ENGINEERING PHYSICS

LABORATORY MANUAL

I Year B.Tech

(Common to all branches)

Institute of Aeronautical Engineering

Department of Basic Sciences & Humanities

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INSTITUTE OF AERONAUTICAL ENGINEERING

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LIST OF EXPERIMENTS

1. Torsional Pendulum
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3. Dispersive Power of the Material of a Prism- Spectrometer
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CONTENTS

1. 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, screw guage, and Vernier calipers.
Principle:

Rigidity Modulus: $\eta = \frac{4\pi MR^2}{a^4}\left(\frac{l}{T^2}\right)$ ***dynes/cm²***

M - Mass of the disc.

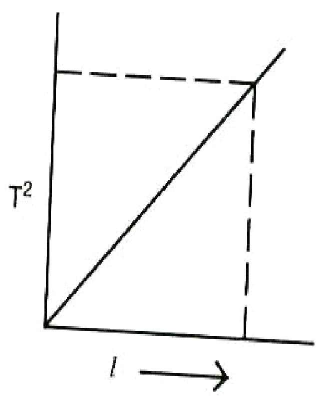
R - Radius of the disc.

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.
Graph:



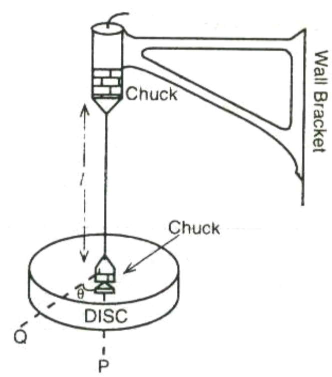


Figure 1 : *Torsional Pendulum*

Procedure:

The circular metal disc is suspended as shown in above figure. The length of the wire 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 of10cm 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 T^2 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.

Observations:

To determine the radius of the disc:

Least count of the Vernier calipers= $\frac{\text{One Main scale division}}{No.of\ Vernier\ scale\ divisions}$ =

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

To determine the radius of the wire:

Least count of the Screw Gauge = $\frac{\text{pitch of the screw}}{No.of Headscale\ divisions}$ =

Screw Gauge Error -

Correction:

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

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)	Time taken for 20 oscillations			Time for one Oscillation (Timeperiod) $T=\frac{t}{20}$	T^2	$\frac{l}{T^2}$
		Trail1	Trail2	Average(t)			
1	100						
2	90						
3	80						
4	70						
5	60						

Result: The rigidity modulus of the material of the given wire is _________________.

2. MELDE'S EXPERIMENT - TRANSVERSE AND LONGITUDINAL MODES

Aim:

To determine the frequency of a vibrating bar (or) tuning fork using Melde's arrangement.

Apparatus:

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

Principle:

Longitudinal mode:

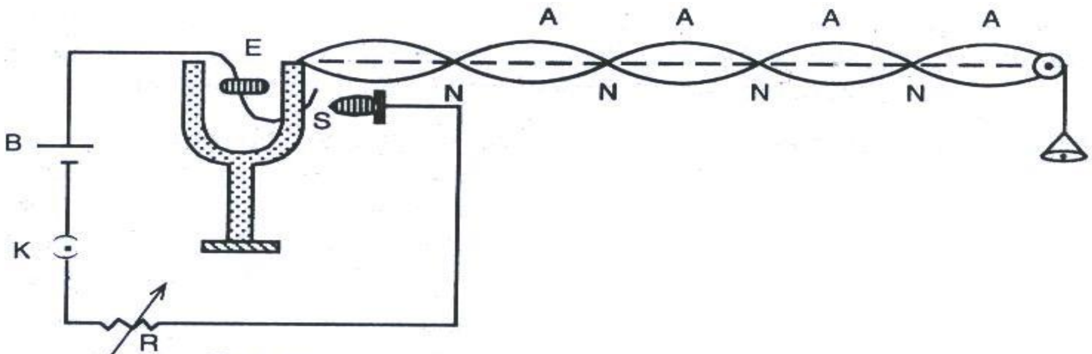


Fig. 1 (a)

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

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

T - Tension= (M+m) g.

l – Length of a single loop.

Transverse mode:

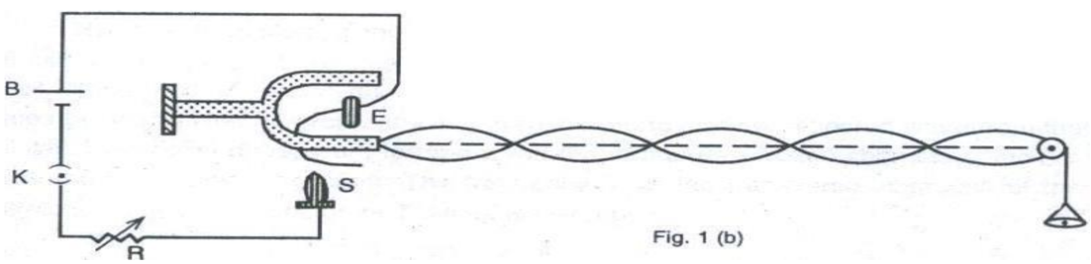


Fig. 1 (b)

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

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

T - Tension= (M+m) g.

l – Length of a single loop.

Procedure:

Transverse mode:-

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 Meld'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.

Longitudinal mode:-

In longitudinal mode, the tuning fork is parallel to the vibrating thread. Set the Meld'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) = ______ gms
Length of the thread (y) = _______cm
Mass of the pan (p) = _______ gms
Linear density (m) = _______ gm/cm

Transverse mode vibrations:

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 $l=\frac{d}{x}$	$\sqrt{T}$	$\frac{\sqrt{T}}{l}$	$n=\frac{1}{2l}\sqrt{\frac{T}{m}}$
1								
2								
3								
4								
5								

Average of n =

Longitudinal mode vibrations:

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 $l=\frac{d}{x}$	$\sqrt{T}$	$\frac{\sqrt{T}}{l}$	$n=\frac{1}{l}\sqrt{\frac{T}{m}}$
1								
2								
3								
4								
5								

Average of n =

PRECAUTIONS:

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

RESULT:

Frequency of the tuning fork in longitudinal mode _____________Hz
Frequency of the tuning fork in Transverse mode _____________Hz
Frequency of the tuning fork =___________________Hz

3. Dispersive power of the Material of a Prism - Spectrometer

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

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

For Red color

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

For Blue color

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

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 60^0 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.

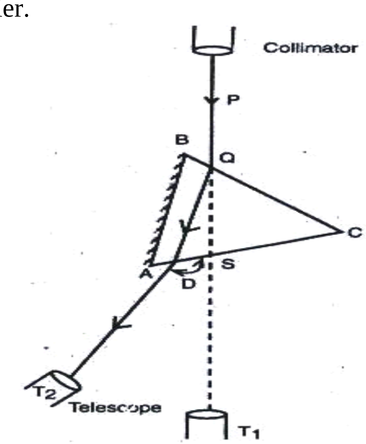


Figure 2 : *Arrangement of Prism for dispersive power*

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 –
Vernier 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	Vernier 2	Vernier 1	Vernier 2	Average
1	Blue					
2	Red					

Precautions:

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

Result: Dispersive power of the material of the given prism ω = ______________.

4. TIME CONSTANT OF AN R-C CIRCUIT

Aim:
To study the charging and discharging of voltage in a circuit containing resistance and capacitor and compare the experimental RC time constant with theoretical RC time constant.

Apparatus:
Power supply, Resistors, Electrolyte, capacitors, voltmeter, stop watch, commutator, connecting wires.

Principle:
Theoretical Time constant of RC circuit **t =RC.**

Where
t – Time constant
R - Resistance
C – Capacitance

Circuit Diagram:

Graph:

Procedure:
This circuit is connected as shown in fig, taking one set of R and C values.

Charging:
When the terminal1 is connected to A, the capacitor will change with time. This changing in charge is noted as a voltage across the capacitor with time. The change in charging voltage is noted for every 5sec with help of stop watch and recorded in the observation table. The graph is drawn between time on x-axis and voltage on y-axis. The time constant is calculated from the graph by calculating the time corresponding to 63% value of maximum value and comparing with theoretical value of time constant(RC).

Discharging:
When the terminal1 is connected to B, the charged capacitor will be discharged with time. The decayed voltage across the capacitor is noted with 5sec time interval upto zero voltage. The graph is drawn between the voltage across the capacitor and time on x-axis. The time constant is calculated at 36% of maximum voltage across the capacitor and comparing with theoretical value of time constant (RC).
This experiment is repeated with different set of R and C values.

Observation:

S. No	SET-1 R= C=		SET-2 R= C=	
	VOLTAGE (volts)	TIME (secs)	VOLTAGE (volts)	TIME (secs)

Applications:

- When a capacitor is charged by a DC Voltage, the accumulation of charge on its plates is a method of storing energy which may be released at different rates. An example of the energy storage application is the photoflash capacitor used in flashguns of photographic cameras.
- The charging time and discharging time is calculated for a R.C circuit and is connected to series of decorative bulbs.
- Capacitors are of two types; a) fixed and b) variable, both of which are used in a wide range of electronic devices. Fixed capacitors are further divided into electrolytic and non-electrolytic.

Result :

SET	R in Ohms	C in farads	Theoretical value of t (t=RC)	Practical value of t (from graph)
1				
2				

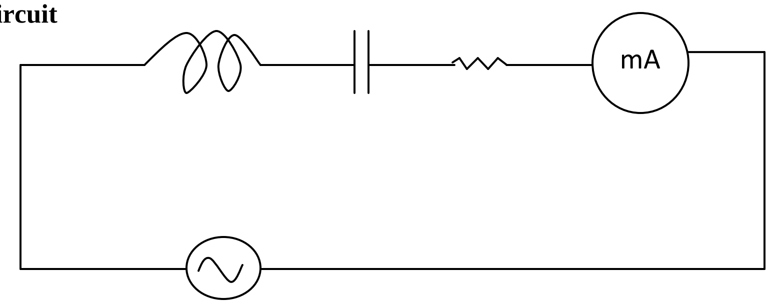
5. LCR CIRCUIT

Aim:
To experimentally determine the resonance frequency in a series and parallel LCR circuit and compare this to the theoretical resonance value.

Apparatus:
Proto -board, resistor, capacitor, inductor, ammeter, function generator, and wire leads.

Experimental Procedure:

LCR Series Circuit



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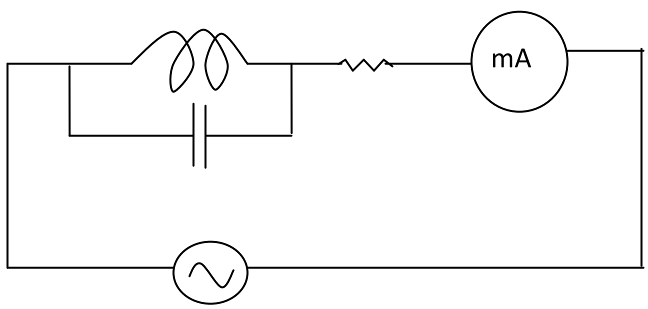
LCR Parallel Circuit



Before you connect the circuit to the function generator set the frequency properly. Then, using the voltmeter to set the generator's output within scale. Using the proto -board and wire leads connect the resistor, capacitor, and inductor along with the output of the function generator to construct the circuit shown in Figure. Here, we measure the peak to peak voltage across the resistor using the oscilloscope.

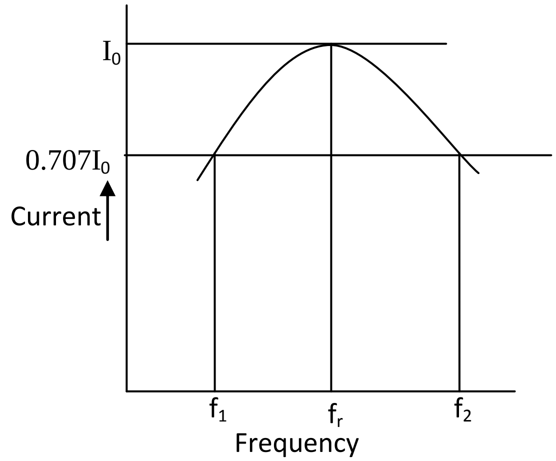
1. The three components are connected in series with the function generator acting as the power supply.
2. Connect the black leads together at the end of the resistor as noted in Figure .
3. Record the values of R, L, and C for this circuit in the space provided in the data section.
4. Use equation 1 to compute the expected resonance frequency and record your result in data table 1.

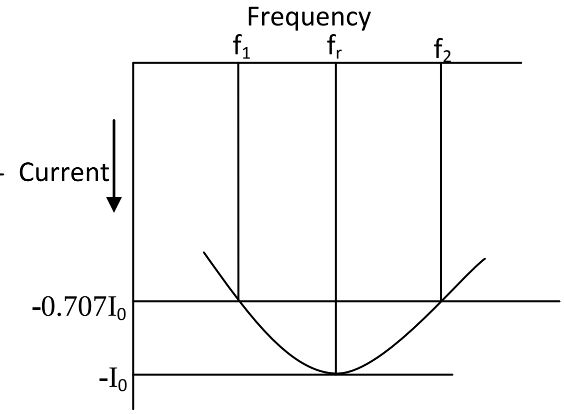
1. Change the function generator frequency to 50Hz and record the peak to peak voltage from the oscilloscope in data table
2. Then, adjust the output frequency to 100 Hz and record the voltage. Adjust the output frequency to 200 Hz And record the voltage.
3. Continue adjusting the output frequency to each value below the expected resonance frequency computed in step
4. Record the voltage for each of these values.
5. Determine an experimental value for resonance frequency by finding the frequency that produces the largest voltage on the oscilloscope. Record this frequency and voltage.
6. Record the voltage for frequency values that are above the resonance frequency determined in step 6.
7. Turn all equipment off and disconnect the circuit.

Table:

S:No	SERIES		PARALLEL	
	FREQUENCY	CURRENT	FREQUENCY	CURRENT

Graphs:





LCR Parallel combination

LCR Series combination

Band width = $f_2 - f_1$, Quality factor = Resonating frequency f_r / Band width

$$In\ series\ combination,\ f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$In\ parallel\ combination,\ f_r = \frac{1}{2\pi}\sqrt{\left(\frac{1}{LC}\right) - \left(\frac{R}{L}\right)^2}$$

Result:

Series

Resonant frequency f_r =__________________Hz

Band width =_____________________________Hz

Parallel

Resonant frequency f_r =__________________Hz

Band width =____________________________Hz

6.STUDY OF CHARACTERISTICS OF LED AND LASER SOURCE

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.

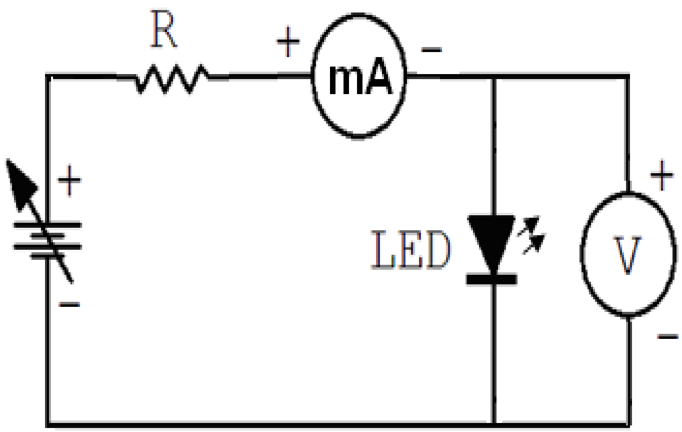
THEORY

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.

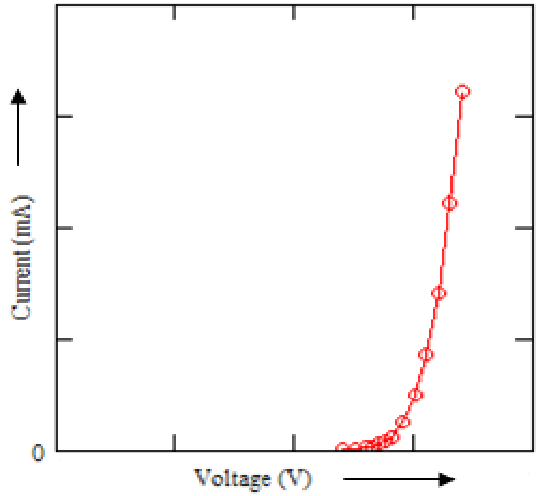
PROCEDURE FOR V-I CHARACTERISTICS

1. Connect the Light emitting diode as shown in figure 1.
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



MODEL GRAPH



OBSERVATIONS

S. No.	Voltage (Volts)	Current (mA)

CALCULATIONS

Result - V-I characteristics of given LED are studied.

Calculated Threshold Voltage V_{th} = ________V and Forward Resistance R_f = _______Ω

7. ENERGY GAP OF MATERIAL OF p-n JUNCTION

Aim:
To determine the width of the forbidders energy gap in a semiconductor material by reverse bias pn-junction diode method.

Apparatus:
Power supply, heating arrangement, thermometer, micro ammeter, germanium diode.

Principle:
The width of the forbidden

Energy gap [E_g] = 2.3026 x 10^3 x K x m eV

K=Boltzmann constant

M=slope of the line from the graph drawn between $\log I_0$ and $10^3/T$

$$E_g = \frac{2.3026 \times 2 \times k \times \text{slope(m)}}{1.6 \times 10^{-19}} \text{ eV}$$

E_g = 1.9833 x 10^{-4} x m (slope) eV

Slope (m) =

Procedure:

- Sufficiently long wires are soldered to the diode terminals and the diode is connected into the circuit as shown in the figure.
- The diode is immersed in an oil bath which in turn is kept in a heating mantle. A thermometer is also kept in the oil bath such that its mercury bulb is just at the height of the diode.
- The power supply is switched on and the voltage is adjusted to say 5 volts. The current through the diode and the room temperature are noted.
- The power supply is switched off. The heating mantle is switched on and the oil bath is heated up to 90^0.
- The heating mantle is switched off when the temperature of the oil bath reached 90^0. The current corresponding to this temperature is noted. With a decrease of every 5^0 the current is noted.
- As the temperature decreases the current through diode decreases. And the observations are noted in the table.
- A graph is plotted taking $10^3/T$ on X-axis and $\log I_0$ on Y-axis. A straight line is obtained.
- The slope of the straight line is determined and hence the energy band gap is calculated.

Circuit diagram

Graph

Precautions:

- The diode and the thermometer are placed at the same level in the oil bath.
- The maximum temperature of the diode is not allowed to go beyond 90^0C.

Observations:

S.No	Current (I) μA	Temperature (t) ^{0}C	Temperature T=(t+273) ^{0}K	$\frac{1}{T}$X10^3	R=V/I	logR

Result: The width of the forbidden gap in germanium semiconductor is found to be _____________ eV.

8.MAGNETIC FIELD ALONG THE AXIS OF CURRENT CARRYING COIL- STEWARTAND 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 flows 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

$$B = \frac{\mu_0 n i a^2}{2\left(x^2 + a^2\right)^{3/2}} \quad \_\_\_\_\_\_\_\_(1)$$

Where B is the magnetic induction on the axial line of the coil = 4π X 10^{-7}

n is number of turns in the coil =

i is the current through the coil =

a is the radius of the coil (in cms) =

x is the distance from the centre of the coil(in cms)=

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,

$$\mathbf{B = B_e \tan\Theta} \_\_\_\_\_\_\_\_\_\_\_\_\_\_(2)$$

B_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).

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.

Figure:

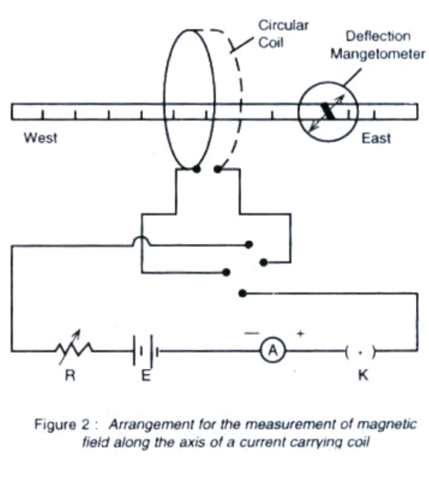


Figure 2 : *Arrangement for the measurement of magnetic field along the axis of a current carrying coil*

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 60^0. 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 2^0 or 3^0 , 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 $_{\mathbf{E}}$. The magnetometer is further moved towards east in steps of 5cm each time and the deflections before and after reversal of current are noted, until the deflection falls to 30^0.

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 $_{\mathbf{W}}$.

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$_{\mathbf{E}}$andTan$_{\mathbf{W}}$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.

S.No	Distance of deflection magnetometer from centre of the coil(X) in meters	Deflection in the magnetometer East side						Deflection in the magnetometer West side						$\theta=\frac{\theta e+\theta w}{2}$	Tan θ	B=B_e tan θ	$B=\frac{\mu_0\, n\, i\, a2}{2(x2+a2)^{3}/_{2}}$
		θ_1	θ_2	θ_3	θ_4	Mean θe	Tan θe	θ_1	θ_2	θ_3	θ_4	Mean θw	Tan θw				

Result : The theoretical and calculated values are approximately same.

9. **WAVE LENGTH OF LASER RADIATION**

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.

Description:
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 are written on the diffraction grating by the manufacturers. The laser consists of a mixture in the ratio of about 10:1, placed inside a long narrow discharge tube. The pressure inside the tube is about 1 mm of Hg.

The gas system is enclosed between a pair of plane mirror or pair of concave mirror so that a resonator system is formed. One of the mirrors is of very high reflectivity while the other is partially transparent so that energy may be coupled out of the System. The 6328 A° transition of beam corresponding to the well known red light of Laser are light amplification by stimulated emission of radiations.

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.

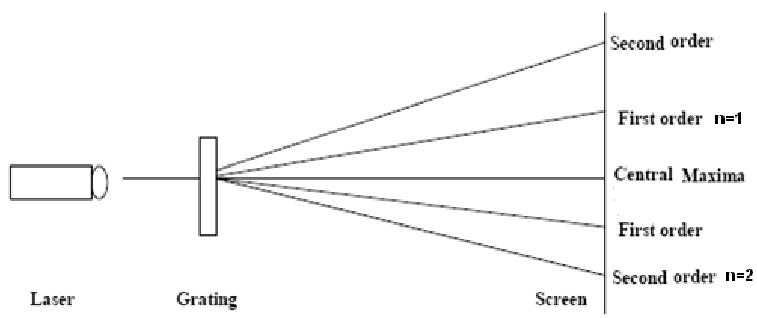
$$\lambda = \frac{2.54 \sin\theta}{nN}$$

Where

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

Procedure:
Keep the grating in front of the laser beam such that light is incident normally on it. When light of laser falls on the grating the central maxima along with four other lights are seen on the screen. The light next to central maxima is called the first order maxima and the light next to first order is second order maxima. Now measure the distance between the grating and the screen and tabulate it as “d1” and the distance between central maxima to first order and then central maxima and second order is “d2 and it is also tabulated.

Diagram



Tabular form:

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

Result: Wavelength of given Laser light = ____________A^0

10. 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 1.

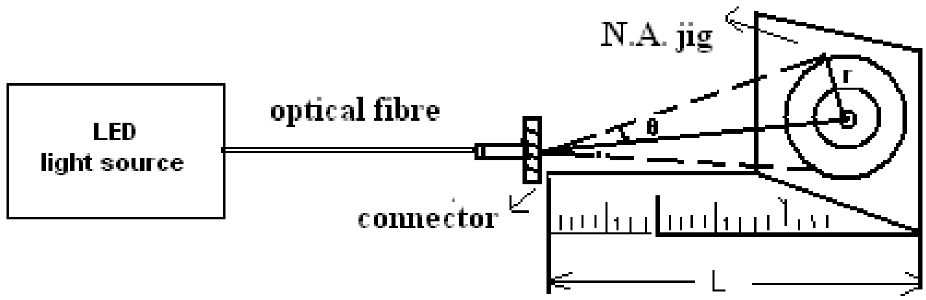


Figure 1 Arrangement for N.A. measurement

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) =** $\mathbf{n_i \sin\theta_{max}}$ ……………….. (1)

For air $n_i = 1$

For a step index fibre, the N.A. is given by: $\mathbf{NA = (n^2_{core} - n^2_{cladding})^{1/2}}$ ……………….. (2)

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

$\mathbf{NA = n_{core}(2\Delta)^{1/2}}$ ……………….. (3)

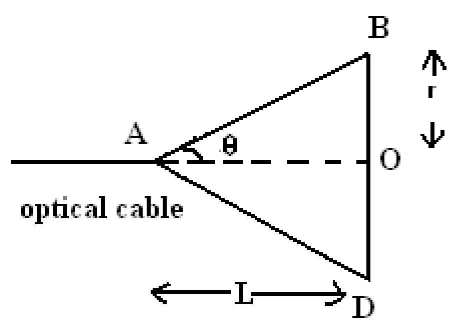
Where Δ is the fractional difference in the refractive indices of the core and the cladding i.e.

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

Light from the fibre end 'A' falls on the screen BD.
Let the distance between the fibre end and the screen = AO = L
From the Δ AOB **sinθ = OB/AB**

OB = r andAB = $[r^2 + L^2]^{1/2}$

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



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.

RESULTS

The NA of the optical fiber is …………………….

The Acceptance angle θ is ……………………..

BENDING LOSSES IN OPTICAL FIBERS

Aim:

To measure the bending loss in optical fiber as a function of bending radius

Equipments

1. Bend board
2. 62.5/125 µm optical fiber
3. Reference light source
4. Optical power meter

Bending losses: Radiativelossesoccurwheneveranopticalfiberundergoesabendoffinite Radius of curvature. Fibers can be subject to two types of bend:

a.Macroscopicbendshavingradiithatarelargecomparedtothefiberdiameter.

b.Randommicroscopicbendofthefiberaxisthatcanarisewhenthefibersareincorporatedintocables.Letusexaminelarge–curvatureradiationlosses,whichareknownasmacro-bendinglosses.Forslightbendtheexcesslossisextremelysmallandisessentiallyunobservable.Astheradiusofcurvaturedecrease,thelossincreasesexponentiallyuntilatacertaincriticalradiusthecurvaturelossbecomesobservable.Asharpbendinafibercancausesignificantlossesas Wellasthepossibilityofmechanicalfailure.Therayissafelyoutsideofthecriticalangleandistherefore propagatedcorrectly.Ifthecorebends,thenormalwillfollowitandtheraywillnowfinditselfonthewrongSideofthecriticalangleandwillescape.Thetighterthebendcausetheworsethelosses.Therefore;thecriticalradiusdeterminedbyattached instrumentsindicatedalossofover6dB.Ifbendingradiusissmallerthancriticalradiuscausesdamagein optical fiber.

Procedure

1. Connect the first ST end of optical fiber to the reference light source and the second ST end to the optical power meter. Make sure the optical fiber straight line no loops or bend.
2. Turn on both reference light source and optical power meter,
   And then write the measured value of optical power.
3. By using bend board (25mm diameter part); bend the optical fiber according to the figure of bending.
4. Record the optical power against as shown in table below.
5. Repeat steps(3,4)with bending diameters(17.5mm,15mm,10mm).
6. Connect the digital transmitter and receiver on the training optical fiberboard. Then insert the optical fiber.
7. Starttotransmitthedataoveropticalfiber.Makesuretheopticalfiberwithnoloopsorbend.
8. Plot the output signal on the graph paper.
9. By using bend board (25mm diameter part); bend the optical fiber according to the figure of bending. Then plot the output signal on the graph paper.
10. Repeat step (9) with bending diameters (17.5mm, 15mm, 10mm, and 8mm).

S.No.	Diameter	Radius	Output power	Power loss

Result:

11. NEWTONS RINGS

Aim :
To determine the wavelength (λ) of 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:

λ - Wave length of sodium light

R - Radius of curvature of the of Plano convex lens.

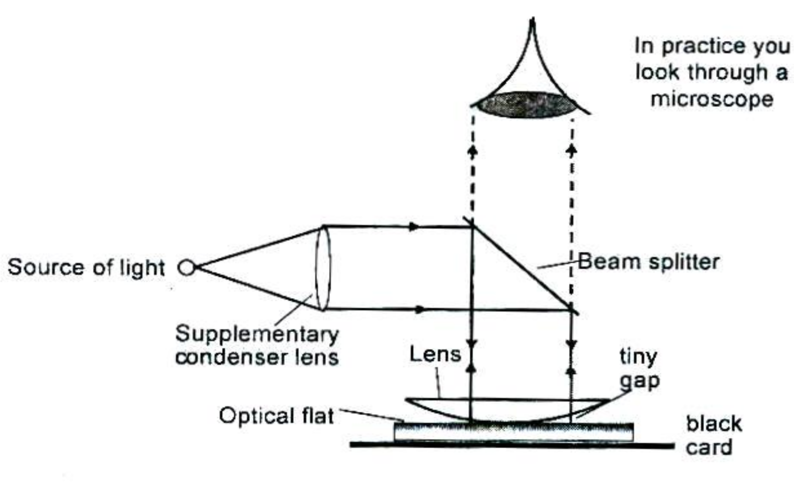
D_m - Diameter of the m^{th} ring.

D_n- Diameter of the n^{th} ring.

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 45^0 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.

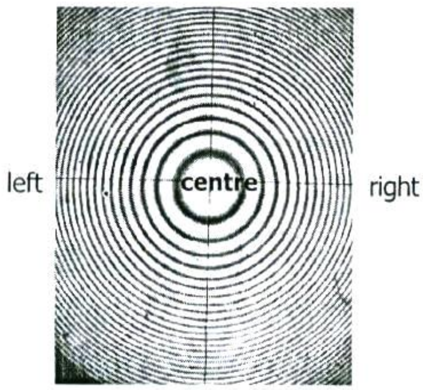
PROCEDURE: The point of intersection of the cross wires in the microscope is brought to the centre of the ring system. The wire is set tangential to any one ring, and starting from the centre of the ring system, the microscope is moved on to one side; say left, across the field of view counting the number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



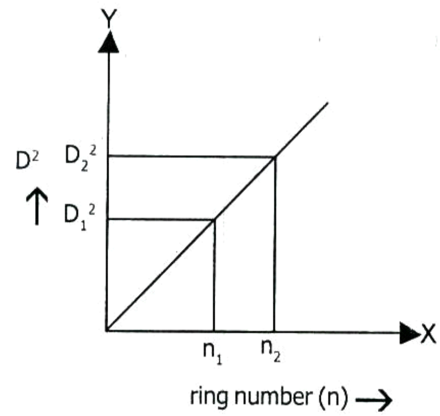
Schematic diagram of Newton's rings setup

Experimental set-up



Photograph of Newton's rings formed

Graph



Observations:

S.no	No. of the ring (n)	Microscope reading			D^2
		On the left side (a)	On the right side (b)	Diameter of the ring D = (a - b)	
1	30				
2	25				
3	20				
4	15				
5	10				

PRECAUTIONS:

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

RESULT: The wave length of sodium light is __________________.