2}} = \frac{E_0}{\sqrt{R^2+(X_L-X_C)^2}} = \frac{E_0}{Z}$

Where, $X_L = \omega L$ and $X_c = \frac{1}{\omega c}$ are the inductive and capacitive reactance and Z is the total reactance of the circuit.

At resonance, $\omega L = \frac{1}{\omega c}$; $\omega^2 = \frac{1}{LC}$; $\omega_0 = \frac{1}{\sqrt{LC}}$; $2\pi f_0 = \frac{1}{\sqrt{LC}} \rightarrow f_0 = \frac{1}{2\pi\sqrt{LC}}$

PROCEDURE:

SERIES RESONANCE CIRCUIT DIAGRAM:

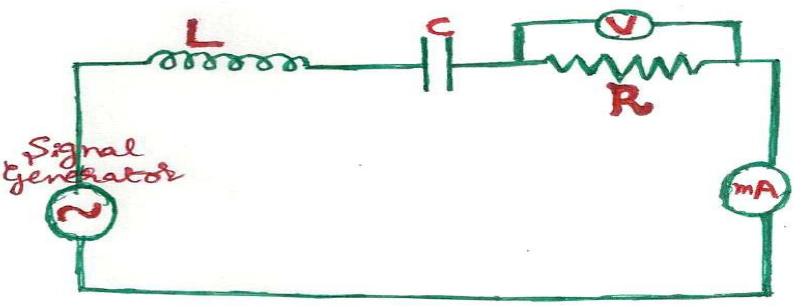


Figure1.

1. The capacitance (C), inductance (L), resistance (R) and A.C milli Voltmeter are connected in series with a function generator as shown in the figure1.

2. The frequency oscillator is adjusted to a minimum value of 10Hz.

3. The current shown by A.C milli – ammeter and the readings are noted.

4. The frequency of function generator is increased in steps and the corresponding A.C milli –voltmeter readings are noted.

5. A graph is drawn with frequency along the X-axis and the voltage along the Y-axis. The frequency at which the voltage is maximum is the resonant frequency.

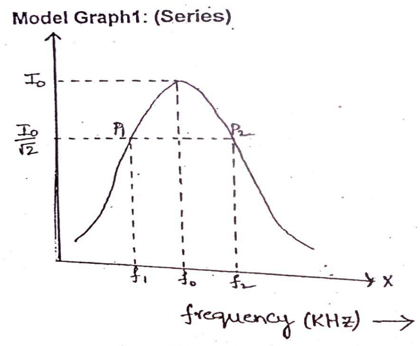
6. If the maximum voltage is E_0, then the points P_1 and P_2 corresponding to the half-power maximum are called half power points. They correspond to I_0½.

   The frequencies f_1 and f_2 corresponding to the half-power points P_1 and P_2 are called half-power frequencies.

Capacitance of the coil **C** **=** **Farad**
Self inductance of the coil **L** **=** **Henry**
Resistance of the resistor **R** **=** **Ohm**
Input voltage **V_i** **=** **Volt**

Observations:

S.No	Frequency (KHz)	Output Current I (mA)	S.No	Frequency (KHz)	Output Current I (mA)
1			15		
2			16		
3			17		
4			18		
5			19		
6			20		
7			21		
8			22		
9			23		
10			24		
11			25		
12			26		
13			27		
14			28		



From graph: Experimental values

1. Resonant frequency **f_0** =
2. Bandwidth (β) **Δf** = $f_2 - f_1$ =
3. Quality factor **Q** = $\frac{f_0}{f_2 - f_1}$ =

APPLICATIONS:

1. There are many applications for this circuit particularly in radio and communication engineering. They are used in different types of oscillator circuits.
2. Another important application is for tuning, such as in radio receivers or television sets, where they are used to select a narrow range of frequencies from the spectrum of radio waves.
   For example, AM/FM radios typically use an LCR circuit to tune as radio frequency.
3. A very frequent use of these circuits is in the tuning circuits of analogue radios. Adjustable tuning is commonly achieved with a parallel plate variable capacitor which allows the value of C to be changed and tune to stations on different frequencies.
4. An L C R circuit can be used as a low pass filter, high pass filter, band pass filter etc. The tuning application, for instance, is an example of band-pass filtering.

Calculations:

Theoretical values:

1. Resonant frequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$ =

2. The Quality factor is given by **Q** = $\frac{1}{R}\sqrt{\frac{L}{C}}$ =

PRECAUTIONS:

1. Fixed amplitude of voltage should be applied to the circuit for the selected values of L, C and R at different frequencies.
2. The input voltage applied to the circuit should be checked at all the frequencies.

RESULT:

Parameter	Experimental value	Theoretical Value
Resonant frequency (f_0)		
Quality factor (Q)		

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2 & PO9** are attained.

VIVA QUESTIONS

1.) What is an inductor?

An inductor is a device which is used to store the energy in a magnetic field. In the laboratories, a coil or solenoid is treated as inductor.

2) What is resistor?

A resistor is an electrical component which is employed to control the current in an electrical circuit

3) What is a capacitor (or condenser)?

A capacitor is an electrical device or arrangement which comprises two metallic conductors (plates) separated by an insulating medium (dielectric) and carrying equal and opposite charges.

4) What is the difference between a conductor and capacitor?

A conductor has some capacitor to store the charge. This quantity of charge is very small. Where as a capacitor has a large capacity to store the charge because it has more than one conductor

5) What is meant by inductance?

The property of an electric circuit by virtue of which any change in the magnetic flux with it induces an e.m.f it is called inductance.

6) What is the condition for resonance in an LCR series circuit?

The frequency of the applied voltage must be equal to the natural frequency of the circuit.

7) What is a signal generator?

A device which produces sine or square waves with variable frequency and variable amplitude is called a signal generator. It is also called as an oscillator or function generator.

8) What is meant by resonance frequency of the LCR series circuit?

The frequency at which the impedance of the circuit becomes minimum and therefore the current becomes maximum is called the resonant frequency of the circuit.

9) What is an 'Acceptor Circuit?

In a series LCR circuit, at resonant frequency the current is maximum. As the circuit offers minimum impedance to the flow of current at resonant frequency, this circuit is called as Acceptor Circuit.

10) What is 'Rejector circuit'?

In a parallel LCR circuit, at resonant frequency the current is minimum. As the circuit offers maximum impedance to the flow of current at resonant frequency, this circuit is called as Rejector circuit.

11) How the resonance takes place in this experiment?

When the applied frequency of the function generator is equal to the natural frequency of the LCR series circuit ($f_0 = \frac{1}{2\pi\sqrt{LC}}$) then the resonance takes place.

Experiment No:
Date:

EXPERIMENT No-14

NUMERICAL APERTURE & ACCEPTANCE ANGLE

AIM:
To determine the numerical aperture and the acceptance angle of the optical fiber.

APPARATUS:
Optical Fiber Trainer set, NA measuring Jig, one meter & three meter Optical fiber Cables, Mandrel and in-line SMA adaptor.

FORMULAE: $$NA = W/ (4L^2 + W^2)^{1/2} \quad \& \quad \theta = Sin^{-1} (NA)$$

Where NA is the Numerical Aperture of the fiber, L is the distance of the screen from the fiber end, W is the diameter of the spot and θ is the acceptance angle of the fiber.

WORKING PRINCIPLE: ***Total Internal Reflection:-*** "When a ray of light traveling in a medium of higher refractive index n_1 strikes a second medium of lower refractive index n_2 with an angle of incidence $\mathbf{i > \theta_c}$ (Critical angle $\mathbf{\theta_c = n_2/n_1}$) then the ray is totally reflected into the same medium". This phenomenon is called *Total Internal Reflection.*

THEORY:
Numerical aperture of any optical system is a measure of how much light can be collected by the optical system. It is the product of the refractive index of the incident medium and the sine of the maximum ray angle.

$NA=n_i.\sin\theta_{max}$, n_i for air is 1, hence $NA=\sin\theta_{max}$

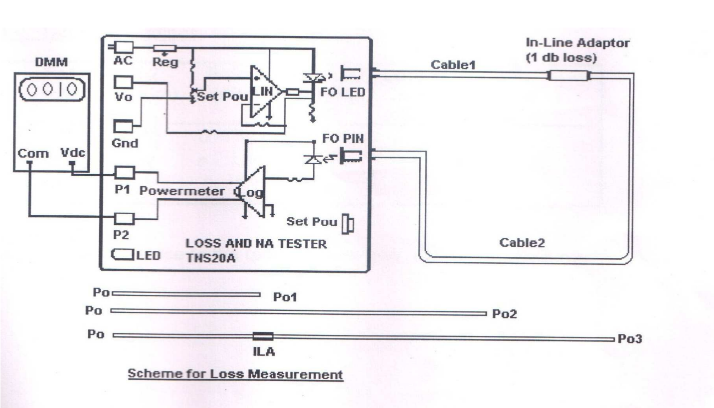
The numerical aperture is given by $NA =(n_1^2-n_2^2)^{1/2}$

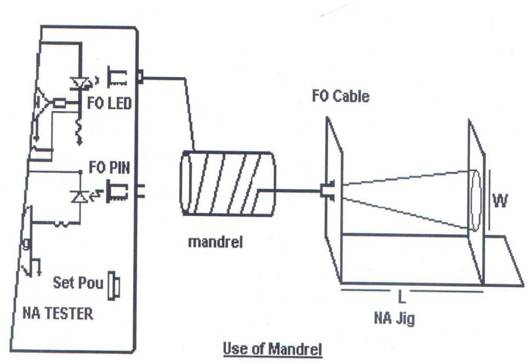
For a step-index fiber, as in the present case, the numerical aperture is given by

NA =, where Δ is the fractional difference in refractive indices,

The experimenter may refer to the specifications of the optical fiber given in Appendix and record the manufacture's NA, n_1, n_2 and θ.

Circuit Diagram:





PROCEDURE:
The schematic diagram of the numerical aperture measurement system is shown in Figure and is self explanatory.

Step 1: Connect one end of the Cable 1 (1-metre FO cable) to FO LED of TNS20A and the other end to the NA Jig, as shown.

Step 2: Plug the AC mains. Light should appear at the end of the fiber on the NA Jig, Turn the Set Pout knob clock wise to set to maximum Po. The light intensity should increase.

Step 3: Hold the white screen with the concentric circles (10, 15, 20 and 25 mm diameter) vertically at a suitable distance to make the red spot from the emitting fiber coincide with the 10mm circle. Note that the spot (outermost) must coincide a with the circle. A dark room will facilitate good contrast. Record L, the distance of the screen from the fiber end and note the diameter (W) of the spot. You may measure the diameter of the circle accurately with a suitable scale.

Step 4: Compute NA using the above formula. Tabulate the reading and repeat the experiment for 15mm, 20mm and 25mm diameters too.

Step 5: In case the fiber is under filled, the intensity within the spot may not be evenly distributed. To ensure even distribution of light in the fiber, first remove twists on the fiber and then wind 5 turns of the fiber on to the mandrel as shown. Use an adhesive tape to hold the windings in position. Now view the spot. The intensity will be more evenly distributed within the core.

TABLE:

S.No	Distance b/n the fiber end & the screen L (mm)	Diameter of the spot W (mm)	Numerical Aperture (NA)	Acceptance angle (θ) in degrees

PRECAUTIONS:

1. Take the readings without parallax error.
2. Fiber should be free from all the twists & bendings.
3. The circumference of the spot must coincide with the circle on the NA measuring Jig.

APPLICATIONS:

1. These are used in hospitals in the treatment of eyes surgery, Laparoscopic surgery, angioplasty etc.
2. These are used in defence like army, navy, airplane applications.
3. These are used as sensors in satellite communication system.

4. These are used in many communication systems such as TV, Internet & telecommunication etc.

RESULT:

The numerical aperture of the optical fiber NA =

The acceptance angle of the fiber **θ =**

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Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2, PO5 & PO9** are attained.

VIVA QUESTIONS

1) **What is meant by an optical Fiber?**
An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.

2) **What is the principle of an optical Fiber?**
The principle of an optical fiber is Total Internal Reflection.

3) **What is meant by Total Internal Reflection?**
When a ray of light traveling in a medium of higher refractive index n_1 strikes a second Medium of lower refractive index n_2 with an angle of incidence $\mathbf{i > \theta_c}$ (Critical angle $\mathbf{\theta_c = n_2/n_1}$) then the ray is totally reflected into the same medium". This phenomenon is called Total Internal Reflection.

4) **What is meant by Numerical Aperture of an optical Fiber?**
Numerical aperture is thus considered as a light gathering capacity of an optical fibre. Numerical Aperture is defined as the Sine of half of the angle of fiber's light acceptance cone.

5) **What is meant by Acceptance angle of an optical Fiber?**
The acceptance angle of an optical fiber is defined based on a purely geometrical consideration (ray optics): it is the maximum angle of a ray (against the fiber axis) hitting the fiber core which allows the incident light to be guided by the core.

6) **What is meant by Fiber-optic communication?**
Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber.

Experiment No:
Date:

EXPERIMENT No-15

BENDING LOSSES IN OPTICAL FIBERS

AIM:

Study various types of losses that occur in optical fibers and measure the loss in dB of two optical fiber patch cords.

APPARATUS:

Optical Fiber Trainer set, NA measuring Jig, one meter & three meter Optical fiber Cables, Mandrel, in-line SMA Adaptor and digital multi meter.

FORMULA:

Po3-Po1 = Loss in the (Cable2+ ILA) & Po3-Po2 =Loss in (Cable1+ILA).

Where Po1, Po2 & Po3 → Power Meter Readings in 1meter, 3meter & (1+3) 4meter optical fibers respectively & ILA → In-line Adaptor (1dB Loss).

WORKING PRINCIPLE: ***Total Internal Reflection:-*** "When a ray of light traveling in a medium of higher refractive index n_1 strikes a second medium of lower refractive index n_2 with an angle of incidence **$i > \theta_c$** (Critical angle **$\theta_c = n_2/n_1$**) then the ray is totally reflected into the same medium". This phenomenon is called *Total Internal Reflection.*

THEORY:

Attenuation in an optical fiber is a result of a number of effects. This aspect is will covered in the books referred to. We will confine our study to attenuation in a fiber due to macro bending and estimate the losses in two patch cords. Preferably we will use patch cords two different lengths.

The loss as a function of the length of the fiber is measurable only when we use one-meter cable in the experiments. Fiber loss variations with wavelength for the optical finer under consideration are shown in Apendix1.

The optical power at a distance, L, in an optical fiber is given by Pl=P0 10(α l/10) where P0 is the launched power and is the attenuation coefficient in decibels per unit length. The typical attenuation coefficient value for the fiber under consideration here is 0.3 dB per meter at a wavelength of 660n/ Loss in fibers expressed in decibels is given by -10 log (P0/PF) where, P0 is the launched power and PF is power at the far end of the fiber. Typical losses at connector junctions may vary from 0.3 dB to 0.5dB.

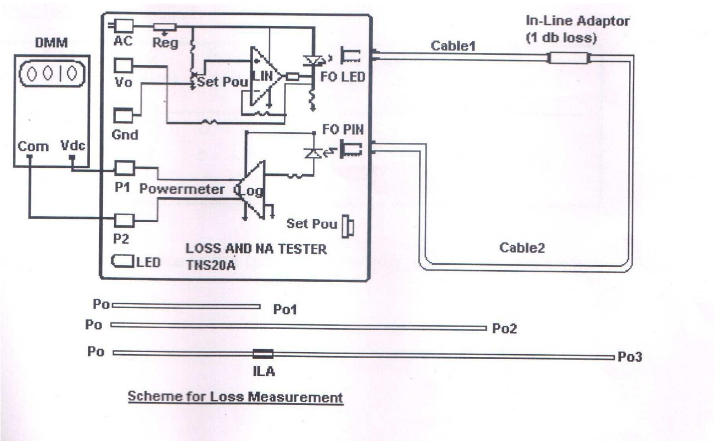
Losses in fibers occur at fiber-fiber joints or splices due to axial displacement, angular displacement, separation (air gap), mismatch of cores diameters, mismatch of numerical apertures, improper cleaving and polishing at the ends. The loss equation for a simple fiber optic link is given as:

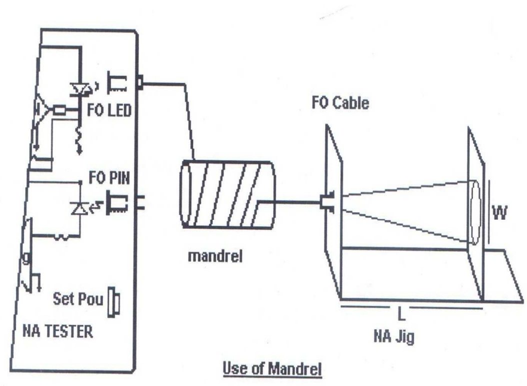
Pin(dBM)-Pout(dBM) =LJ1+LF1B1+J3(db): Where, LJ1 is the loss at the LED-connector junction,LF12B1(dB) is the loss in cable1, LJ2(dB) is the insertion loss at a splice or in-line adaptor,LF1B2(dB) is the loss in cable2 and LJ3(dB) is the loss the connector-detector junction.

PROCEDURE:

The schematic diagram of the optical fiber loss measurement system is shown in the Figure and is self explanatory.

Circuit Diagram:





Step 1: Connect one end of FO Cable1 (1-Metre) to the FO LED of the TNS20A and to the FOPIN.
Step2 : Set the DMM to the 2000 mV range. Connect the DMM on .The power meter is now ready for use.
Step 3: Plug the AC mains. Connect the optical fiber patch cord securely, as shown, after relieving all twists and strains on the fiber. Adjust the Set Pour knob to set P0 to a suitable value, say,m-15.0dBm m (The DMM will read 150mV). Note this as P_{01}.
Step 4: Wind one turn of the fiber on the mandrel, as shown in Experiment 1 and note the new reading of the power meter P02. Now the loss due to bending and strain on the plastic fiber is po1-P02 dB. For more accurate readout set the DMM to the 200.0mV range and take the measurement. Typically the loss due to the strain and bending the fiber is 0.3 to 0.8db.
Step5 : Next remove the mandrel and relieve the cable of all twists and strains. Note the reading p01 for Cable 1 (1-Metre cable). Repeat the measurement with the Cable 2(5-Metre cable) and note the readingP02. Use the in-line SMA adaptor and connect the cables in series as shown. Note the measurement P03.

Po3-Po1 gives loss in the Cable2+Loss in ILA

Po3-Po2 gives loss in the Cable1+Loss in ILA.

Assuming a loss of l.0dB in the in-line adaptor, we obtain the loss in each cable.
The experiment may be repeated in the higher sensitivity range of 200.0mV.

TABLE:

S.No	Power Meter Reading P01 (dBm)	Power Meter Reading P02 (dBm)	Power Meter Reading P03 (dBm)	Loss in Cable1 (dB)	Loss in Cable2 (dB)	Loss/Meter (dB)
1						
2						
3						
4						
5						

PRECAUTIONS:

1. Take the readings without parallax error.
2. Fiber should be free from all the twists & bendings.
3. The circumference of the spot must coincide with the circle on the NA measuring Jig.

RESULT:

The bending losses are determined and the readings are closer to the recorded readings of the Manufacturer.

Conclusion: Course outcomes **CO1 to CO6** and Program outcomes **PO1, PO2, PO5 & PO9** are attained.

Signature of Faculty with date & Remark

APPLICATIONS:

5. These are used in hospitals in the treatment of eyes surgery, Laparoscopic surgery, angioplasty etc.
6. These are used in defence like army, navy, airplane applications.
7. These are used as sensors in satellite communication system.
8. These are used in many communication systems such as TV, Internet & telecommunication etc.

VIVA QUESTIONS

7) What is meant by an optical Fiber?
An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.

2) What is the principle of an optical Fiber?
The principle of an optical fiber is Total Internal Reflection.

3) What is meant by Total Internal Reflection?
When a ray of light traveling in a medium of higher refractive index n_1 strikes a second medium of lower refractive index n_2 with an angle of incidence **$i > \theta_c$** (Critical angle **$\theta_c = n_2/n_1$**) then the ray is totally reflected into the same medium". This phenomenon is called Total Internal Reflection.

4) What is meant by transmission loss or Attenuation in optical fiber?
Attenuation in fiber optics, also known as transmission loss, is the reduction in intensity of the light beam (or signal) as it travels through the transmission medium.

APPENDIX- I

Fundamental Physical constants

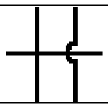
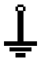
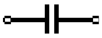
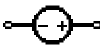
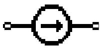
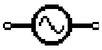
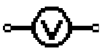
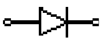
Name	Symbol	Constant Value
Speed of light	c	$2.99792458 \ x \ 10^{8} \ m/s$
Planck constant	h	$6.6260755 \ x \ 10^{-34} \ J \cdot s$
Planck constant	h	$4.1356692 \ x \ 10^{-15} \ eV \cdot s$
Gravitation constant	G	$6.67259 \ x \ 10^{-11} \ m^{3} \cdot kg^{-1} \cdot s^{-2}$
Boltzmann constant	k	$1.380658 \ x \ 10^{-23} \ J/K$
Avogadro's number	N_A	$6.0221 \ x \ 10^{23} \ mol^{-1}$
Charge of electron	e	$1.60217733 \ x \ 10^{-19} \ C$
Permeability of vacuum	μ_0	$4\pi \ x \ 10^{-7} \ N/A^{2}$
Permittivity of vacuum	ε_0	$8.854187817 \ x \ 10^{-12} \ F/m$
Coulomb constant	$1/4\pi\varepsilon_0 = K$	$8.987552 \ x \ 10^{9} \ N \cdot m^{2}/C^{2}$
Faraday constant	F	$96485.309 \ C/mol$
Mass of electron	m_e	$9.1093897 \ x \ 10^{-31} \ kg$
Mass of electron	m_e	$0.51099906 \ MeV/c^{2}$
Mass of proton	m_p	$938.27231 \ MeV/c^{2}$
Mass of neutron	m_n	$1.6749286 \ x \ 10^{-27} \ kg$
Mass of neutron	m_n	$939.56563 \ MeV/c^{2}$
Bohr magneton	μ_B	$9.2740154 \ x \ 10^{-24} \ J/T$
Flux quantum	Φ_0	$2.067834 \ x 10^{-15} \ T/m^{2}$
Bohr radius	a_0	$0.529177249 \ x \ 10^{-10} m$
Earth's magnetic field	H	0.38 oersted

APPENDIX –II

Physical Density of Metal's & Alloy's

S.No.	Metal or Alloy	Density *(kg/m³)*
1.	Actinium	10070
2.	Aluminum	2712
3.	Barium	3594
4.	Beryllium	1840
5.	Bismuth	9750
6.	Brass 60/40	8520
7.	Bronze (8-14% Sn)	7400 – 8900
8.	Brass - casting	8400 – 8700
9.	Cadmium	8640
10.	Cast iron	6800 – 7800
11.	Chromium	7190
12.	Cobalt	8746
13.	Copper	8940
14.	Iron	7850
15.	Nichrome	8400
16.	Nickel	8908
17.	Gold	19320
18.	Red Brass	8746
19.	Silver	10490
20.	Stainless Steel	7480 – 8000
21.	Steel	7850
22.	Tin	7280

APPENDIX –III

Symbol	Component name	Physical Meaning
	Not Connected Wire	Wires are not connected
	Earth Ground	Used for zero potential reference and electrical shock protection.
	Resistor	Resistor reduces the current flow.
	Variable Resistor/Rheostat	Adjustable resistor - has 2 terminals.
	Capacitor	Capacitor is used to store electric charge. It acts as short circuit with AC and open circuit with DC.
	Capacitor	
	Variable Capacitor	Adjustable capacitance
	Inductor	Coil / solenoid that generates magnetic field
	Voltage Source	Generates constant voltage
	Current Source	Generates constant current.
	AC Voltage Source	AC voltage source
	Generator	Electrical voltage is generated by mechanical rotation of the generator
	Battery Cell	Generates constant voltage
	Battery	Generates constant voltage
	Voltmeter	Measures voltage. Has very high resistance. Connected in parallel.
	Ammeter	Measures electric current. Has near zero resistance. Connected serially.
	Diode	Diode allows current flow in one direction only (left to right).
	Zener Diode	Allows current flow in one direction, but also can flow in the reverse direction when above breakdown voltage

REFERENCES

1. Engineering Physics Lab Manual by Dr.Y. Aparna&Dr.K.Venkateswarao (V.G.S.Book links).
2. Physics Practical Manual, Lorven Publication.
3. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
4. "Practical Physics", G.L. Squires, Cambridge University Press, Cambridge, 1985.
5. "Great Experiments in Physics", M.H.Shamos, Holt, Rinehart and Winston Inc., 1959.
6. "Engineering physics Lab Manual; by Narendra Kolla, amigobookssales@gmail.com.
7. "Engineering physics Lab Manual;by M.SriRamarao, Nityanand Choudhary,Daruka Prasad (Acme Learning).
8. "Optics", AGhatak, Tata-McGraw Hill, New Delhi, 1992.
9. "Introductory Readings in the Philosophy of Science", Edited by E.D. Klenke, R. Hollinger, A.D.Kline, Prometheous Books, Buffalo, New York, 1988.

WEB SOURCE REFERENCES

1. http://vlab.co.in/ba_labs_all.php?id=8
2. http://va-iitk.vlabs.ac.in/
3. http://vlab.amrita.edu/?sub=1&brch=282
4. http://vlab.amrita.edu/?sub=1&brch=192
5. http://vlab.amrita.edu/?sub=1&brch=201