ENGINEERING PHYSICS LAB MANUAL

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Branch	:	AE/ME/CE

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INSTITUTE OF AERONAUTICAL ENGINEERING

(AUTONOMOUS) Dundigal, Hyderabad - 500 043

Certificate

This is to cert	tify that it	t is a bonafied	l record of	^c pract	ical work done by					
the Roll No.		of								
Engineering	Physics	laboratory under our s	during supervision	the	branch in th academic yea					
Head of the Depa	rtment			L	ecture In-Charge					
External Examine	er			Int	ernal Examiner					

ENGINEERING PHYSICS LAB SYLLABUS

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ENGINEERING PHYSICS LABORATORY

OBJECTIVE:

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

OUTCOMES:

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

- 1. **Understand** the world around us.
- 2. Understand the concept of error and its analysis.
- 3. **Develop** experimental skills
- 4. **Design** new experiments in Engineering.
- 5. **Compare** the theory and correlate with experiment.
- 6. **Identify** the appropriate application of particular experiment.
- 7. Understand and apply fundamental electronic circuits.
- 8. Analyze the experimental result.
- 9. Understand the applications of physics experiments in day to day life.
- 10. Examine ideas about the real world.



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PROGRAM OUTCOMES

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.

PROGRAM SPECIFIC OUTCOMES

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	AERONAUTICAL ENGINEERING					
PSO1	Professional skills: Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products.					
PSO2	Problem solving skills : imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles.					
PSO3	Practical implementation and testing skills : Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies.					
PSO4	Successful career and entrepreneurship : To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats.					
	CIVIL ENGINEERING					
PSO1	Graduates will have an ability to describe, analyze and solve problems using mathematics and systematic problem-solving techniques.					
PSO2	Graduates will have an ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety manufacturability and sustainability.					
PSO3	Graduates will have a board education necessary to understand the impact of engineering solutions in a global, economic and societal context.					
PSO4	To provide graduates many post graduate educational and research opportunities at top universities and research laboratories for its best engineering minds.					
PSO5	Graduates will have an ability to function on multi disciplinary teams.					
	MECHANICAL ENGINEERING					
PSO1	To produce engineering professional capable of analyzing and synthesizing mechanical systems including allied engineering streams.					
PSO2	An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.					
PSO3	To build the nation, by imparting technological inputs and managerial skills to become technocrats.					

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Expt.	Program Outcomes Attained	Program Specific Outcomes Attained								
No.		AERO	CIVIL	МЕСН						
1	PO1, PO2, PO4, PO5, PO6, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
2	PO1, PO2, PO4, PO5, PO6, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
3	PO1, PO4, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
4	PO1, PO2, PO4, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
5	PO1, PO2, PO4, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
6	PO1, PO3, PO4, PO5, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
7	PO1, PO4, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
8	PO1, PO4, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
9	PO1, PO2, PO4, PO5, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
10	PO1, PO3, PO4, PO5, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
11	PO1, PO3, PO4, PO5, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						
12	PO1, PO3, PO4, PO5, PO9, PO11, PO12	PSO1, PSO2, PSO3	PSO1, PSO2, PSO3, PSO5	PSO1, PSO2, PSO3						

EXPERIMENT - I

MEASUREMENT OF THICKNESS OF A WIRE AND RADIUS OF A DISC

Aim:

To determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers respectively.

Apparatus: A circular brass disc, steel wire, screw guage, and vernier calipers.

Figures:

Vernier calipers:



Procedure:

Vernier calipers:

First insert the circular disc in between the jaws of vernier calipers. The reading on a vernier caliper is a combination of the value shown on the main scale and the value indicated on the sliding vernier scale. When taking a measurement, first read the value on the main scale. The value on the main scale is the number immediately to the left of the 0 marker of the vernier scale. When reading the vernier scale, identify the coincidence division of vernier scale with the main scale division. To get total reading, multiply vernier coincidence division (VCD) with least count (LC) of vernier and add this value to the main scale reading using the formula

Actual diameter = Main scale reading + (Least count \times Vernier coicidence devision). Repeat the experiment at different positions of disc and then take average.

Observations:

To determine the radius of the disc:

Least count of the Vernier calipers = $\frac{One \ main \ scale \ division}{No.of \ Vernier \ scale \ divisions} = \frac{1 \ mm}{10} = 0.1 \ mm = 0.01 \ cm$

S. No	Main scale reading (a)	Vernier coincidence division (VCD)	Vernier Reading (b = LC × VCD)	Total Reading (a+b) cm Diameter D						
	Average diameter, D =									

Radius of the disc R = (D / 2) =

cm



Bring the fixed shaft (anvil) 'A' and movable shaft (screw) 'B' in contact with each other and find the error as shown in the figure. Note down the correction with opposite sign. Move the screw away from the anvil and place the wire in between both the shafts and move the screw towards the anvil A, using the ratchet head H. Stop when the ratchet slips without moving the screw. Note the number of divisions on the pitch scale that is visible and uncovered by the edge of the barrel. This reading is called the pitch scale reading(PSR). Note the number of the division of the circular scale lying over the reference line. This gives Head scale reading (HSR). Error correction added to HSR gives Corrected HSR (CHSR).

Final diameter of the wire given by the formula

Diameter of wire = $PSR + (LC \times CHSR)$.

Repeat the experiment at different positions of wire and then take average.

Observations:

To determine the radius of the wire:

Least count of the Screw Gauge = $\frac{\text{pitch of the screw}}{No.ofHeadscale divisions}$ = $\frac{1 mm}{100}$ = 0.01 mm

> Screw Gauge Error = Correction =

S. No	PSR (a)	HSR	CHSR	Fraction (b = LC × CHSR)	Total reading Diameter of wire (a+b) (mm)

Calculations:

Result:

The diameter of given wire, d = _____cm.

The radius of a given wire = _____cm.

- 1. Define least count.
- 2. What is the value of least count of vernier calipers?
- 3. What is the value of least count of screw gauge?
- 4. Explain positive and negative zero error in screw guage.
- 5. What is positive correction in screw gauge?
- 6. Explain difference in usage of vernier calipers and screw gauge.

EXPERIMENT - II

DETERMINATION OF RIGIDITY MODULUS OF MATERIAL OF STRING - TORSIONAL PENDULUM

Aim:

To determine the modulus of rigidity (η) of the material of the given wire using a Torsional pendulum.

Apparatus:

A circular brass disc provided with a chuck and nut at its centre, steel wire, a rigid clamp, stop watch, meter scale.

Principle:

Rigidity Modulus: $\eta = \frac{4\pi MR^2}{a^4} (\frac{l}{T^2}) dyne/cm^2$

M - Mass of the disc.
R - Radius of the disc.
a - Radius of the wire. *l* - Length of the pendulum.
T - Time period.

Description:

The Torsional pendulum consist of a uniform circular metal disc of about 8 to 10cm diameter with 1 or 2cm thickness, suspended by a wire at the centre of the disc as shown in figure. The lower end is gripped into another chuck, which is fixed to a wall bracket.



Procedure:

The circular metal disc is suspended as shown in above figure. The length of the wire l between the chucks is adjusted to 100cm, when the disc is in equilibrium position; a small mark is made on the curved edge of the disc. This marking will help to note the number of oscillations made by slowly turning the disc through a small angle. Care is to be taken to see that there is no lateral movement of the disc.

When the disc is oscillating the time taken for 20 oscillations is noted with the help of a stopwatch and recorded in the observations table in trail 1. The procedure is repeated for the same length of the wire and again the time taken for 20 oscillations is noted and noted as trail2 in the observation table. From trail 1 & 2 the mean time for 20 oscillations is obtained. The time period (T), i.e., the time taken for one oscillation is calculated.

The experiment is repeated by decreasing the length of the wire in steps of 10cm and the results are tabulated in the table.

By using the Vernier calipers the radius of the disc (R) is calculated, the radius of the wire (a) is calculated by means of screw gauge and the mass of the disc (M) is found by means of rough balance and these values are substituted in the formula. The mean value of $(l //T^2)$ is calculated from the observations and hence η is determined.

A graph is drawn with 'l' on X-axis and T² on Y-axis. It is a straight line graph and the value of (l/T^2) is calculated and the rigidity modulus of the material of the wire η is calculated.

Precautions:

- 1. The wire should not have any bending.
- 2. The chuck nuts should be tight because the wire becomes loose and the oscillations may not be perfect.
- 3. The time period between the oscillations must be uniform.
- 4. Galvanometer is an example of making use of the Torsional oscillations.

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Observations:

Mass of the disc (M)

Radius of the disc (R) =

Radius if the wire (a) =

Time Period of the Pendulum:

S. No	Length of the wire 'l' (cm)	Т	ime taken oscillatio	for 20 ons	Time for one Oscillation	T^2	$\frac{l}{T^2}$
		Trail 1	Trail 2	Average(t)	(Timeperiod)		_
					$T=\frac{t}{20}$		

Result:

Average $l / T^2 =$

The rigidity modulus of the material of the given wire is _____dyne/cm.

- 1. What is Rigidity modulus?
- 2. What is unit of rigidity modulus?
- 3. Define stress.
- 4. What is unit of stress?
- 5. Define strain.
- 6. What is unit of strain?
- 7. State Hook's law.
- 8. Define time period.
- 9. What are factors that influence time period?

EXPERIMENT - III

MAGNETIC FIELD ALONG THE AXIS OF CURRENT CARRYING COIL – STEWART AND GEE'S METHOD

Aim:

To determine the field of induction at several points on the axis of a circular coil carrying current using Stewart and Gee's type of tangent galvanometer.

Apparatus:

Stewart and Gee's galvanometer, battery eliminator, ammeter, commutator, rheostat, plug keys, connecting wires.

Principle:

When a current of i-amperes exists through a circular coil of n-turns, each of radius a, the magnetic induction B at any point(P) on the axis of the coil is given by

$$\mathbf{B} = \frac{\mu_0 \operatorname{nia}^2}{2(\mathbf{x}^2 + \mathbf{a}^2)^{3/2}} \tag{1}$$

Where B is the magnetic induction on the axial line of the coil

B

 $B = 4\pi \times 10^{-7}$ H/m (permeability of free space) n is number of turns in the coil i is the current through the coil a is the radius of the coil (in cm) x is the distance from the centre of the coil to the centre of the magnet (in cm)

When the coil is placed in the magnetic meridian, the direction of the magnetic field will be perpendicular to the magnetic meridian; i.e., perpendicular to the direction f the horizontal component of the earth's field; say B_e . When the deflection magnetometer is placed at any point on the axis of the coil such that the centre of the magnetic needle lies exactly on the axis of the coil, then the needle is acted upon by two fields B and B_e , which are at right angles to one another. Therefore, the needle deflects obeying the tangent law,

B $_{\rm e}$ the horizontal component of the earth's field is taken from standard tables. The intensity of the field at any point calculated from equation (2) and verified using equation (1).

Figure:



Figure Arrangement for the measurement of magnetic field along the axis of a current carrying coil

(2)

Procedure :

With the help of the deflection magnetometer and a chalk, a long line of about one meter is drawn on the working table, to represent the magnetic meridian. Another line perpendicular to this line is also drawn. The Stewart and Gee's galvanometer is set with its coil in the magnetic meridian, as shown in the figure. The external circuit is connected, keeping the ammeter, rheostat away from the deflection magnetometer. This precaution is very much required because, the magnetic field produced by the current passing through the rheostat and the permanent magnetic field due to the magnet inside the ammeter affect the magnetometer reading, if they are close to it.

The magnetometer is set at the centre of the coil and rotated to make the aluminum pointer read (0, 0) in the magnetometer. The key, K, is closed and the rheostat is adjusted so as the deflection in the magnetometer is about 60°. The current in the commutator is reversed and the deflection in the magnetometer is observed. The deflection in the magnetometer before and after reversal of current should not differ much. In case of sufficient difference say above 2° or 3°, necessary adjustments are to be made.

The deflections before and after reversal of current are noted when d = 0. The readings are noted in Table 1. The magnetometer is moved towards East along the axis of the coil in steps of 5 cm at a time. At each position, the key is closed and the deflections before and after reversal of current is noted. The mean deflection be denoted as Tan Θ_E . The magnetometer is further moved towards east in steps of 5cm each time and the deflections before and after reversal of current is noted.

The experiment is repeated by shifting the magnetometer towards west from the centre of the coil in steps of 5cm, each time and deflections are noted before and after reversal of current. The mean deflection is denoted as $Tan\Theta w$.

It will be found that for each distance (X) the values in the last two columns are found to be equal verifying equation (1) and (2).

A graph is drawn between X on x-axis and the corresponding $Tan\Theta_E$ and $Tan\Theta_W$ along y-axis. The shape of the curve is shown in the figure. The points A and B marked on the curve lie at distance equal to half the radius of the coil (a/2) on either side of the coil.

Graph:



Precautions:

- 1. The ammeter, voltmeter should keep away from the deflection magnetometer because these meters will affect the deflection in magnetometer.
- 2. The current passing through rheostat will produce magnetic field and magnetic field produced by the permanent magnet inside the ammeter will affect the deflection reading.

	Distance of deflection	Deflection in the magnetometer East side			Deflection in the magnetometer West side						θ	1/2						
S.No	magnetometer from centre of the coil(X) in meters	θ1	θ2	θ3	θ4	Mean <i>θ</i> e	Tan <i>θ</i> e	θ1	θ2	θз	θ4	Mean $ heta w$	Tan $ heta$ w	$\theta = \frac{\theta e + \theta w}{2}$	Tan 0	B=B _e tan	$\mathbf{B} = \frac{\mu_0 n i a2}{2(x2+a2)^3}$	Error %

Calculations:

Result :

The theoretical and calculated values are approximately same

- Define magnetic field induction.
 Write units of magnetic field induction.
 What is the principle behind the experiment?
 Define the tangent law.

EXPERIMENT - IV

DETERMINING FREQUENCY OF LONGITUDINAL WAVES

Aim:

To determine the frequency of a tuning fork in longitudinal mode using Melde's arrangement.

Apparatus:

Melde's arrangement, rheostat, plug keys, connecting wires, meter scale, thread, weight box, power supply.



Principle:

Frequency of tuning for $n = \frac{1}{l} \sqrt{\frac{T}{m}} Hz$

m - Mass per unit length (or) linear density.

T - Tension= $(M+m) \times g$.

l – Length of a single loop.

Procedure:

In longitudinal mode, the tuning fork is parallel to the vibrating thread. Set the Melde's experiment in the longitudinal mode of vibrations and note the observations in observation table for different lengths. Calculate the frequency of the tuning fork by using the formula.

Observations:

Mass of the thread $(w) = _ ___ gm$, Length of the thread $(y) = _ __ cm$,

Mass of the pan $(p) = ____gm$, Linear density $(m) = ____gm/cm$.

S .No	Load applied in the pan(M)gm	Tension T=(M+p)g	No. of loops (x)	Length of the x loops (d)	Length of the each loop $l = \frac{d}{x}$	\sqrt{T}	$\frac{\sqrt{T}}{l}$	$n_l = \frac{1}{l} \sqrt{\frac{T}{m}}$

Average of n =

Precautions:

- 1. The thread should be uniform and inextensible.
- 2. Well defined loops should be obtained by adjusting the tension with milligram weights.
- 3. Frictions in the pulley should be least possible.

Calculations:

Result:

Frequency of the tuning fork in longitudinal mode _____Hz.

- What is frequency?
 What are standing waves?
- 3. Explain the difference between longitudinal and transverse waves.
- 4. What is Resonance?

EXPERIMENT - V

CALCULATING FREQUENCY OF TRANSVERSE WAVES

Aim:

To determine the frequency of a tuning fork in transverse mode using Melde's arrangement.

Apparatus:

Melde's arrangement, rheostat, plug keys, connecting wires, meter scale, thread, weight box, power supply.



Principle:

Frequency of tuning for
$$n = \frac{1}{2l} \sqrt{\frac{T}{m}} Hz$$

m - Mass per unit length (or) linear density.

T - Tension= $(M+m) \times g$.

l – Length of a single loop.

Procedure:

In transverse mode, the tuning fork is made to vibrate perpendicular to vibrating thread. The vibrating thread forms many well defined loops. These loops are due to the stationary vibrations set up as a result of the superposition of the progressive wave from the prong and the reflected wave from the pulley. The frequency of each segment coincides with the frequency of the fork.

Set the Melde's experiment in transverse mode vibrations with 2-3meters length of thread and note the number of loops and length of the thread are recorded in observations table. Repeated the same procedure for different length and recorded is in the observation table and calculated the frequency of the tuning fork.

Observations:

Mass of the thread $(w) = ____ gm$,

Mass of the pan

 $(p) = ____ gm,$

Length of the thread $(y) = ___cm$,

Linear density

Table:

S. No	Load applied in the pan(M)gm	Tension T=(M+p)g	No. of loops (x)	Length of the x loops (d)	Length of the each loop $l = \frac{d}{x}$	\sqrt{T}	$\frac{\sqrt{T}}{l}$	$n_t = \frac{1}{2l} \sqrt{\frac{T}{m}}$

Average of n =

 $(m) = \underline{\qquad} gm/cm$.

Precautions:

- 1. The thread should be uniform and inextensible.
- 2. Well defined loops should be obtained by adjusting the tension with milligram weights.
- 3. Frictions in the pulley should be least possible.

Calculations:

Result:

Frequency of the tuning fork in Transverse mode _____Hz.

- 1. Define nodes and anti-nodes.
- 2. Define resonance condition.
- 3. Explain the importance of Melde's experiment.
- 4. Give some important application of Melde's experiment.

EXPERIMENT - VI

WAVELENGTH OF LASER SOURCE – DIFRACTION GRATING

Aim:

To determine the wavelength of a given source of laser using a plane transmission grating.

Apparatus:

Plane diffraction grating, laser source, a scale and prism table.

Theory:

An arrangement consisting of large number of parallel slits of the same width and separated by equal opaque space is known as the "diffraction grating". A grating is constructed by rubbing equidistant parallel lines 'N' ruled on the grating per inch are written over it.

$$\lambda = \frac{2.54 \; Sin\theta}{n.N}$$

Where

 λ is the wavelength of light. N Lines per inch on the plane diffraction grating n is the order of diffraction light.

Procedure:

A plane diffraction grating consists of parallel sides glass plates with equidistant fine parallel lines drown very closely upon it by means of a diamond point. The number of lines drawn per inch is written on the diffraction grating by the manufacturers like 15000 LPI or 25000 LPI. The laser system used in this experiment is semiconductor laser.

Place the grating in front of the laser beam such that light incident normally on the grating. When a semiconductor laser light incidents on the grating, the diffraction pattern is produced on the other side of the it. This diffraction pattern can be observed by arranging a screen at certain distance from the gratting. The diffraction pattern consists of central maxima and secondary maxima. The secondary maxima in the diffraction pattern observed is on either side of cetral maxima due to first order, second order and so on.

Now measure the distance between the grating and the screen and tabulate it as 'D' and the distance between central maxima to first order on left side of central maxima as ' d_1 ' and then central maxima and first order on right side of central maxima as ' d_2 ' and it is tabulated. Similarly, note down the raedings for second order on both sides of central maxima.

Diagram:



Tabular form:

S. No.	Distance (D)	Order (n)	Left side (d ₁)	Right side (d ₂)	$d=\frac{d_1+d_2}{2}$	$\sin\theta = \frac{d}{\sqrt{d^2 + D^2}}$	$\lambda = \frac{\sin\theta}{Nn} \mathbf{A}^{\mathrm{o}}$
1							
2							

Average wavelength =

 $\mathbf{A}^{\mathbf{0}}$

Calculations:

Result:

Wavelength of the given Laser light = $___A^0$

- 1. Define spontaneous emission.
- 2. Define stimulated emission.
- 3. What is diffraction?
- 4. What are the characteristics of LASER?

EXPERIMENT - VII

ADJUSTMENTS AND MINIMUM DEVIATION IN SPECTROMETER

Aim:

To study about spectrometer and its parts and to adjust spectrometer in minimum deviation position.

Apparatus:

Spectrometer, prism, mercury vapor lamp, table lamp, reading lens.

Introduction:

A spectrometer is an optical instrument used to measure the properties of light over visible region of electromagnetic spectrum. It is also used for the study the spectra, produced by prism & grating for the measurement of the dispersive powers, wavelengths of the spectral lines, the refractive indices of transparent solids and liquids etc.

The spectrometer includes, following parts;

Collimator:

It consists of a horizontal tube of variable length with an adjustment slit (\mathbf{S}) at one end and a convex lenses at the other. The collimator is rigidly fixed to the main part of the instrument. If a source of light, like an arc lamp or sodium lamp is placed closed to slit \mathbf{S} , a parallel beam of light will emerge from the other side of collimator. The collimator is fitted with 6 mm long slit of adjustable width. The slit width width has to be adjusted as a thin line. The distance between convex lens and the slit can be varied and adjusted equal to the focal length of the convex lens of collimator using the rock and pinion screw provided on collimator.

Telescope:

It is an astronomical telescope fitted with a Ramsden's eye-piece (consists of two Plano-convex lenses) and crosswires. When a parallel beam of light coming out of the prism falls on the objective, the spectrum is produced can be viewed through the eye-piece. To make the image clear without blurring, the distance between objective and eyepiece can be adjusted properly by adjusting the rock and pinion screw provided on telescope. The cross-wire can be made to coincide with any spectral line and corrosponding on circular scale of the spectrometer can be noted.



Rotating Bases:

The telescope and the spectrometer table are mounted on, independently rotating bases. The vernier scale provide measurement of the relative position of these bases to within 1 minute of arc. The rotation of each base is controlled with a lock-screw and a fine adjustment knob. With the tight lock-screw, the fine adjust knob can be used for more precise positioning.

Spectrometer table:

The spectrometer table is fixed to its rotating base with a thumb-screw, so the table height is adjustable. Three leveling screws on the underside of the table used to adjust the optical alignment of the instrument. The table must

be leveled with respect to the optical axes of the collimator and the telescope, if the diffracting element is to retain it's alignment for all positions of the telescope. Thumb-screws are used to attach the prism clamp and the grating mount to the table, and reference lines are etched in the table for easy alignment.

Circular scale:

The circular scale has 0° to 360° , with each degree divided in to half degree again. There are two windows povided to observe the reading. The circular scale is also provided with a vernier 30 divisions on it

Procedure:

1. Adjustment of spectrometer:

The following essential adjustments are to be made step by step in a spectrometer experiment :

Alignment : In the first step, you must see the alignment of the axis of the telescope with hat of collimator, so that they must intersect with the principal vertical axis of the telescope.

Adjustment of telescope and collimator for parallel light : The telescope is firstly directed towards a 'bright object' like lamp globe or the sky. The eye-piece is adjusted so that the cross wire became as sharp as possible, when some one see through it. This fixes position of eye-piece relative to the cross wires. The telescope is turned towards the collimator, with it's Slit illuminated with a monochromatic source of light. The collimator slit is then adjusted, until a direct image of the slit falls on the 'cross wires'. Now the instrument is then adjusted, so that parallel rays passes from the collimator to the telescope.

Leveling the prism table : Place the spirit level at the center of the prism table , parallel to the line joining two of the leveling screws of the prism-table. Bring the air bubble of the spirit level, at the centre by turning these two screws in the opposite directions. Place the spirit level perpendicular to the line joining the two screws and get the bubble at the centre by adjusting the third screw, whichmakes the top of the prism table horizontal.

Adjusting cross wires and focusing image : First of all, rotate the telescope towards any illuminated background. On looking through the eye-piece, you will found the cross wires appear blurred. Now move the eye-piece inwards the and outwards until the cross wires appears to be distinct. Now place the telescope in line to the collimator and look into the eye- piece, without any accumulation in the eye. (The image of the slit may appeared blurred) Make the image very sharp by turning the focusing knob of the telescope and also of the collimator. If the image does not appear vertical, then make it vertical by turning the slit in it's own plane. Adjust the width of the slit to get an image of the desired intensity.

2. Measurement of angle of minimum deviations :

Place the prism so that its centre should coincides with the centre of the prism-table and the light falls on, one of the polished faces and emerged out of the other polished faces after refraction. In this position the spectrum of light can be obtained.

Since the spectrum is seen through the telescope and telescope is adjusted for minimum deviation position for a particular color (or wavelength) in the way give here- Set up telescope of a particular color and rotate the prismtable in one direction, the telescope should moved in such a way that to keep the spectral line in view. By doing this, a position will come spectral line recede in opposite direction although the rotation of the table is continue in the same direction. Now the particular position, where the spectral line begins to recede in opposite direction is the minimum deviation position for that color. Note the reading of the two verniers. Remove the prism-table and bring the telescope in,the line of collimator .Now see the slit directly through the telescope and coincide the image of slit with vertical cross-wire. Again, note the reading of the two verniers.

The difference between the minimum deviation position, and the direct position gives rise to the angle of minimum deviation for that color.

Repeat the same procedure to obtain the angles of minimum deviation for other colors.

Result:

The least count of spectrometer is _____.

The basic adjustments of the spectrometer are made and minimum deviation positon in spectrometer is identified.

- 1. What do you understand by minimum deviation?
- 2. What is the least count of spectrometer?
- 3. Which eye piece is used in the telescope of spectrometer?
- 4. Does the angle of minimum deviation vary with the colour of light?
- 5. What is the function of collimator?

EXPERIMENT - VIII DISPERSIVE POWER OF A MATERIAL OF PRISM

Aim:

To determine the dispersive power of the material of the given prism.

Apparatus:

Spectrometer, prism, mercury vapor lamp, reading lens.

Principle:

The Refractive Index of the material of the prism is given by

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

For Red color

$$\mu_R = \frac{\sin(\frac{A+D_R}{2})}{\sin(\frac{A}{2})}$$

For Blue color

$$\mu_B = \frac{\sin(\frac{A+D_B}{2})}{\sin(\frac{A}{2})}$$

Where D_R and D_B are angle of minimum deviations of red and blue colors.

Dispersive power of the prism is

$$\omega = \frac{\mu_B - \mu_R}{\mu - 1}$$

Where μ = average refractive index of blue and red colors.

i.e;
$$\mu = \frac{\mu_B + \mu_R}{2}$$

Description:

Spectrometer setup:

- Check the prism table horizontally aligned or not with the help of spirit level.
- Position the instrument so that the telescope can be pointed at some distant object and adjust the eyepiece of the telescope, until the cross wires are in focus and focus on the distant object. When you have apparently got the image of the cross wires located at this distance comfortable for the eyes. Do not disturb the spectrometer adjustment.
- Position the instrument on laboratory optical bench ensure that we can see through the telescope when it is at least 60⁰ to either side of the principal axis of the collimator.
- Position a discharge lamp close to the slit at the end of collimator and make sure the slit is narrow, sharp and bright. Adjust the collimator only until the slit image is in focus.
- Rotate the telescope so that it focus the collimator and observe the slit image and adjust the slit width its image is just wider than the cross wire.
- Determine the least count of the Vernier.



First the basic adjustments of the spectrometer are made:

Measurement of minimum angle of deviation D_{min}:

- Rotate the prism table and telescope until light will pass symmetrically through the prism.
- Locate the position of spectrum in the field of telescope.
- Looking at the spectrum rotate the prism table until the position of minimum deviation (D_{min}) is achieved. Minimum deviation is obtained by slowly moving the prism table to one direction, the spectrum also moves in the same direction. But at a certain point the spectrum reverses (D_{min}) its direction is called minimum deviation.
- Fix the table in the stationary position, so that the spectrum will not deviate from its minimum deviation position, and use the slow motion screw fitted to the telescope to set the cross wires accurately on the centre of required color and the reading = A.
- Take direct ray reading by making telescope in line with the collimator and record as B. The readings (A-B) will give the angle of minimum deviation.

Observation:

Least count of the Vernier of the spectrometer =

Angle of the prism (A) =

Direct ray reading :

Vernier 1, $V_1 =$

Vernier 2, $V_2 =$

S. No	Colour of the line	Reading corresponding to minimum deviation position		Angle of minimum deviation = (direct reading) -(Reading of the minimum deviation position)					
		Vernier 1 Vı'	Vernier 2 V2'	Vernier 1 V ₁ ' ~ V ₁	Vernier 2 V2' ~ V2	Average D	Refra ind	ctive ex	Dispersive power ω
1	Blue					$D_B =$	μ _B =		
2	Red					D _R =	μ _B =	μ=	

Precautions:

- 1. Don't touch polished surface of the prism with hands to avoid finger prints.
- 2. Use reading lens with light while taking the readings in Vernier scale.
- 3. The mercury light should be placed inside a wooden box.

Calculations:

Result:

Dispersive power of the material of the given prism $\omega =$ _____.

- 1. What is Dispersion?
- 2. Define dispersive power.
- 3. Define Refractive Index of a material.
- 4. On what factors, the dispersive power depends?
- 5. How refractive index vary with wavelengths?

EXPERIMENT - IX

NEWTON'S RINGS - RADIUS OF CURVATURE OF PLANO-CONVEX LENS

Aim:

To determine radius of curvature of plano convex lens using sodium light by forming Newton's rings.

Apparatus:

Travelling microscope, sodium vapour lamp, plane convex lens, plano convex lens, a thin glass plate and a magnifying glass.

Principle:

 $\begin{array}{l} \lambda \mbox{ - Wave length of sodium light} \\ R \mbox{ - Radius of curvature of the of Plano convex lens.} \\ D_m \mbox{ - Diameter of the } m^{th} \mbox{ ring.} \\ D_n \mbox{ - Diameter of the } n^{th} \mbox{ ring.} \end{array}$

Description:

A black paper is laid on the base of the travelling microscope over which the thick glass plate is placed. Over this thick glass plate, a plano convex lens is placed. A parallel beam of light from the sodium lamp is made to fall on the glass plate which is inclined at 45° with the horizontal, as shown in the figure 1. The beam of light is reflected on to the setup made by means of a glass plate. As a result of interference between the light reflected from the lower surface of the lens and the top surface of the thick glass plate. Concentric rings, called Newton's rings, with alternate bright and dark rings, having a central black spot are seen through the microscope shown in figure2. The microscope is focused properly so that the rings are in sharp focus. The rings so formed are not to be disturbed till the experiment is completed.

Procedure:

The point of intersection of the cross wires in the microscope is brought to the centre of the ring system. The wire is set tangential to any one ring, and starting from the centre of the ring system, the microscope is moved on to one side; say left, across the field of view counting the number of rings. Now the cross wires are set at 30th ring and the reading on the microscope scale is noted, using a magnifying glass. Similarly, the readings with the cross wires set on 25th, 20th, 15th, 10th dark rings are noted. The microscope is moved in the same direction and the readings corresponding to 10th, 15th, 20th, 25th, 30th dark rings on the right side are noted. The readings are tabulated in the observation table.

A graph is drawn with the number of rings on X-axis and the square of diameter of the rings on Y-axis. The nature of the graph is a straight line as shown in figure3. From the graph, the values of and D_n^2 corresponding to m and n values are noted. The slope of the graph is calculated from the formula, using these values the wave length of sodium light is calculated.

Experimental set-up:



Schematic diagram of Newton's rings setup



Photograph of Newton's rings formed

Graph:



Observations:

	D'				
S.no	number (n)	On the left side (a)	On the right side (b)	Diameter of the ring D = (a - b)	\mathbf{D}^2

Slope of the straight line $= \frac{D_2^2 - D_1^2}{n_2 - n_1}$ Radius of curvature, $R = \frac{Slope}{4\lambda}$

 λ = Wavelength of sodium light = 5890 A°.

Precautions:

- 1. Wipe the lens and the glass plates with cloth before starting the experiment.
- 2. The centre of the rings must be dark.
- 3. Use reading lens with light while observing the readings.
- 4. Before starting the experiment make sure that the movement of microscope in both sides of the rings.

Calculations:

Result:

The radius of curvature of plano convex lens is _____cm.

- 1. What is Interference?
- 2. How Newton's rings are formed?
- 3. What is the least count of travelling microscope?
- 4. Why the central spot is dark?
- 5. Define radius of curvature of lens.

EXPERIMENT - X

EVALUATION OF NUMERICAL APERTURE OF A GIVEN FIBRE

Aim:

To determine the numerical aperture of a given optical fiber.

Apparatus:

Step index fiber optic cable 1 or 2m length, light source, N.A. measurement jig.

Description:

The schematic diagram of the fiber optic trainer module is shown in figure.





Theory:

The numerical aperture of an optical system is a measure of the light collected by an optical system. It is the product of the refractive index of the incident medium and the sine of the maximum angle.

> Numerical Aperture (NA) = $n_i \sin \theta_{max}$ (1) For air $n_i = 1$

For a step index fibre, the N.A. is given by:

NA = $(\mathbf{n}^2_{\text{core}} - \mathbf{n}^2_{\text{cladding}})^{1/2}$ (2)

For small differences in refractive indices between the core and cladding, equation (2) reduces to

$$\mathbf{NA} = \mathbf{n}_{\mathbf{core}} (\mathbf{2\Delta})^{1/2} \quad \dots \qquad (3)$$

Where Δ is the fractional difference in the refractive indices of the core and the cladding i.e.

$\Delta = [n_{core} - n_{cladding}] / n_{core}$

Light from the fibre end 'A' falls on the screen BD. Let the distance between the fibre end and the screen = AO = L $\sin\theta = OB/AB$ From the \triangle AOB OB = r and $AB = [r^2 + L^2]^{1/2}$ 2

$$NA = \sin \theta = r / [r^2 + L^2]^{1/2}$$

Knowing r and L, the N.A. can be calculated. Substituting this value of N.A. in equation (1), the acceptance angle θ can be calculated.



Procedure:

- 1. LED is made to glow by applying about 1.5 V DC power supply.
- 2. Light is allowed to propagate through an optical fiber cable whose NA is to be determined.
- 3. The output is screened on a concentric circles of known diameter is placed at a distance of 1, 2, 3, 4 and 5 cm and corresponding radius of the concentric circles is noted.
- 4. The experiment is repeated for different lights.

Observations:

S.No.	L (mm)	r (mm)	N.A. = $r / [r^2 + L^2]^{1/2}$	θ (degrees)

Applications:

- 1. Optical fibers may be used for accurate sensing of physical parameters and fields like pressure, temperature and liquid level.
- 2. For military applications like fiber optic hydrophones for submarine and underwater sea application and gyroscopes for applications in ships, missiles and air craft's.

Calculations:

Result:

The NA of the optical fiber is

The Acceptance angle θ is

EXPERIMENT - XI

V-I CHARACTERISTICS OF LED

Aim:

To study the V-I characteristics of light emitting diode and find the Threshold voltage and forward resistance of LED.

Apparatus:

Light emitting diode, 0-5V variable Supply, 0-10v Voltmeter, 0-50mA DC Ammeter.

Theory:

In a PN junction charge carrier recombination takes place when the electrons cross from the N-layer to the P-layer. The electrons are in the conduction band on the P-side while holes are in the valence band on the N-side. The conduction band has a higher energy level compared to the valence band and so when the electrons recombine with a hole the difference in energy is given out in the form of heat or light. In case of silicon or germanium, the energy dissipation is in the form of heat, whereas in case of gallium-arsenide and gallium phosphide, it is in the form of light. This light is in the visible region. Germanium and silicon, which have E_g about 1ev cannot be used in the manufacture of LED. Hence Gallium arsenide, Gallium phosphide which emits light in the visible region are used to manufacture LED.

Procedure for V-I Characteristics:

- 1. Connect the Light emitting diode as shown in figure.
- 2. Slowly increase forward bias voltage in steps of 0.1 volt.
- 3. Note the current passing through the LED.
- 4. Do not exceed 30mA current.
- 5. Plot a graph of light emitting diode
- 6. Voltage vs light emitting diode current.

Circuit diagram:



Observations:

S. No.	Voltage (Volts)	Current (mA)] г	C N		
2.2.101		(iiii i)	1	S. No.	Voltage (Volts)	Current (
] [

Calculations:

Result :

V-I characteristics of given LED are studied.

Calculated Threshold Voltage $V_{th} = __V$.

Forward Resistance $R_f = ___ \Omega$.

- 1. What is forward biased diode?
- 2. What are p-type and n-type semiconductors?
- 3. Define threshold voltage.
- 4. What is depletion layer?

EXPERIMENT - XII

STUDY OF L-I CHARACTERISTICS OF LASER DIODE

Aim:

To study L-I characteristics of a laser diode.

Apparatus:

Laser diode, 0-5 V variable supply, 20mW digital optical power meter, 20V digital voltmeter, 200mA DC digital ammeter.

Theory:

In a PN junction charge carrier recombination takes place when the electrons cross from the N-layer to the P-layer. The electrons are in the conduction band on the P-side while holes are in the valence band on the N-side. The conduction band has a higher energy level compared to the valence band and so when the electrons recombine with a hole the difference in energy is given out in the form of heat or light. In case of silicon or germanium, the energy dissipation is in the form of heat, whereas in case of gallium-arsenide and gallium phosphide, it is in the form of light. This light is in the visible region. Germanium and silicon, which have E_g about 1ev cannot be used in the manufacture of laser diode. Hence Gallium arsenide, Gallium phosphide which emits light in the visible region are used to manufacture laser diode.

Procedure for L-I Characteristics:

- 1. Connect the laser diode as shown in figure.
- 2. Slowly increase supply voltage using variable power supply coarse and finr knobs..
- 3. Note down the optical power measured by the optical power meter in mW at increasing current through the laser diode of 1mA to 20mA at 1mA step..
- 4. Do not exceed current limit of 30mA.
- 5. Plot a graph of laser diode intensity Vs. laser diode current .
- 6. Calculate the slope of this curve.
- 7. This slope is efficiency of laser diode in terms of mcd/mA.

Circuit diagram:

Model graph:





Observations:

S. No.	Current (mA)	Intensity (mcd)

Calculations:

Result :

L-I characteristics of given Laser diode are studied.

- What is Laser, explain?
 What is the difference between laser light and ordinary light?
 Explain basic principle involved in the laser.
 What are the applications of laser?