ENGINEERING PHYSICS LAB MANUAL
CUM OBSERVATION

FOR

MECHANICAL ENGINEERING

Sir C.V. RAMAN LABORATORY FOR EXPERIMENTAL PHYSICS

DEPARTMENT OF PHYSICS

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
Approved by AICTE & Permanently Affiliated to JNTUK, Kakinada
Accredited by NAAC with “A” Grade and NBA (ECE,CSE, EEE & ME)
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 interferencein thin air films.

2. To determine the wavelengths of various spectral lines in the polychromatic source (Hg source) and to determine thewavelength 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 pendulum 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 Determine the velocity of sound using acoustics of volume resonator
7. To impart the knowledge in preparation of composite materials by hand-lay up technique.

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 (ME)

SNO	DESCRIPTION	PO(1..12) MAPPING	PSO(1..2) MAPPING
CO1	Identify the working principles of laboratory experiments in optics, mechanics, electromagnetic and electronics.	PO1, PO2, PO5, PO9	
CO2	Apply the working principles of laboratory experiments in optics, mechanics, electromagnetic and electronics and perform the experiments using required apparatus.	PO1, PO2, PO5, PO9	
CO3	Compute the required parameter by suitable formula using experimental values (observed values) in mechanics, optics, electromagnetic and electronic experiments.	PO1, PO2, PO9	
CO4	Analyze the experimental results through graphical interpretation.	PO1, PO2, PO9	
CO5	Recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.	PO1, PO2, PO9	
COURSE OVERALL PO/PSO MAPPING: PO1, PO2, PO5, PO9			

SNO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1			1	1			2			1	1	
CO2	3	1							2			1	1	
CO3	3	1							2			1	1	
CO4	3	1			1	1			2				1	
CO5	3	1			1	1			2			1	1	
PH1105	3	1							2				1	

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
CO1	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.
CO2	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.
CO3	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.
CO4	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.

CO5	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.

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I B.Tech. MECH–II Semester

APPLIED/ENGINEERING PHYSICS LAB

L	T	P	C
0	0	3	2

List of Experiments

1. Determine the rigidity modulus of material by Torsional pendulum
2. Verify the laws of transverse waves using Sonometer.
3. Determination of wavelength of laser light by normal incidence method
4. Determine the radius of curvature of Plano-convex lens by Newton's Rings Method.
5. Determine the energy band gap of a given semi-conductor
6. Determine the velocity of sound using acoustics of volume resonator
7. Determine the acceleration due to gravity at a place in the inertial frame of reference using compound pendulum.
8. Preparation of composite material by hand lay-up technique

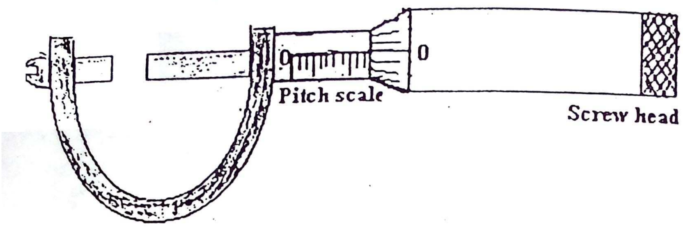
Virtual Lab Experiments

9. Determination of elastic constants of the Perspex beam using Cornus interference method.
10. Determination of velocity of ultrasonic waves and Young's modulus of various materials by Kundt's tube apparatus.

- 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 verinercalipers. 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.

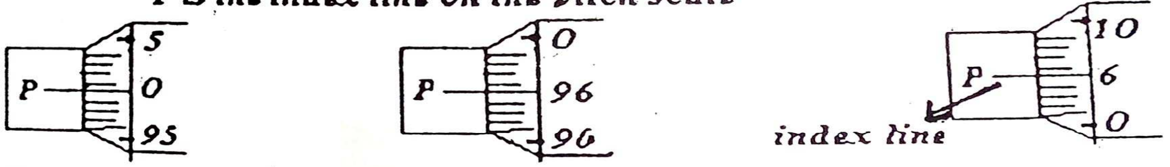


L.C of the screw gauge = pitch of the screw/No of Head scale divisions.
Pitch of the screw = Distance moved on the pitch scale for one rotation of the head.
The distance is divided by 5 gives the value of the pitch of the screw. Again the pitch of the screw is divided by the number of head scale divisions 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

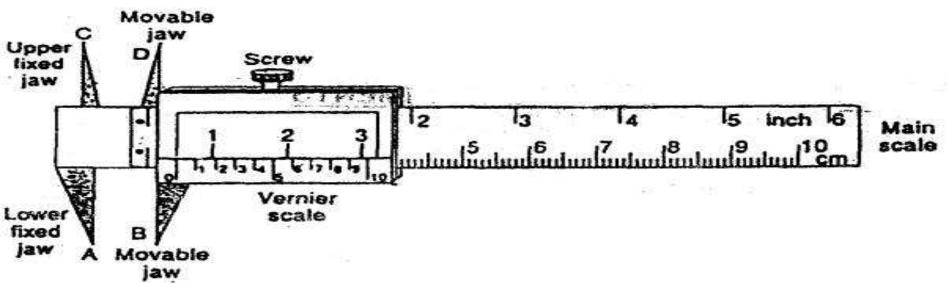
A scale is used to measure the length of an object. One end of the object is made to coincide with the zero of the scale, the other end of the object falls between the fifth and sixth divisions. This means that the length of the object is greater than 5 divisions and less than 6 divisions. So the length 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 verinerscale (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

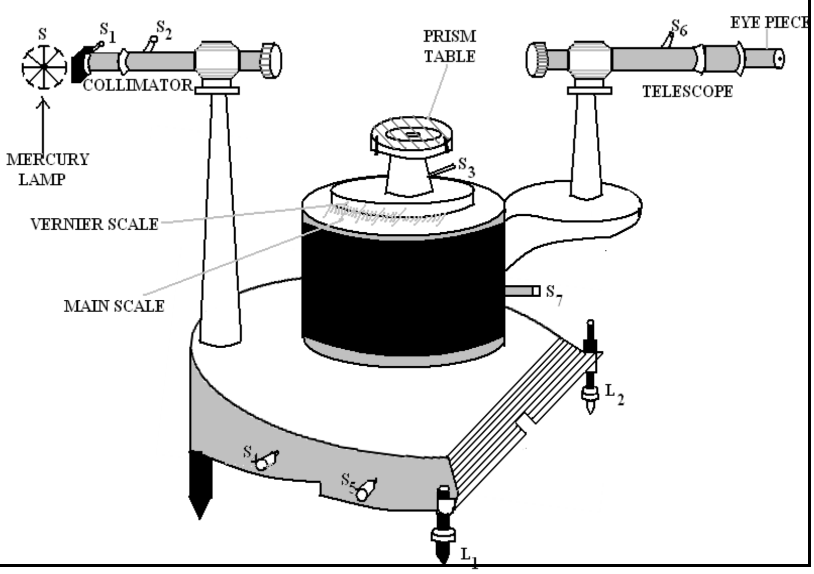
Least count of verinercalipers = 1MSD – 1 VSD = (1-9/10) MSD = 1/10 MSD

= (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 coincidencexL.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 imaginea 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.***

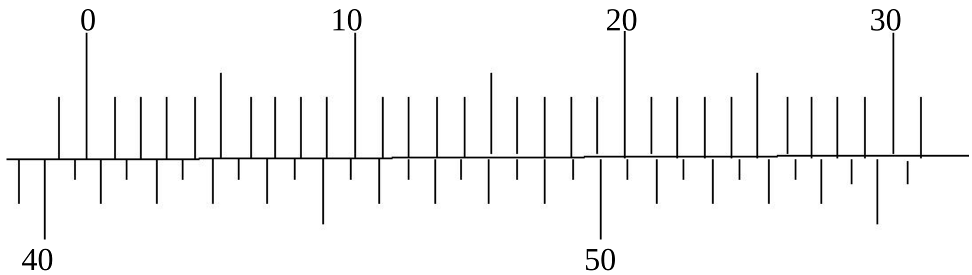
d) **Prism placement**: Now you should place the prism in the center of the silver table. Recall that light is bent toward the base of the prism, so it should be placed on the silver table so that the gray plastic part makes a "C" shape if you were to look at it from the telescope side of the apparatus. 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 crosshair 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.

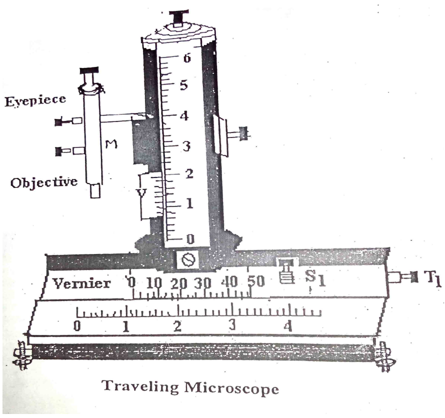
PROCEDURE: Become familiar with the spectrometer identify each component: the black table, the prism table, the collimator, and the telescope (see figure above). Note the clamping screws and the fine adjustment screws for the telescope and the black table. Note the clamping screw for the prism table. 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°.

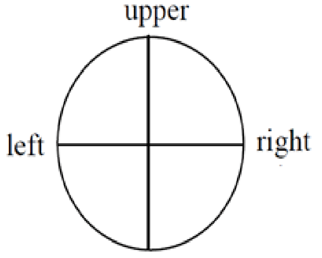
A Travelling Microscope



Traveling 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 coincide 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 = 0.001cm

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-1

TORSIONAL PENDULUM

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

Apparatus: Torsional pendulum, stop watch, screw gauge, Vernier 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

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

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:

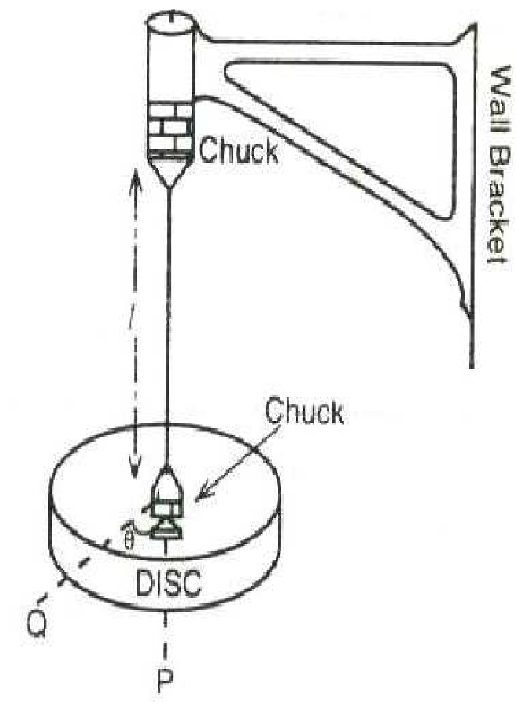


Figure : Torsional Pendulum

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

Then the restoring couple set up in it is equal to

$$\frac{(\pi.n.a^4.\theta)}{2l} = c\theta \text{ Where } \frac{(\pi.a^4.n)}{2l} = c \text{ --------} \quad 1$$

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. $\frac{dw}{dt} = -c.\theta \quad \frac{dw}{dt} = -\left(\frac{c}{I}\right)\theta$

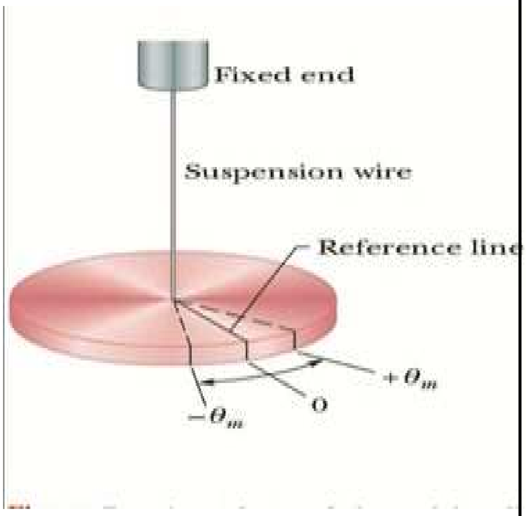
i.e the angular acceleration ($\frac{dw}{dt}$) of the angular displacement(θ).

Therefore its motion is simple harmonic hence time period is

given by $T = 2\pi\sqrt{\frac{I}{c}}$ ---- 2

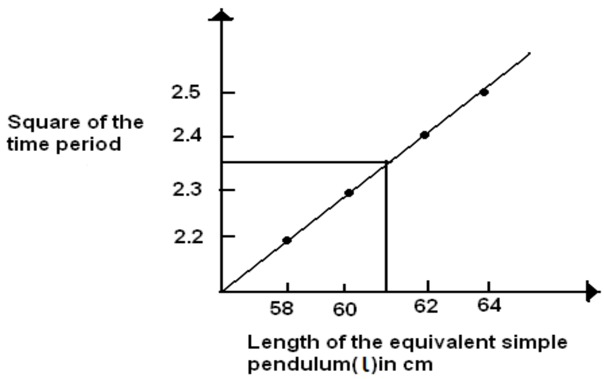
From 1 & 2 $\eta = \frac{8\pi I}{a^4} \times \frac{l}{T^2}$

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.



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

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)	TotalReading (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 thevolume 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-2

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).

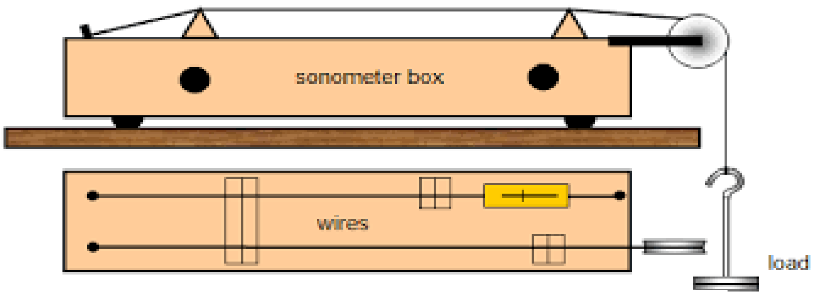
Working Principle: ***Resonance:*** Resonance takes place when the frequency of the external body/tuning fork is equal to the natural frequency of the segment of the wire (vibrating air column in between the bridges inside the Sonometer).

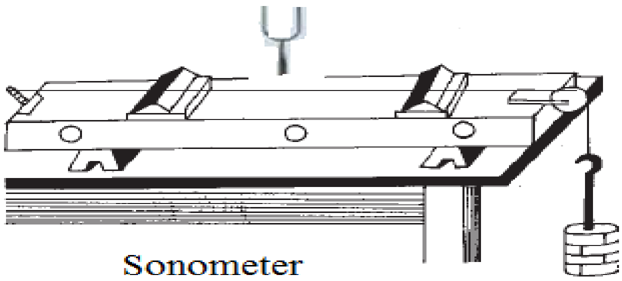
Formula: The frequency of transverse wave is

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

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 $l = (l_1 + l_2)/2$	$\sqrt{T}$	$\sqrt{T}/l$ = constant
		Trail 1 l_1 cm	Trail 2 l_2 cm			

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 $l = (l_1 + l_2)/2$	$l\sqrt{m}$ = constant
		Trail 1 l_1 cm	Trail 2 l_2 cm		
	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 + (nxL.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 + (nxL.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 + (nxL.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.

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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 amplitudeat 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:

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

$$W = \lambda Dn / d$$

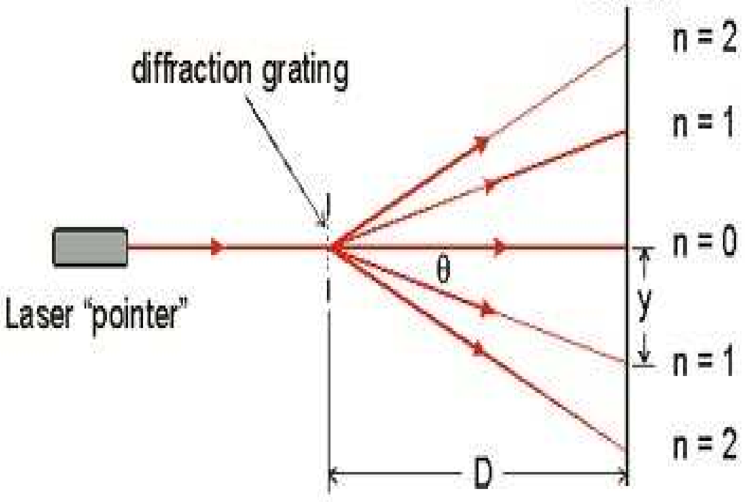
Where, **λ** is the wavelength of laser light, **D** is the distance between the slits and the screen, **d** is the distance on the screen from the center of the pattern (central maximum) to the **n**th maximum.

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.

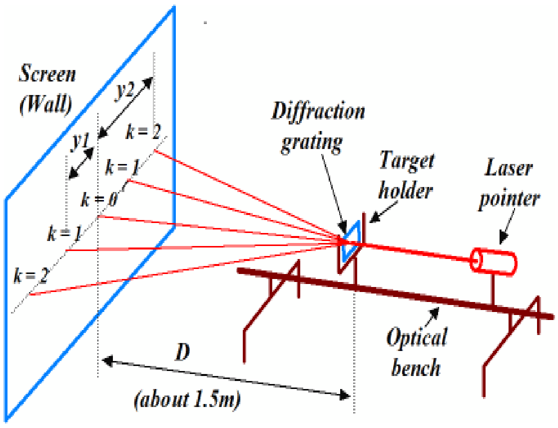
THEORY:

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

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**	$\lambda = \frac{Sin\theta}{nN} A^0$
			Left d1	Right d2	Mean d =(d1+d2)/2			
1	1	15						
2	1	20						
3	1	25						
4	1	30						
5	1	35						
6	1	40						
7	1	45						
8	1	50						
9	2	15						
10	2	20						
11	2	25						
12	2	30						
13	2	35						
14	2	40						
15	2	45						
16	2	50						

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.

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 mth dark ring is given by $D_m=2\sqrt{m\lambda R}$ where m=,1,2.. etc and diameter of the nth 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

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

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 mth and nth 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

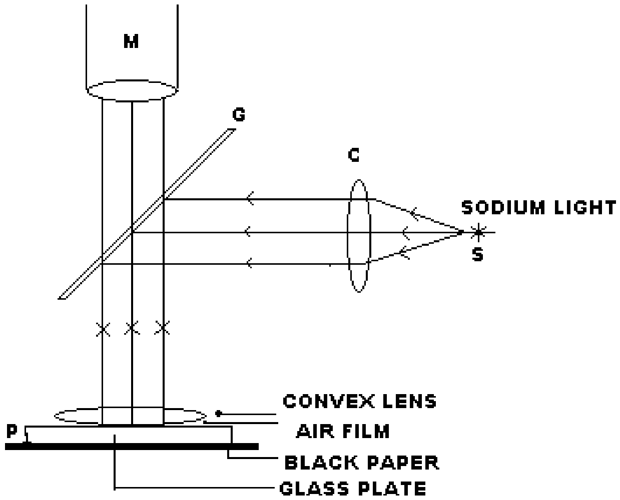


Fig: Experimental arrangement to observe Newton's Rings

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:

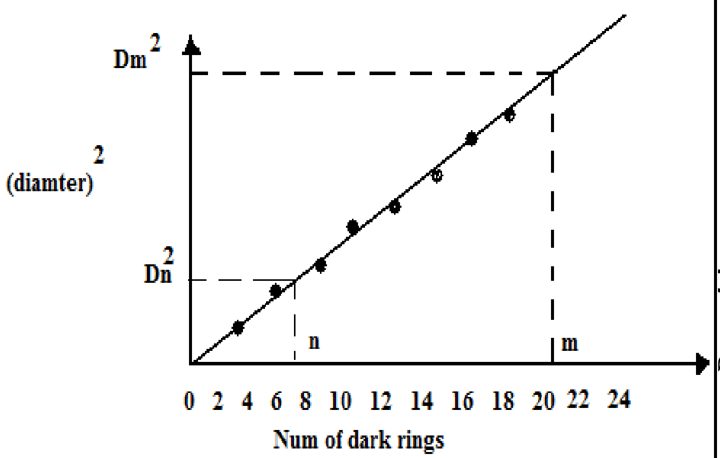
$$\text{Least count of the microscope} = \frac{\text{Value of one } M.S.D}{\text{Total Number of vernier scale divisions}}$$

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 mth (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:

1) m = 13, n =3;

$D_m^2 =$

$D_n^2 =$

2) m = 15, n =5;

$D_m^2 =$

$D_n^2 =$

3) m = 17, n =7;

$D_m^2 =$

$D_n^2 =$

$$R_1 = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} \text{ cm}$$

$$R_2 = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} \text{ cm}$$

$$R_3 = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} \text{ cm}$$

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 – 5

ENERGY GAP OF THE SEMICONDUCTOR

Aim

To determine the energy band gap of a 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,

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

where, A is the constant, E_g is t[...]e 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 = $5.036 \times E_g$. From this the energy band gap of the p-n junction diode is calculated to be

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

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:

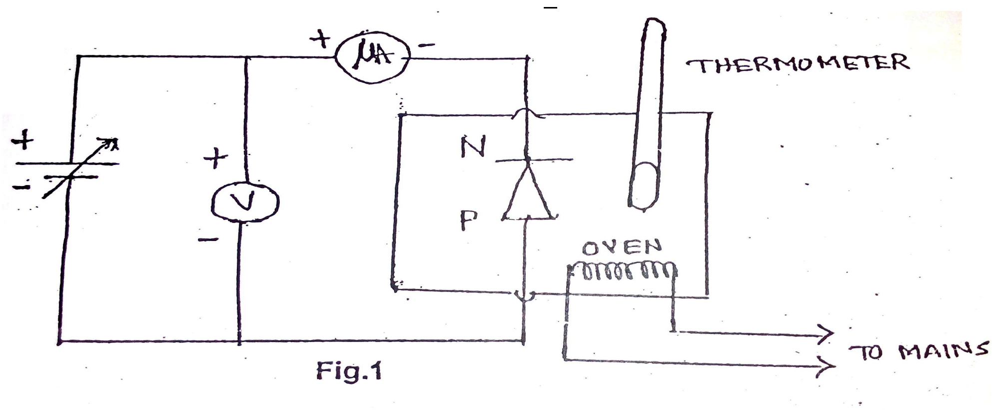
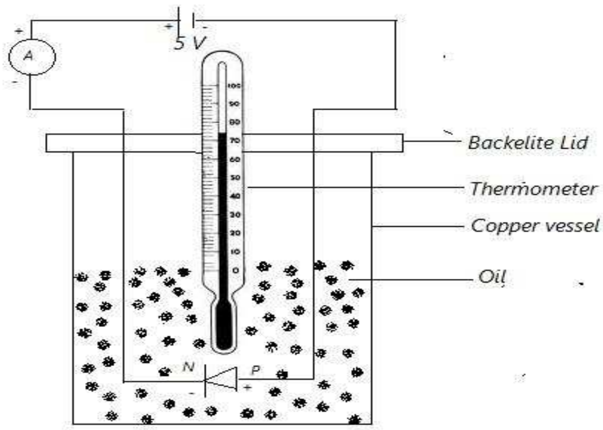


Fig.1

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.

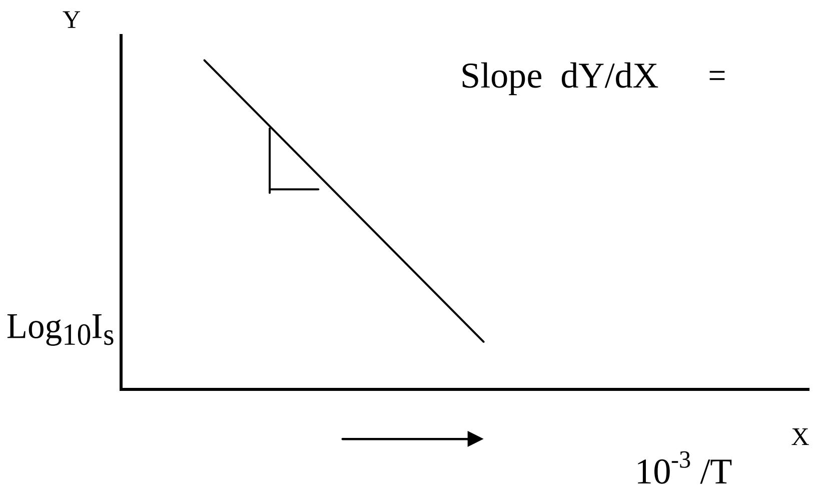
At any temperature, the average value of reverse saturation current will be considered. $I_S = ((I_S)_{increase} + (I_S)_{decrease}) / 2$.

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)	$1/T \times 10^{-3}$ 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°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 **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?
Thisis 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

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, Vernier 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

$$n = \frac{V_t}{2\pi}\sqrt{\frac{A}{VL}}$$

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,

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

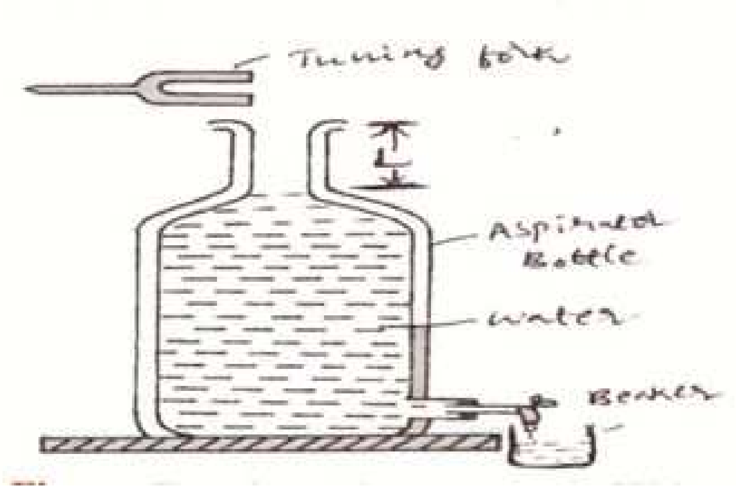
Or

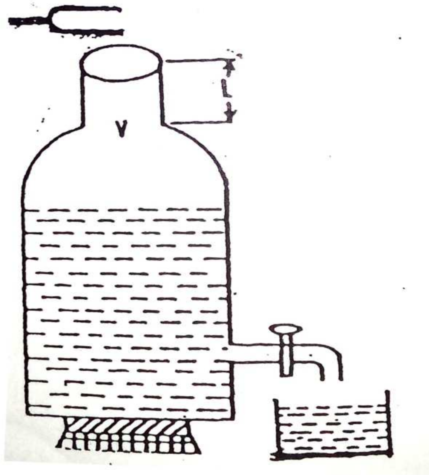
$$n^2(V+e) = \text{constant}$$

Description:

The volume resonator consists of an aspirator bottle filled with water having asmall 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 columnpresent 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.

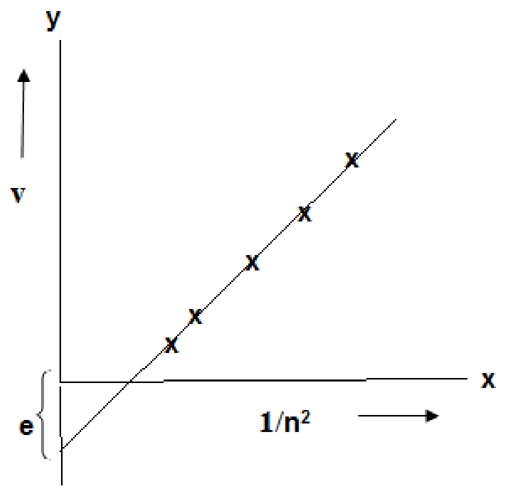
Observations:

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 $\mathbf{1/n^2}$ 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)**

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



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

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

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

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

$\mathbf{V_0}$ is the velocity of air at 0^0 C, $\mathbf{V_t}$ is the velocity of air at $\mathbf{t^0}$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.

Signature of Faculty with date & Remark

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 – 7

COMPOUND PENDULUM

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

Experiment No:
Date:

ndpendulum with suitable support for its suspension, stop-clock and a scale.

E: ***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.

$$\boxed{g = 4\Pi^2 (\frac{l}{T^2}) \, {}^{cm}\!/_{s^2}}$$

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

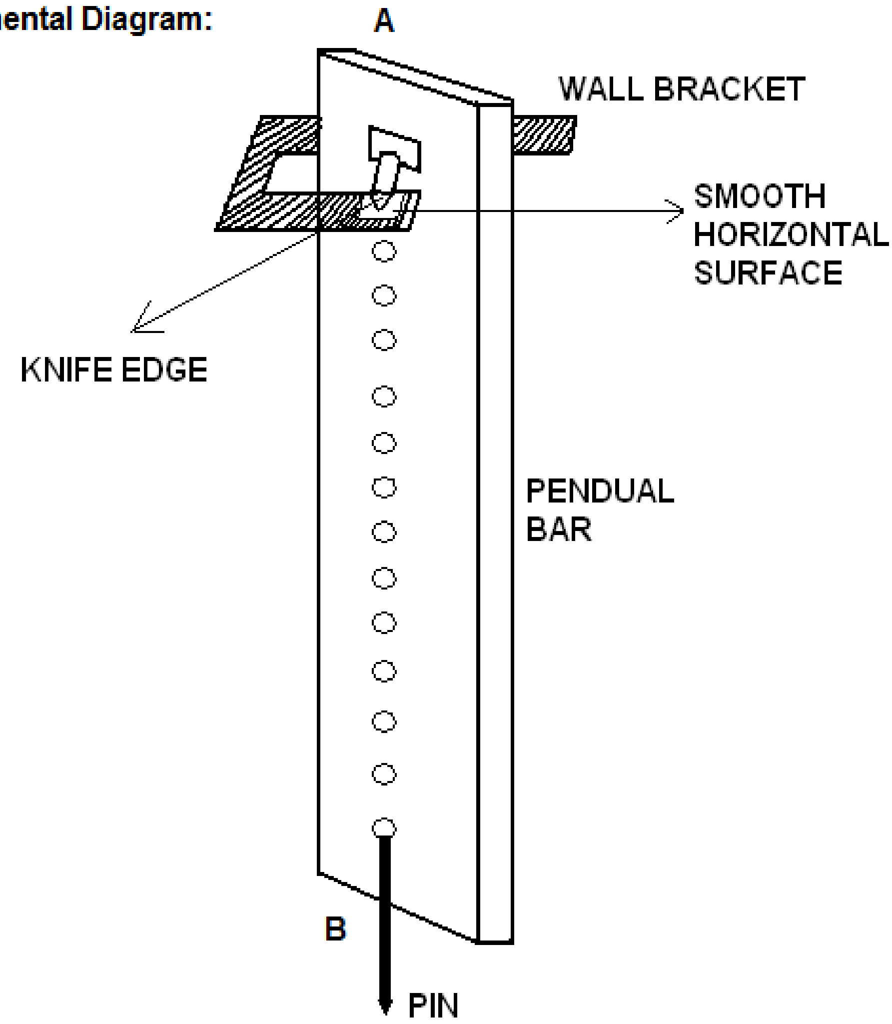
$$g = 4\Pi^2 (\frac{l}{T^2}) \, {}^{cm}\!/_{s^2}$$

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.

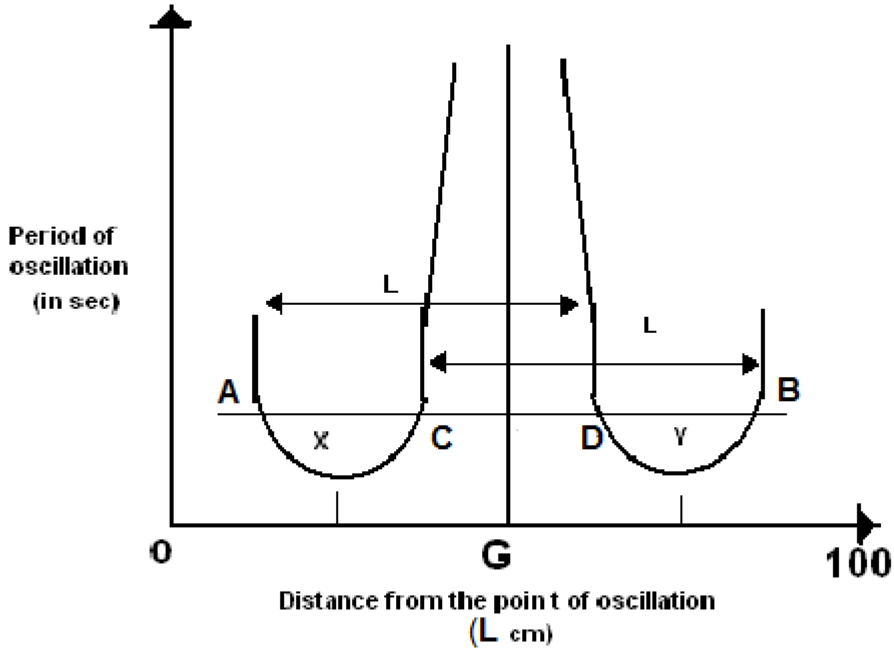
A graph is drawn with the distance of the point of oscillation from one end (A end) on the X-axis and the period of oscillation on the Y-axis. The graph consists of two symmetrical curves corresponding to the two halves of the bar. The bar is taken out and is balanced on a knife edge (the centre point) 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.

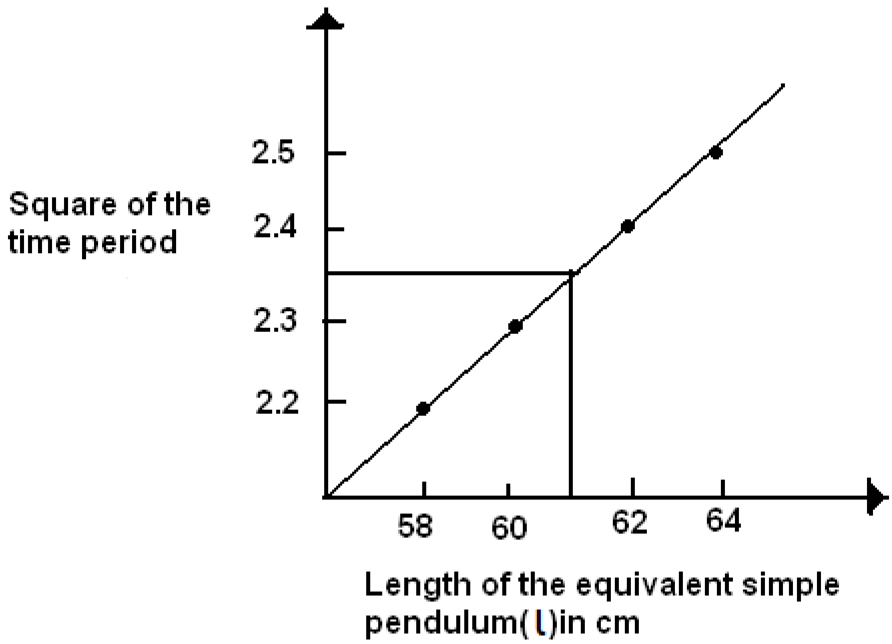
On the graph paper, a line ABCD is drawn parallel to x-axis intersecting the two curves at four points A, B, C, and D. It is to be noted that AC will be equal to BD. Each being equal to the length of the equivalent pendulum (*l*), corresponding to the time period (T).This value of l and t are substituted 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 compoundpendulum

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 9.83m/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 apoint 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 Notthe 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).

E XPERIMENT No-8

Preparation of composite material by hand lay-up technique

Aim:
To prepare composite materials by hand layup technique.
Apparatus:
Mold, release agent, roller, mixing container and mixing stick, epoxy resin, hardener, fiber glass woven cloth, acetone
Theory:
A Lay-Up process is a moulding process for composite materials, in which the final product is obtained by overlapping a specific number of different layers, usually made of continuous polymeric or ceramic fibres and a thermoset polymeric liquid matrix. It can be divided into Dry Lay-up and Wet Lay-Up, depending on whether the layers are pre-impregnated or not. Dry Lay-up is a common process in the aerospace industry, due to the possibility of obtaining complex shapes with good mechanical properties, characteristics required in this field. On the contrary, as Wet Lay-Up does not allow uni-directional fabrics, which have better mechanical properties, it is mainly adopted for all other areas, which in general have lower requirements in terms of performance. The main stages of the Lay-Up process are cutting, lamination and polymerization. Even though some of the production steps can be automated, this process is mainly manual hence often referred to as the Hand Lay-Up process, leading to laminates with high production costs and low production rates with respect to other techniques.
Cutting fabrics is the first stage of the Lay-Up process. fibres, in general, have high tensile strength and the shear strength is quite low, so they are fairly easy to cut. This process can be manual, semi-automatic or completely automatic. As far as cutting tools are concerned, the most common are scissors, cutters, knives and saws.
Lamination of the fabrics is the second stage of the Lay-Up process. It is the procedure of overlapping all the layers in the correct order and with the correct orientation. In the case of Wet Lay-Up, the preparation of the resin is included in this operation, as the fabrics are not already impregnated. Lamination is usually performed in a clean-room to avoid particle inclusions within the layers, which would interfere with the characteristics of the final product.
The most important tool is the mould, It can be made of different materials, depending on the shrinkage and the thermal expansion coefficient of the composite material, the stiffness required, the surface finish needed, the draft angles and the bending angle.
Polymerization of the laminate is the third and final stage of the Lay-Up process. This phase is of utmost importance to obtain the required characteristics of the final product. Polymerization in an autoclave is a technique which allows laminates with the best mechanical properties to be obtained, but it is the most expensive and permits only the use of open moulds. The advantage is due to the fact that the pressure helps to bond the composite layers and to eject air inclusions and volatile products, increasing the quality of the process. Typically, the three cycles of temperature, pressure and vacuum are studied experimentally to obtain the best combination of the three parameters.
Procedure:
The materials used in this process are mould, release agent, resigns and reinforcing fibers. A mold is used for making parts using lay-up process to place layer in or on to obtain the desired shape. Different materials such as metals, composites, wood, plastic etc can be used as molds.
Releasing agent is used to prevent resign from sticking to the mold. Waxes, spray releases, internal releases etc are used as release agents. Resigns act as the matrix of the composite to bind the composite materials together and transfer component stresses that may act on the part to the fibers in the composite.
There are many different fibers that can be used to make up a composite and each material can be obtained in different formats. Both of these variables are design options that are available according to the design constraints of the final product and make up a significant part of the material selection process. In this experiment

Hand lay-up technique:

The first step is to mix the resin and the hardener. The proportions are usually given by the supplier and can be found on the containers of the hardener or resin. The portions can be either measured by weight for by volume but it is important to follow these proportions exactly as this is a complete chemical reaction and all components must react completely for maximum strength of the matrix. It is easiest to measure proportions using the volume method and a screw in pump that inserts into the cans of resin and hardener. These pumps can be purchased along with the containers of 6 resin and hardener. The first layer of fiber reinforcement is then laid. This layer must be wetted with resin and then softly pressing using a brush or a roller make the resin that was added in the previous step wick up through the fiberglass cloth/jute/fiber material. If the fiber is not completely wet, more resin can be added over the top and spread around as shown in figure 1.

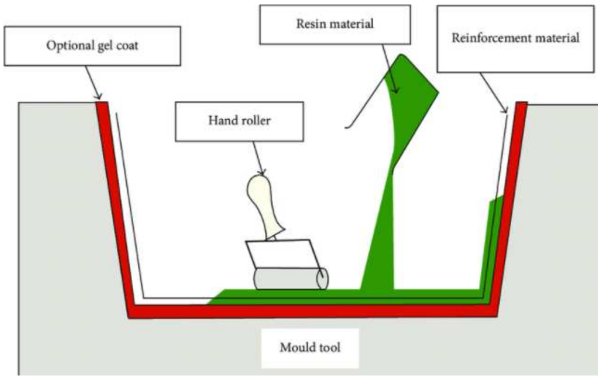


Fig. 1 Hand lay-up process

At this stage a second layer of glass fiber is added and special care must be taken to eliminate all air bubbles possible. This can be accomplished by either rolling any air bubbles out with a small hand rolling tool or brushing out the air bubbles with a paintbrush. This step is repeated until the desired thickness is obtained. As the glass fiber layers are added to build laminates and total part thickness the individual layers may be oriented at varying angles to accomplish specific strength in the direction of the reinforcement weave- this is called ‘clocking’. Sometimes during the build-up of successive layers of reinforcement a cover sheet of plastic can be temporarily put over the layup and rolled together with the layers underneath to reduce the mess and squeeze out excess resin. It is important when the proper amount of resin has been used for the layup that any excess resin in the cup is placed on and in an area that does not have any flammable material, such as a concrete sink or slab. The students should watch the exothermic reaction that is taking place as the resin ‘gels’. Typically, the cup gets hotter than the composite panel, because of the heat of reaction that is being transferred to the cup.
Once that part is ready to be cured, it must be moved to an adequate location. In this case it can be moved to a curing oven or simply left to cure in place until the next day.
Applications:
Largest number of reinforced plastics, composite products are produced by hand lay-up process. Parts of some of accessories can be made from an open fiber reinforced mould. Few examples of this process uses are:

- Boats
- Car bodies
- Hard-shell truck bed covers
- Air craft skins

Result:
Preparation mechanism of composite material by hand up process is learnt.

Virtual lab experiments:

Experiment 9

Cronus Experiment

AIM:

To find the elastic constants of the Perspex beam using Cornus interference method.

1. Young's modulus(Y)
2. Poisons ratio (σ)
3. Bulk modulus (b)

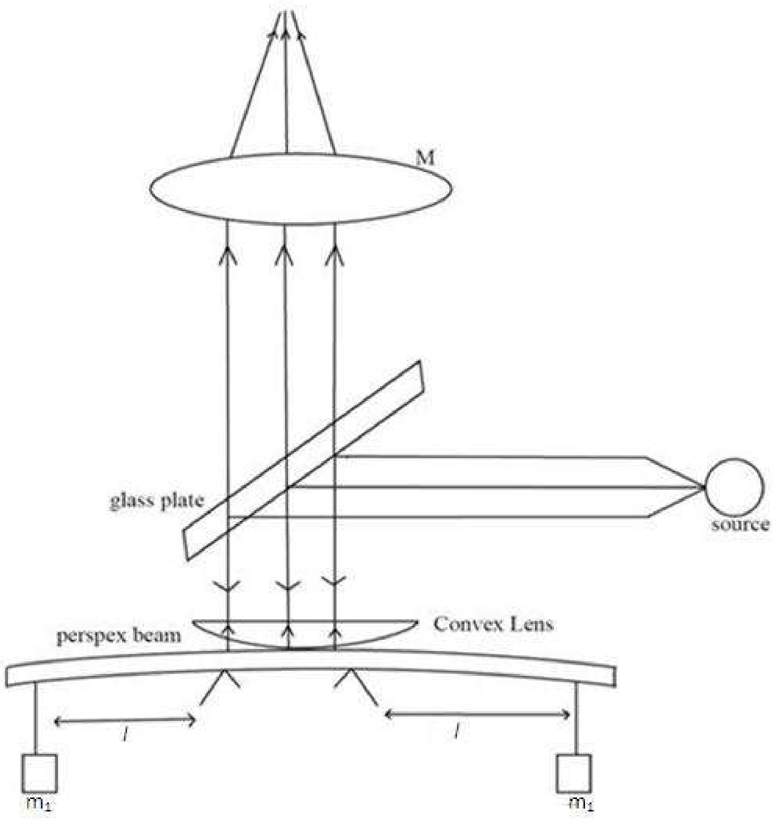
APPARATUS

Sodium vapor lamp, transparent beam, convex lens, travelling microscope, two knife edges, a set of weights, weight holders and a mirror.

EXPERIMENTAL SET UP

Consider a rectangular Perspex beam of length 'L',breadth 'a' and thickness 'b'.A Plano convex lens is placed over the beam. Weight hanger is placed at both ends in which mass can be added. Knife edges were placed at a distance 'l' from both weight hangers. A light source is used to illuminate the arrangement.

THEORY



An air film is obtained between convex lens and Perspex beam. The light is made to fall normally on the air film with the help of a glass plate on the arrangement.

The interference fringes formed is viewed by means of travelling microscope. Without adding any mass in the weight hanger we get circular rings. But as we uniformly add mass on the weight hangers the beam bends and we get elliptical fringes.

During bending, an extension is caused on the upper surface and compression on the lower surface.

Let R1 be the longitudinal radius of curvature of the beam. The internal bending moment caused by extension of the surface above the bar and compression below the bar is given by

$$\frac{YAK^2}{R_1}$$

where ,

Y is the young's modulus

A=ab, is the cross sectional area of bar

$$K = \frac{b}{\sqrt{12}}$$,the radius of gyration for rectangular cross section.

In equilibrium condition the internal bending moment must be balanced by the moment due to weight m_1g attached to its ends

$$m_1 g = \frac{YAK^2}{R_1} \qquad (1)$$

On rearranging we get, young's modulus,

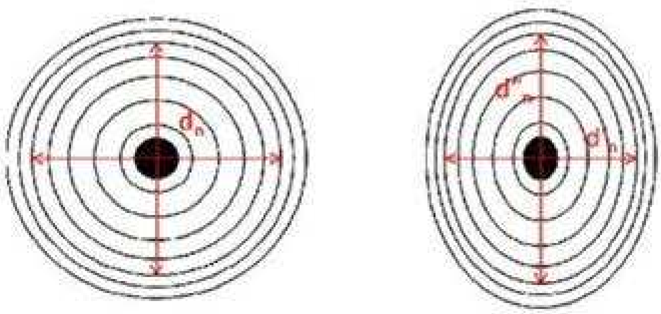
$$Y = \frac{12 m_1 g l R_1}{ab^3} \qquad (2)$$

Also when the bar undergoes longitudinal bending, it also undergoes a lateral bending, resulting in lateral strain R_2.

The ratio between these two quantities is the Poisson's ratio and is given by

$$\sigma = \frac{R_1}{R_2} \qquad (3)$$

The longitudinal bending R_1 can be found out using the



equation, W = 0 W = m_1g

$$R_1 = \frac{1}{4n\lambda} \frac{d'^2_n d^2_n}{(d^2_n - d'^2_n)} \qquad (4)$$

where d_n' and d_n are the diameters of nth ring with mass and without mass in longitudinal direction. Similarly

$$R_2 = \frac{1}{4n\lambda} \frac{d''^2_n d^2_n}{(d^2_n - d''^2_n)} \qquad (5)$$

where d_n" and d_n are the diameters of nth ring with mass and without mass in transverse direction.

So from the values of diameter of rings with mass and without mass, we calculate R_1 and R_2.

$$Y = \frac{12 m_1 g l R_1}{ab^3}$$

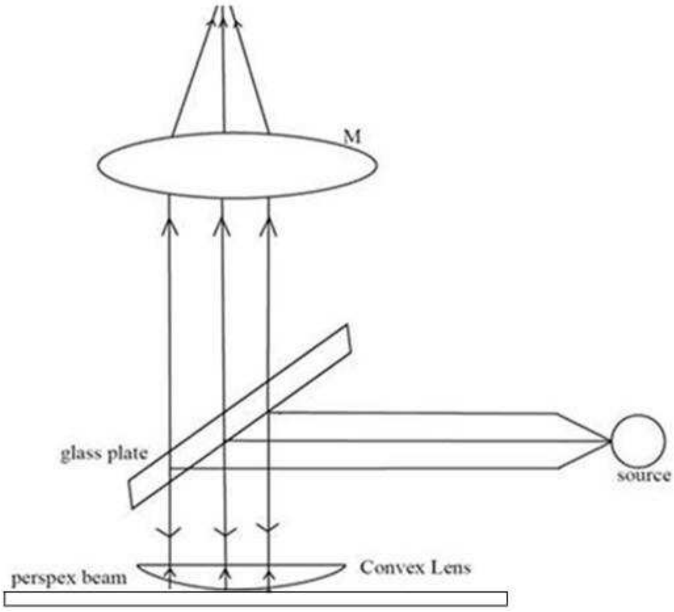
From those values of R_1 and R_2 we calculate young's modulus

Poisson's ratio, $\sigma = \frac{R_2}{R_1}$ and bulk modulus, $b = \frac{Y}{3(1-2\sigma)}$

Procedure

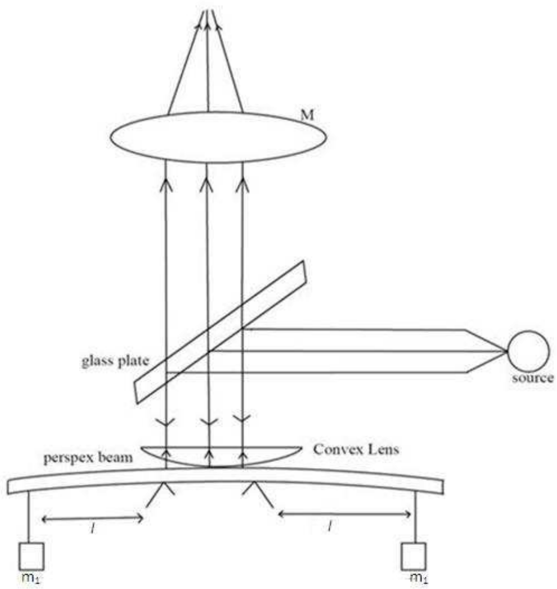
1. Real lab

To find the diametre of rings without mass



1. Place the given Perspex beam symmetrically over the two knife edges.
2. A convex lens is placed over beam.
3. As shown in figure light is allowed to fall normally on the air film with the help of glass plate.
4. On focusing, interference fringes formed are viewed by means of travelling microscope.
5. Fix the cross wire on any of the nth ring on one side (left or right) using the knob.
6. Corresponding value of MSR and VSR is noted.
7. Move the cross wire to the $(n-1)^{th}$ or $(n-2)^{nd}$ ring on the same side.
8. Take the readings of the rings on either side of the centre position.
9. Now repeat the same procedure by moving the cross wire up and down on either side of centre position.

Diametre of rings with mass



1. Adjust the distance between the weight hanger and the knife edges.
2. Add mass on the weight hanger.
3. Repeat steps 4-9 to measure the horizontal and vertical position of rings.

2. Simulator

To find the diametre of rings without mass

1. Mass on weight hanger is set as zero g.
2. Select desired values for the variables by clicking on the sliders for each variable.
3. Click on the 'Light On' button.
4. Now the repeat the steps 5-9 of real lab.
5. The reading of rings during the horizontal/vertical motion is shown by the horizontal/vertical

position value of microscope under variables section.

6. Click 'Reset' button for another values of variables

To find the diametre of rings with mass

1. Adjust the variables and position of weight hanger by clicking on their corresponding sliders.
2. Add suitable mass on weight hanger.
3. Repeat steps 3-6 of simulator.

Observations

- **To find the thickness of Perspex beam using screw gauge**

Zero correction=

No	MSR	VSR	Total reading (cm)

Thickness of Perspex beam, b=………..mm

- **To find the breadth of Perspex beam using Vernier calipers**

No	MSR (cm)	VSR	Total reading (cm)

Breadth of plate, a=…………cm

- **To find the diameter of rings in horizontal direction**

λ=………..nm, l=………cm

Order,n	Mass(g)	Microscope reading		Diametre,d_n (cm)	d_n^2	d_n^2-$d_n'^2$	$d_n^2 d_n'^2$
		Left	Right				
	0						
Order,n	Mass(g)	left	right	Diametre,d_n' (cm)	$d_n'^2$	d_n^2-$d_n'^2$	$d_n^2 d_n'^2$
	100						

Longitudinal bending $R_1 = \frac{1}{4n\lambda}\frac{d'^2_n d^2_n}{(d^2_n - d'^2_n)}$

<u>To find the diameter of rings in vertical direction</u>

Order,n	Mass(g)	Microscope reading		Diametre,d_n (cm)	d_n^2	d_n^2-$d_n''^2$	$d_n^2 d_n''^2$
		Up	Down				
	0						
Order,n	Mass(g)	up	down	Diametre,d_n'' (cm)	$d_n''^2$	d_n^2-$d_n''^2$	$d_n^2 d_n''^2$
	100						

Lateral strain, $R_2 = \frac{1}{4n\lambda}\frac{d''^2_n d^2_n}{(d^2_n - d''^2_n)}$

Result:

For a given plate

Young's modulus, Y=……………….Nm^{-2}

Poisson's ratio, σ =…………………

Bulk modulus, b =………………….. Nm^{-2}

Kundt's Tube Apparatus

Aim:

To find the velocity of sound waves in a given rod with Kundt's tube apparatus.

To find the Young's modulus of the material of the rod.

Apparatus:

A long glass tube, piston, metal rod, powdered cork, ruler, clamps and leather piece.

Theory:

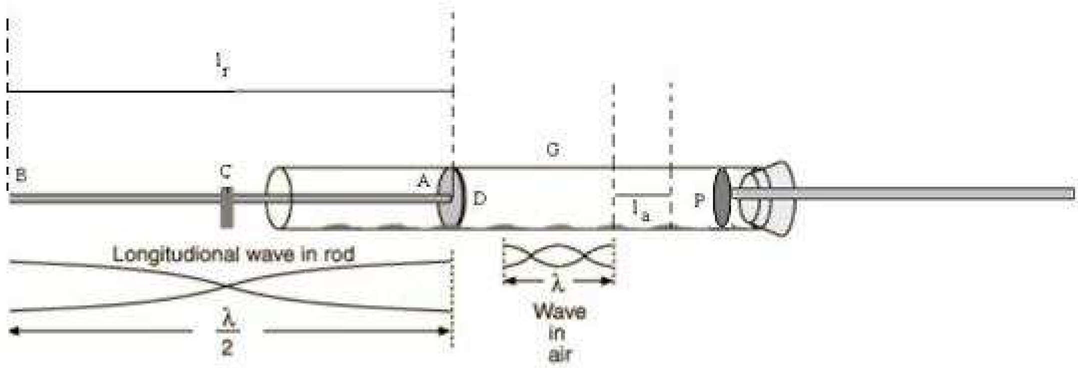
Kundt's tube is an acoustical apparatus, invented by German Physicist, August Kundt (1866). Knowing the speed of sound in air, the speed of sound **V** in a solid rod can be calculated based on the measurement of sound wavelength, **λ**. If the frequency of the sound wave, **f** is known, we can calculate the speed of sound as,

$$V = f\lambda$$

<u>Kundt's tube apparatus:</u>

The apparatus consists of a long transparent horizontal pipe G, which contains a fine powder such as cork dust or talc. At the ends of the tube, there are metal fittings. At one end of the tube, a metallic rod AB, of uniform radius having one or two meter length is introduced. This rod is clamped at the middle and carries a circular disc D, rigidly fixed at one end. The radius of the disc is slightly less than the radius of the glass tube. The rod is inserted a few centimeters inside the tube, without touching it. The other end of the glass tube is closed by a metallic piston, P. The position of the piston can be adjusted by moving it in or out. The whole apparatus is tightly clamped on a table, so that there will be no jerks on the tube during the experiment.

The schematic diagram of a Kundt's tube is shown below.



The tube is dried and fixed in position after spreading a thin layer of cork dust in it. When the rod is set into longitudinal vibrations at its fundamental frequency by rubbing it with a piece of rosined leather at B, the ends of the rod act as anti-nodes and the middle point acts as node. The length of the metal rod is equal to half the wavelength of the sound wave in the material of the rod. The disc begins to vibrate backward and forward. The air inside the glass tube is set into forced vibrations with the frequency of the wave emitted and stationary waves are produced by reflection at the piston. On altering the position of the piston, a point is reached where an overtone of the air column coincides with the fundamental of the rod, and thus produces resonance within the tube. At this stage, the cork dust in the tube is violently agitated and collected as heaps at the nodes. The average distance between the successive heaps will be equal to half the wavelength of sound in air.

If l_a be the mean distance between the consecutive nodes of cork dust in air and l_r, the length of the metal rod, then,

Wavelength of sound wave in air,

$$\lambda_a = 2l_a$$

Wavelength of sound wave in the rod,

$$\lambda_r = 2l_r$$

If f is the frequency of vibration produced, the velocity of the sound wave through the rod and air is given by,

$$V_r = 2fl_r \qquad (1)$$

$$V_a = 2fl_a \qquad (2)$$

Hence,

$$V_r = V_a \frac{l_r}{l_a} \qquad (3)$$

Knowing the speed of sound in air, we can calculate the speed of sound in the rod.

The velocity of sound in a solid material is given by,

$$V_r = \sqrt{Y/\rho} \qquad (4)$$

Where Y is the Young's modulus of the material of the rod and **ρ** is the density.

Then,

$$Y = V_r^2 \rho \qquad (5)$$

Procedure for performing real lab:

- Take the glass tube and put some powdered cork dust in it.
- By fast rotatory movement, distribute the powder uniformly inside the tube.
- Fix the tube tightly with the holder.
- Tightly clamp the metal rod at the centre.
- The piston is introduced to the other end of the glass tube.
- The rod is rubbed at B, lengthwise with a piece of rosined leather and set into longitudinal vibrations at its fundamental frequency.
- Move the piston in and out of the tube till the resonance is obtained.
- Now the cork dust inside the tube becomes deposited as heaps.
- Select the position of the extreme nodes very carefully and measure the distance between them. Find the number of heaps and calculate the average distance between two consecutive peaks.
- Note the length of the rod and repeat the experiment.
- We have the velocity of sound through air equals, 343m/s.
- Using equation (3), the velocity of sound through the rod can be calculated.
- The Youngs modulus of the rod can be calculated from equation (5).
- **Note:**
- The glass tube must be perfectly dry as moisture afects sound velocity.
- The metallic rod should be clamped exactly at the middle.
- The powder must be evenly spread.
- The disc should not touch the glass tube, since it causes the tube to break.

- **<u>Procedure for simulator:</u>**
- From the combo box **Select Material** select the material of the rod.
- By clicking the button **Start Rubbing** set longitudinal vibrations in the rod.
- Using the slider **Rod length**, select desired length of the experimental rod.
-

- The slider **Piston Position** helps the user to move the piston in and out of the glass tube to obtain the resonance condition. At resonance, the dust will appear as heaps.

- Using this slider **Scale Position**, move the ruler and measure the length between the desired number of heaps. From that, one can calculate the length of one heap.

- The option **Show Result** displays the velocity of the sound waves and the Young's modulus of the material of the rod.

- The **Reset** button resets the conditions.

- The experiment can be repeated for different materials of rod and different rod lengths.

- **<u>Observations:</u>**

Length of the rod, l_r= …………… m.
Frequency of sound used, f = ……… Hz.
Velocity of sound in air, V_a = 343 m s^{-1}.

No:	Distance between extreme nodes, L (m)	Number of Heaps n	Average distance between two consecutive heaps $l_a = \frac{L}{n-1}$ (m)

Mean l_a = ……………. m.
Then,

$$V_r = V_a \frac{l_r}{l_a}$$

Result:

The velocity of sound wave through the rod = ………………… m s^{-1}.

Young's modulus of the material of the rod = ………………. N m^{-2}.

APPENDIX- I

Fundamental Physical constants

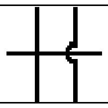
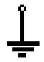
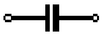
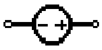
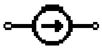
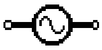
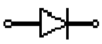
Name	Symbol	Constant Value
Speed of light	c	$2.99792458 \ x \ 10^{8} \ m/s$
Planck constant	h	$6.6260755 \ x \ 10^{-34} \ J \cdot s$
Planck constant	h	$4.1356692 \ x \ 10^{-15} \ eV \cdot s$
Gravitation constant	G	$6.67259 \ x \ 10^{-11} \ m^{3} \cdot kg^{-1} \cdot s^{-2}$
Boltzmann constant	k	$1.380658 \ x \ 10^{-23} \ J/K$
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	0.38oersted

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

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