SRI INDU INSTITUTE OF ENGINEERING AND TECHNOLOGY

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(Approved by AICTE, New Delhi and Affiliated to JNTUH, Hyderabad)
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DEPARTMENT OF HUMANITIES AND SCIENCES

APPLIED PHYSICS LAB MANUAL

(AP105BS &AP205BS)

APPLIED PHYSICS LAB (BR-22)

LIST OF EXPERIMENTS:

1. Determination of work function and Planck’s constant using photoelectric effect.

2. Determination of Hall co-efficient and carrier concentration of a given semiconductor.

3. Characteristics of series and parallel LCR circuits.

4. V-I characteristics of a p-n junction diode and Zener diode

5. Input and output characteristics of BJT (CE, CB & CC configurations)

6. a) V-I and L-I characteristics of light emitting diode (LED)

   b) V-I Characteristics of solar cell

7. Determination of Energy gap of a semiconductor.

8. Determination of the resistivity of semiconductor by two probe method.

9. Study B-H curve of a magnetic material.

10. Determination of dielectric constant of a given material

11. a) Determination of the beam divergence of the given LASER beam

    b) Determination of Acceptance Angle and Numerical Apertureof an optical fiber.

12. Understanding the method of least squares – torsional pendulum as an exampl

INSTRUCTIONS FOR LABORATORY

- The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments. Conduct the experiments with interest and an attitude of learning.
- Students need to come well prepared for the experiment.
- Work quietly and carefully (the whole purpose of experimentation is to make reliable measurements) and equally share the work with your partners.
- All presentations of data, tables and graphs calculations should be neatly and carefully done.
- Bring necessary graph papers for each of experiment. Learn to optimize on usage of graph papers.
- Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- Students those finished the experiment early; spend the remaining time to complete the calculations and drawing graphs. Come equipped with calculator, scales, pencils etc.

EXPERIMENT 1

PHOTO ELECTRIC EFFECT

AIM:

I) To Study the characteristics of a photo cell

ii) To determine the Planck's constant and photo electric work function of the material of the cathode

APPARATUS

A vacuum type photo emissive cell enclosed in a light-tight box, a sensitive galvanometer or microammeter,D.C power supply,voltmeter,rheostat,a source of white light(mercury vapor lamp),a set of optical filters(violet,green,blue,yellow,red),plug key, connecting wires.

FORMULAE:

$$h = \frac{e(v2-v1)\lambda 1\lambda 2}{C(\lambda 1-\lambda 2)}$$

e = Electric charge

V_2 = Stopping potential corresponding to wavelength2

V_1 = Stopping potential corresponding to wavelength1

C = Velocity of light.

DESCRIPTION:

The emission of electrons form the surface of certain substances, mainly metals when they are illuminated by electromagnetic radiations, like X-rays, ultra violet and even visible light. The electrons emitted are called photo electrons (The alkali metals, lithium, sodium, potassium) are emits photo electrons.

The photo cell consists of one electrode made of photo electric metal and another electrode of ordinary metal sealed in a evacuated glass bulb. When suitable monochromatic light falls on the photo electric metal, electrons are ejected from its surface. When the potential applied between cathode and anode, the photo electrons are attracted by the anode and photo electric current flows.

Einestein explained photo electric effect from the quantum theory of radiation. A part of the energy of incident photon **hν** is spent in releasing the electrons from the surface of the metal, called work function (W_0) or photo electric work function, the remaining energy of the photon imparts kinetic energy to the photo electron.

$$\text{i.e } h\nu = \mathbf{h\nu_0} + \frac{1}{2} mv^2$$

$$\text{i.e } h\nu = \mathbf{W_0} + \frac{1}{2} mv^2$$

If V_s is applied stopping potential $h\nu = W_0 + eV_s$

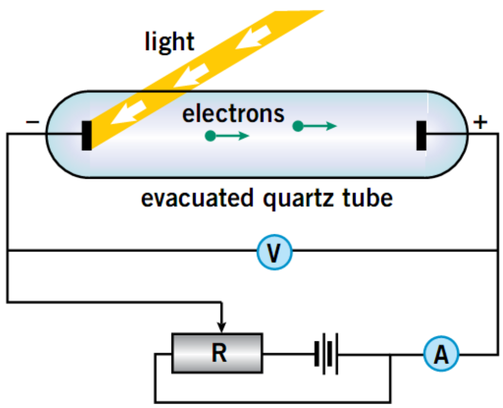
Or $eV_s = h\nu - W_0$

$$V_s = (h/e)\nu - W_0/e$$

The above equation is in the form of $y = mx+c$

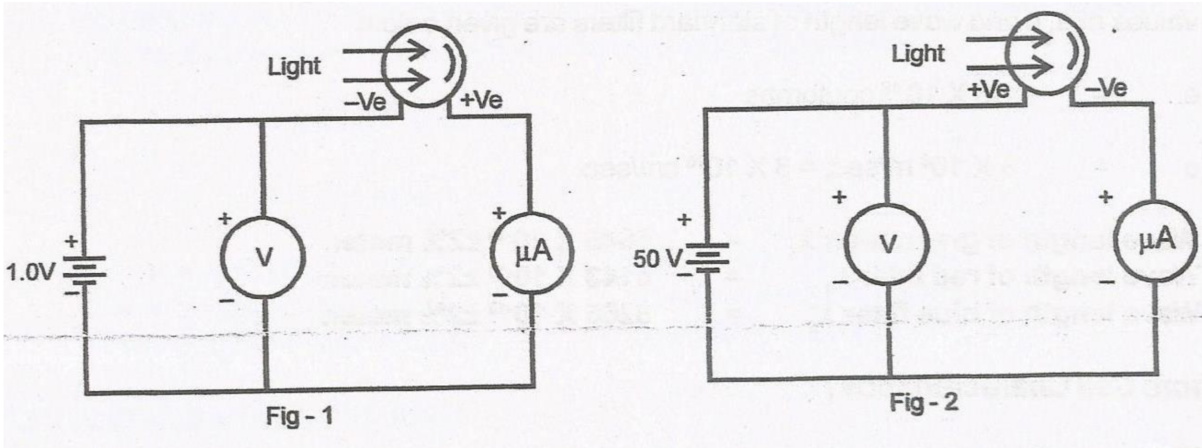
Therefore the slope = h/e

Form above equation $\mathbf{\nu_0}$ is the threshold frequency (i.e the minimum frequency of light required to eject electron from the surface of the metal). Photo electric current depends on applied voltage.



Minimum negative potential applied to anode to reduce the photo electric current to zero

Circuit:



Procedure:

1. Keep the left hand side switch on the panel towards sensitive side and right hand side switch towards 1.0 V side. Switch ON the power supply now set the micro ammeater (μA) reading to zero with the help of potentiometer marked with zero adjustment.

2. The circuit connections are made as shown in diagram (Fig1) Be careful about the polarity shown in diagram.

3. A light source is arranged. The alight is allowed to fall on the photo cell. The distance between cell and light source is adjusted such that there is a deflection of about 8 to 10 divisions in micro ampere (μA). Now suitable filter (say Green) of Known wavelength is placed in the path of light (in the slit provided) say it is with wavelength λ_2

4. A deflection is observed in the micro ammeter. The deflection corresponds to the zero anode potential.

5. A small negative (-ve) potential is applied on the anode. This voltage is recorded with the help of voltmeter provided (1.0 volts range)

6. The negative anode potential is gradually increased in steps and each time corresponding deflection is noted till the micro ammeter deflection reduces to zero. And this is stopping potential V_2 corresponding to filter with wavelengthβ□□□ λ_2

7. This experiment is repeated after replacing the green filter with blue and red filters. Say with wavelength λ_2 and λ_3 respectively and stopping potential V_2 and V_3 are noted.

8. Taking negative anode potential with X-axis and corresponding deflections in micro ammeter on Y axis, Graphs are plotted for different filters.

9. By using above values planck's constant h is calculated.

Observations:

e = 1.6×10^{-19} coulombs

c = 3×10^{8} m/sec. = 3×10^{10} cm/sec

Wave length of green filter λ_3 = $5645 \times 10^{-10} \pm 2\%$ meter.
Wave length of red filter λ_1 = $6143 \times 10^{-10} \pm 2\%$ meter.
Wave length of blue filter λ_2 = $5265 \times 10^{-10} \pm 2\%$ meter.

Table1:

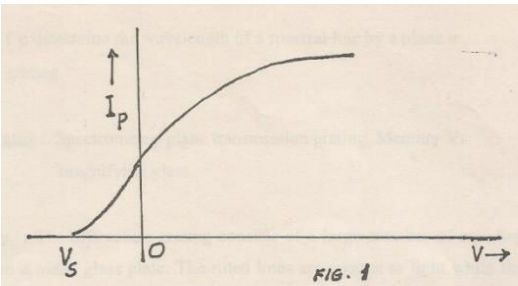
S. No	Voltage (Volts)	Current I (μA)		
		Orange filter	Green filter	Blue filter

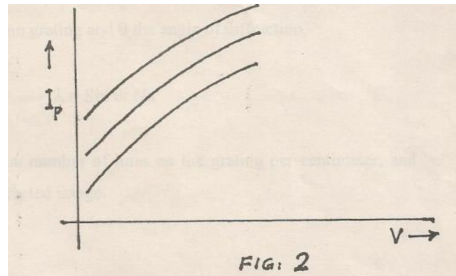
Table2:

S. No	Colour of the filter	Stopping potential V_s	Frequency $\nu = C/\lambda$	Work function $W_o = h\nu - e\nu_s$
1				
2				

3				

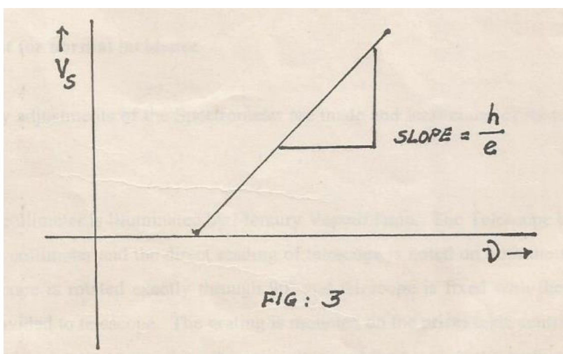
Graph:





Voltage Vs Current

Voltage Vs Current (for filters)



Frequency Vs Stopping Voltage

Calculations:

Work function $W_o = hv - ev_s$

Planck's constant $h = \frac{e(v2 - v1)\lambda 1 \lambda 2}{C(\lambda 1 - \lambda 2)}$

PRECAUTIONS:

1. The mercury vapor lamp, optical filter and the photocell should be placed in a line.
2. The position of the lamp should not be disturbed while performing the experiment.
3. The experiment should be performed in a dark room in order to avoid any stray light to photocell.

4. Ensure the lamp position so that light from the source falls normal on to the window of the light-tight box.

5. Ensure that the indicator lamp flows after switch on the apparatus.

6. The whole surface of the cathode should be illuminated.

7. The stopping potential should be noted accurately.

8. The distance between the mercury vapor lamp and the Photocell should be kept constant throughout the experiment.

RESULT:

Planck's constant	Standard Value	Experimental	Difference
	6.62×10^{-34}		

2. Photoelectric work function of the material of the cathode, Wo =   Joule.

Viva voce:

1. What is photo sensitive device?

   A device that is responsive to electromagnetic radiation in the visible,infrared or ultraviolet spectral regions

2. Howmany types of photo sensitive devices are there?

   There are two basic types of photocells .They are the photovoltaic cell and the photo resistor.

3. What is photo sensitive device area?

   The area in a device that actually collects light and converts it to electrons

4. What is photo electric effect?

   The effect is often defined as the ejection of electrons from a metal plate when light falls on it.

5. What is stopping voltage?

   The voltage difference required to stop electrons from moving between plates and creating a current in the photo electric experiment

6. What do you mean by work function?

   The minimum quantity of energy which is required to remove an electron to infinity from the surface of a given solid

7. Can all light eject electrons?

Light below a certain frequency ejects no electrons at all.Where as light above that threshold frequency can eject electrons.

8.What is the the photo electric cell?

A device using a photoelectric effect to generate current.

9.What is monochromatic light?

Light of a single wavelength is known as monochromatic light.

10.What is photoconductive cell?

A light –sensitive resistors in which resistance decreases with an increase in light intensity when illuminated.

11.What are two common applications for photo conductive cells?

They are used in camera,street light control and flame detector applications.

12.What is threshold frequency?

The minimum frequency of radiation that will produce a photoelectric effect.

13.What is threshold wavelength?

The maximum wavelength of the light for which the metal will emit electrons.

14.What are photo electrons?

The electrons that are ejected from the metal are called photoelectrons.

15.What is the importance of the photoelectric effect?

The photoelectric effect is also widely used to investigate electron energy levels in the matter.

16.Who verified the Einstein photoelectric equation?

Millikan experimentally verified the Einstein's photoelectron equation.

17.What are the characteristics of photo electric effect?

1.Threshold frequency is variable for different metals
2.Current is directly propotional to light intensity
3.Stopping potential is directly proportional to threshold frequency.

18.If the wavelength of electromagnetic radiation is doubled,what will happen to the energy of photons?

The energy of the photon reduces to one-half when the wavelength of radiation is doubled.

19.Why are alkali metals most suited as photo sensitive metals?

Alkali metals have low work functions.Even visible radiation can eject out electrons from them.So alkali metals are the most suitable photo sensitive metals.

20. Which radiations will be most effective for the emission of electrons from a metallic surface?

Ultraviolet rays are most effective for photoelectric emission because they have the highest frequency when compared to the other electromagnetic waves,and hence the most energetic among all.

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EXPERIMENT 2
HALL EFFECT

Aim :

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

Apparatus :

Two solenoids, Constant current supply, Four probe, Digital gauss meter, Hall effect apparatus (which consist

of Constant Current Generator (CCG), digital milli voltmeter and Hall probe).

Theory :

If a current carrying conductor placed in a perpendicular magnetic field, a potential difference will generate in the

conductor which is perpendicular to both magnetic field and current. This phenomenon is called Hall Effect. In

solid state physics, Hall effect is an important tool to characterize the materials especially semiconductors. It

directly determines both the sign and density of charge carriers in a given sample.

Consider a rectangular conductor of thickness ***t*** kept in XY plane. An electric field is applied in X-direction using

Constant Current Generator (CCG), so that current ***I*** flow through the sample. If ***w*** is the width of the sample

and ***t*** is the thickness. There for current density is given by

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

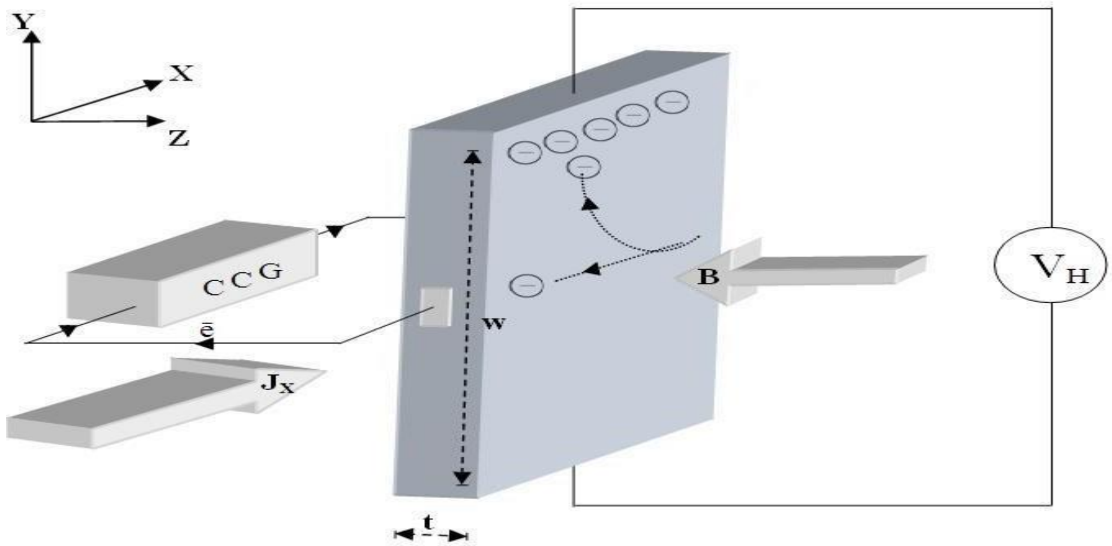


Fig.1 Schematic representation of Hall Effect in a conductor.

CCG – Constant Current Generator, J_X – current density
$\bar{e}$ – electron, ***B*** – applied magnetic field
t – thickness, ***w*** – width
V_H – Hall voltage

If the magnetic field is applied along negative z-axis, the Lorentz force moves the charge carriers (say electrons) toward the y-direction. This results in accumulation of charge carriers at the top edge of the sample. This set up a transverse electric field $\mathbf{E_y}$ in the sample. This develop a potential difference along y-axis is known as Hall voltage V_H and this effect is called Hall Effect.

A current is made to flow through the sample material and the voltage difference between its top and bottom is measured using a volt-meter. When the applied magnetic field B=0,the voltage difference will be zero.

We know that a current flows in response to an applied electric field with its direction as conventional and it is either due to the flow of holes in the direction of current or the movement of electrons backward. In both cases, under the application of magnetic field the magnetic Lorentz force,

$$F_m = q(vxB)$$

causes the carriers to curve upwards. Since the charges cannot escape from the material, a vertical charge imbalance builds up. This charge imbalance produces an electric field which counteracts with the magnetic force and a steady state is established. The vertical electric field can be measured as a transverse voltage difference using a voltmeter.

In steady state condition, the magnetic force is balanced by the electric force. Mathematically we can express it as

$$eE = evB \quad (2)$$

Where 'e' the electric charge, 'E' the hall electric field developed, 'B' the applied magnetic field and 'v' is the drift velocity of charge carriers.

And the current 'I' can be expressed as,

$$I = neAv \quad (3)$$

Where 'n' is the number density of electrons in the conductor of length l ,breadth 'w' and thickness 't'.

Using (1) and (2) the Hall voltage V_H can be written as,

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

$$V_H = R_H \frac{IB}{t} \quad (4)$$

by rearranging eq(4) we get

$$R_H = \frac{V_H * t}{I * B} \quad (5)$$

Where R_H is called the Hall coefficient.

$$R_H = 1/ne \quad (6)$$

Procedure :

- Connect ‘Constant current source’ to the solenoids.
- Four probe is connected to the Gauss meter and placed at the middle of the two solenoids.
- Switch ON the Gauss meter and Constant current source.
- Vary the current through the solenoid from 1A to 5A with the interval of 0.5A, and note the corresponding Gauss meter readings.

- Switch OFF the Gauss meter and constant current source and turn the knob of constant current source towards minimum current.
- Fix the Hall probe on a wooden stand. Connect green wires to Constant Current Generator and connect red wires to milli voltmeter in the Hall Effect apparatus
- Replace the Four probe with Hall probe and place the sample material at the middle of the two solenoids.
- Switch ON the constant current source and CCG.
- Carefully increase the current I from CCG and measure the corresponding Hall voltage V_H. Repeat this step for different magnetic field B.

- Thickness ***t*** of the sample is measured using screw gauge.
- Hence calculate the Hall coefficient R_H using the equation 5.
- Then calculate the carrier concentration ***n***. using equation 6.

Observation Tables :

i)

Trial No:	Current through solenoid	Magnetic field generated
1		
2		
3		
4		

ii)

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

Precautions :

1. Hall Voltage should be measured very carefully and accurately.

2. Distance between pole pieces of Electromagnet should not be changed during the whole experiment.

3. Current passing through semiconductor slab should be strictly within permissible limit.

Result :

Hall coefficient of the material = ...

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

Viva-voce questions

1.What is Hall effect?

The production of a potential difference across an electrical conductor when a magnetic field is applied in a direction perpendicular to that of the flow of current.

2.What is Hall coefficient?

The quotient of the potential difference per unit width of metal strip in the Hall effect divided by the product of the magnetic intensity and the longitudinal current density.

3.What are n-type and p-type semi conductors?

The pentavalent intrinsic semi conductors are called n-type semi conductors

The trivalent intrinsic semi conductors are called p-type semi conductors.

4.What is effect of temperature on Hall coefficient?

As temperature increases at different magnetic field Hall coefficient decreases……..

5.How is Hall's coefficient related with carrier concentration?

The Hall coefficient was found to be dependent on composition and thickness of the films.The increase of film thickness of the films..The increase of film thickness increases while the carrier concentration decreases.

6.On what factors does the sign of the Hall's coefficient depend?

The magnitude of the Hall voltage depends on the strength of the magnetic field,the current, and the carrier density.The carrier mobility is determined from the Hall voltage and the resistivity

7.What is the sign of Hall coefficient for an intrinsic semiconductor?

Hall coefficient of an intrinsic semi conductor is negative under all conditions

8.How is Hall's coefficient related to Hall's voltage and the thickness ?Why?

9.In what units is Hall's coefficient measured in?

The units are $meter^3$/coulomb

10. What is electrical conductivity?

The degree to which a specified material conducts electricity,calculated as the ratio of the current density in the material to the electric field which causes the flow of current

11. How does mobility depend on electrical conductivity?

Conductivity is proportional to the product of mobility and carrier concentration

12. Do the holes actually move?

The holes do not move.Its the electron that occupy a hole and leave a vacant hole behing them.So it seems that electron moved towards the positive terminal and the hole moving towards the negative terminal

13. Does the Hall coefficient depend on the dimensions of the sample?

The Hall coefficient also depends on the length

14. Which type of charge has greater mobility?

In a semi conductor the mobility of electrons is greater than that of a holes because of different band structure and scattering mechanisms of these two carrier types.

15. Define Hall angle?

The electric field ,resulting from the Hall effect,perpendicular to a current ,divided by the electric field generating the current.

16. Define mobility of charge carriers?

The net average velocity with which the free-electrons move towards the positive end of a conductor under the influence of an external field that is being applied

17. Is it possible to measure Hall's coefficient for metals?

18. Should the sample be thin?

Measurements of the Hall voltage are used to determine the density and sign of charge carriers in a conductor.When this is known,the effect is used to a probe for magnetic field measurement.In this experiment,samples of chromium and silver in the form of thin films of various thicknesses are available

19. What is resistivity?

Electrical resistivity is a fundamental property of a material that measures how strongly it resists electric current.

20. What are the units of magnetic filed?

Weber/m^2 or Tesla

EXPERIMENT 3

LCR CIRCUIT

A: SERIES RESONANCE

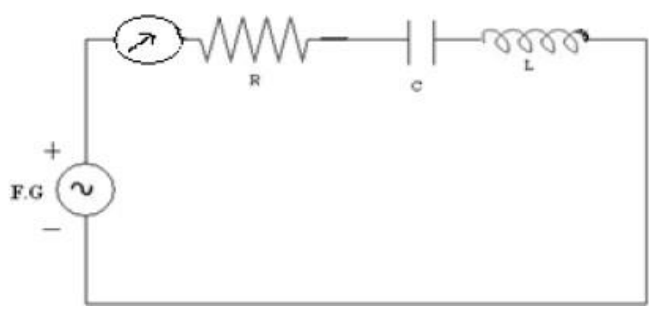
AIM:

To study the frequency response of LCR series circuits and to determine the Resonant Frequency of the circuit

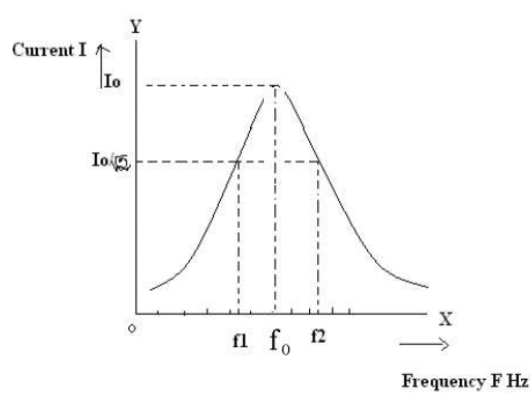
APPARATUS:

LCR Trainer kit, Function generator, connecting wires.

CIRCUIT DIAGRAM:



WAVE FORM:



THEORY:

Inductance (L), Resistance (R) and Capacitor (C) are connected in series with a source of AC supply (signal generator). This circuit is called series resonance circuit.

At resonance frequency, the resultant impedance of the combination is minimum and hence the current is Maximum.

PROCEDURE:

1. Find the resonance frequency for a particular combination of LCR.
2. Keep the input voltage V constant throughout experiment at a constant suitable value.
3. Locate the resonant frequency, which is the frequency at which current increase slowly at the beginning afterwards increases sharply and reaches a peak value.
4. Again increase the frequency of input signal beyond the resonance frequency then the current through the circuit gradually increases.
5. Note the readings at each step and plot a graph I on Y-axis, F on X-axis.

CALCULATION:

Theoretical Valu:

Resonant frequency of the series circuit is given by $f_o = \frac{1}{2\pi\sqrt{LC}}$ = Hz

Quality Factor:

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Practical value:

Resonance frequency of the series circuit is f_o = ---------------------------------- Hz.

Quality Factor:

$Q = f_o / \Delta f$ = , $\Delta f = f_2 - f_1$ = , Δf = Band Width

OBSERVATION TABLE:

S. No	Frequency (KHz)	Current (μA)	S.NO.	Frequency (KHz)	Current (μA)

RESULT:

The Resonance frequency of LCR series circuit is determined as _____________

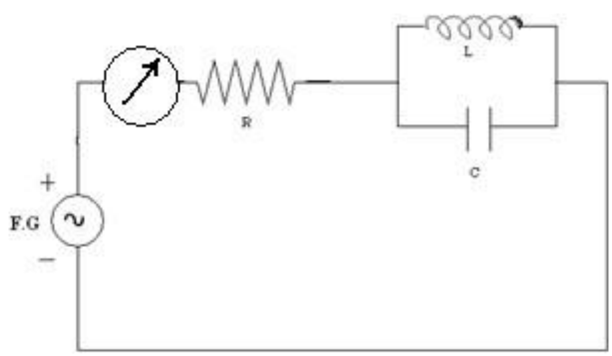
B: PARALLEL RESONANCE

AIM:

To study the frequency response of LCR parallel circuits and to determine the Resonant Frequency of the circuit

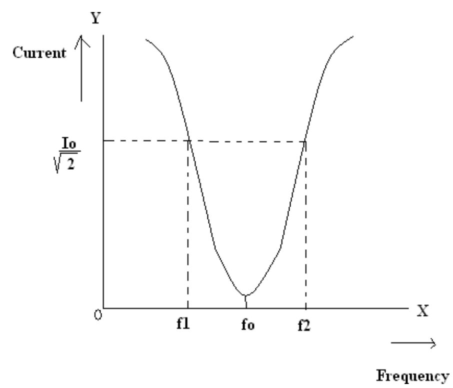
APPARATUS:

LCR Trainer kit, Function generator, connecting wires



CIRCUIT DIAGRAM:

WAVE FORM:



PROCEDURE:

1. Find the resonance frequency for a particular combination of LCR.
2. Keep the input voltage V constant throughout experiment at a constant suitable value.
3. Locate the resonant frequency, which is the frequency at which current is maximum and beyond this frequency the deflection rises gradually.
4. Vary the frequency above and below the resonant frequency in small steps.
5. Note the readings at each step and plot a graph I on Y-axis, F on X-axis.

CALCULATION:

Theoretical Value:

Resonant frequency of the parallel circuit is given by

$$f_o = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \text{ Hz}$$

Quality Factor:

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Practical value:

Resonance frequency of the parallel circuit is f_o = ------------------- Hz.

Quality Factor:

$Q = f_o / \Delta f$,

$\Delta f = f_2 - f_1$ where, Δf = Band Width

OBSERVATION TABLE:

S. No	Frequency (KHz)	Current (μA)	S. No	Frequency (KHz)	Current (μA)

RESULT:

The Resonance frequency of LCR parallel circuit is________________

VIVA QUESTIONS:

1. What is tuning?
2. What is resonance?
3. What is a rejecter circuit?
4. What is an acceptor circuit?
5. What are half – power frequencies?
6. What is meant by Bandwidth?

1. Expected Value or Theoretical Values

2. Achieved Value or Experimental Value

3. Error Value

4. Reasons For Error

5. Suggestions For Error

EXPERIMENT 4

PN JUNCTION DIODE AND ZENER DIODE

AIM:

1. To plot Volt-Ampere Characteristics of Silicon P-N Junction Diode.
2. To find cut-in Voltage for Silicon P-N Junction diode.
3. To find static and dynamic resistances in both forward and reverse biased conditions for Si P-N Junction diode.

COMPONENTS:

Name	Qty
Diodes IN 4007(Si)	1
Resistor 1KΩ	1

APPARATUS:

Name	Range	Qty
Bread Board	-	1
Regulated Power Supply	0-30V DC	1
Digital Ammeter		
Digital Voltmeter	0-200μA/20mA	1
Connecting Wires	0-2V/20V DC	1

SPECIFICATIONS :

For Silicon Diode IN 4007: -

Max. Forward Current = 1A

Max. Reverse Current = 30μA

Max. Forward Voltage = 0.8V

Max. Reverse Voltage = 1000V

Max. Power dissipation = 30mw

Temperature = - 65 to 200^{0}C

THEORY: Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier $V\gamma$ called *Cut- in Voltage.* This is the voltage across the diode at which it starts conducting. The P-N junction can conduct beyond this Potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected to cathode (N- side) then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current (*injected minority current* – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch.

If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called *reverse saturation current* continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by following equation:

$I = I_0 (e^{v/(\eta v_T)} - 1)$ where

I=current flowing in the diode I_0=reverse saturation current

V=voltage applied to the diode

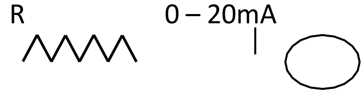
V_T=volt-equivalent of temperature=kT/q=T/11,600=26mV(@ room temp).

η=1 (for Ge) and 2 (for Si)

It is observed that Ge diode has smaller cut-in-voltage when compared to Si diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

CIRCUIT DIAGRAM:

Fig (1) – Forward Bias Condition:



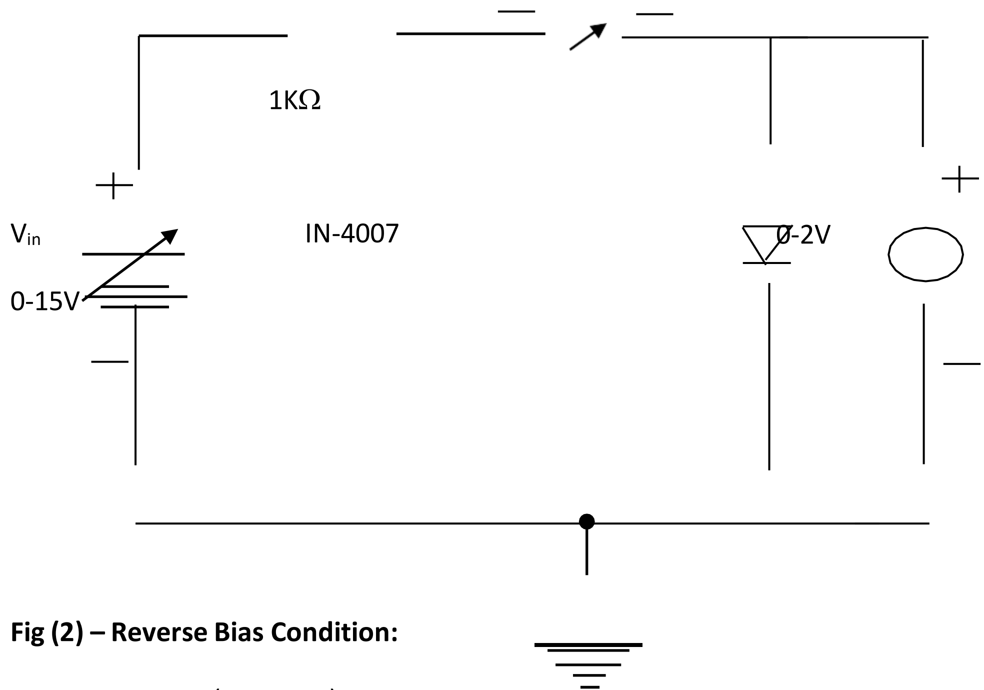
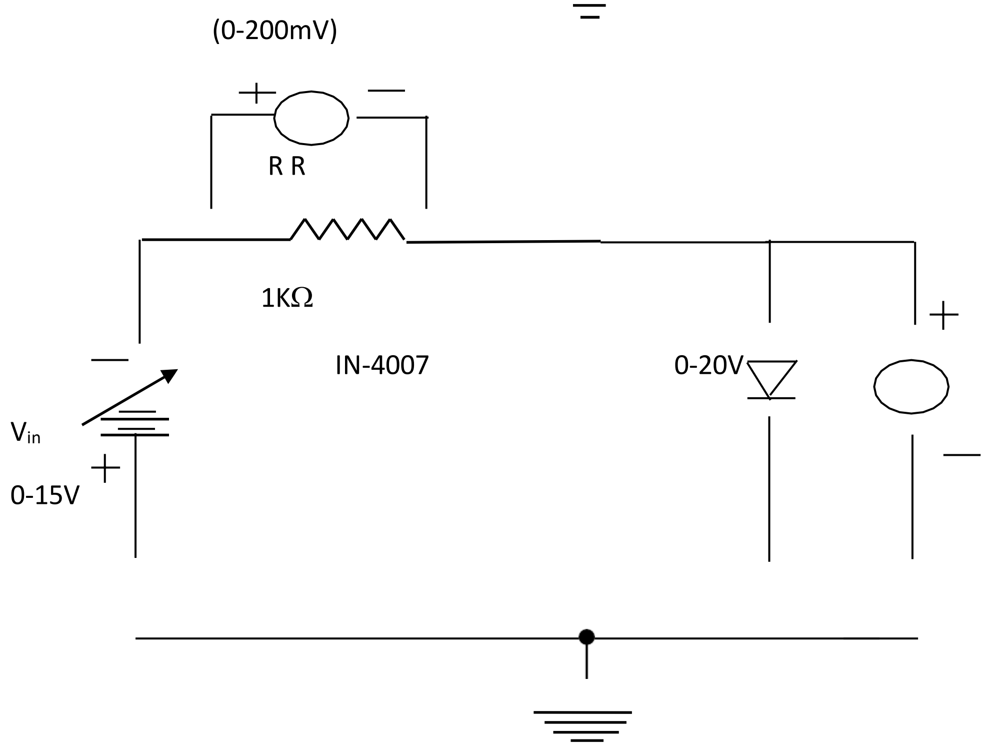


Fig (2) – Reverse Bias Condition:



<u>PROCEDURE:</u>

<u>Forward Biased Condition:</u>

Connect the circuit as shown in figure (1) using silicon PN Junction diode.

Vary V_f gradually and note down the corresponding readings of I_f.

Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e. if output variation is more, decrease input step size and vice versa).

Tabulate different forward currents obtained for different forward voltages.

Reverse Biased condition:

Connect the circuit as shown in figure (2) using silicon PN Junction diode.

Vary V_r gradually and note down the corresponding readings of I_r .

Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e. if output variation is more, decrease input step size and vice versa).

Tabulate different reverse currents obtained for different reverse voltages. ($I_r = V_R / R$, where V_R is the Voltage across 10KΩ (R)

Resistor)

OBSERVATIONS:

Si diode in forward biased conditions:

Forward Voltage across the diode V_f (volts)	Forward current through the diode I_f (mA)

Si diode in reverse biased conditions:

Reverse Voltage across the diode V_r (volts)	Reverse Voltage Across the resistor V_R (mV)	Reverse current through the diode I_r (μA)

GRAPH(Instructions):

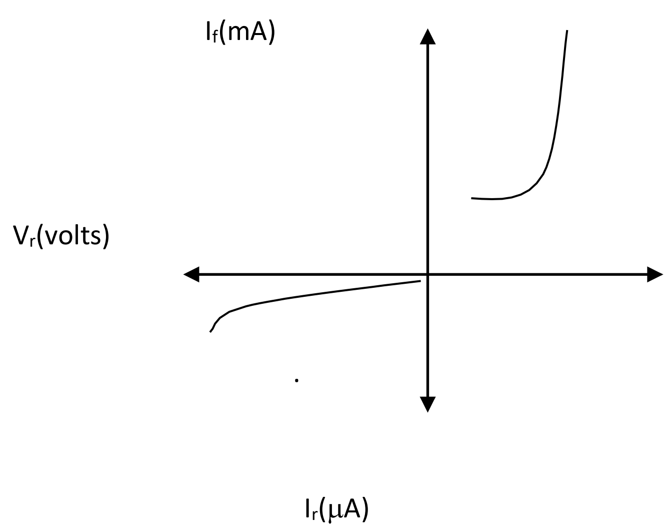
1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.

2. Now mark +ve x-axis as V_f

   -ve x-axis as V_r

   +ve y-axis as I_f

   -ve y-axis as I_r.



3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.

CALCULATIONS FROM GRAPH:

Static forward Resistance $R_{dc} = V_f/I_f\,\Omega$

Dynamic forward Resistance $r_{ac} = \Delta V_f/\Delta I_f\,\Omega$

Static Reverse Resistance $R_{dc} = V_r/I_r\,\Omega$

Dynamic Reverse Resistance $r_{ac} = \Delta V_r/\Delta I_r\,\Omega$

PRECAUTIONS:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage the diode.

2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram. 3.Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

RESULT:

1. Cut in voltage = ……… V

2. Static forward resistance =.......... Ω

3. Dynamic forward resistance =.......... Ω

VIVA QUESTIONS

1. How depletion region is formed in the PN junction?

2. What are trivalent and pentavalent impurities?

3. What is cut-in or knee voltage? Specify its value in case of Ge or Si?

4. What is maximum forward current and maximum reverse voltage? What is it required?

5. What is leakage current?

6. How does PN-junction diode acts as a switch?

7. What is the effect of temperature in the diode reverse characteristics?

8. What is break down voltage?

9. What is incremental resistance of a diode?

10. What is diode equation?

11. What is the value of V_T in the diode equation?

12. Explain the dynamic resistance of a diode?

13. Explain the phenomenon of breakdown in PN- diode?

14. What is an ideal diode? How does it differ from a real diode?

15. What are the specifications of a diode?

16. Temperature co-efficient of resistance of

(i) Metals (ii) Intrinsic semiconductor (iii) Extrinsic semiconductor

(iv) FET (v) BJT

17. What is the internal impedance of

(i) Ideal current source (ii) Ideal voltage source (iii) Ammeter

(iv) Voltmeter

18.How do you test the diode & transistor-using multimeter?

ZENER DIODE CHARACTERISTICS

Objective:

1. To plot Volt-Ampere characteristics of Zener diode.

Equipment:

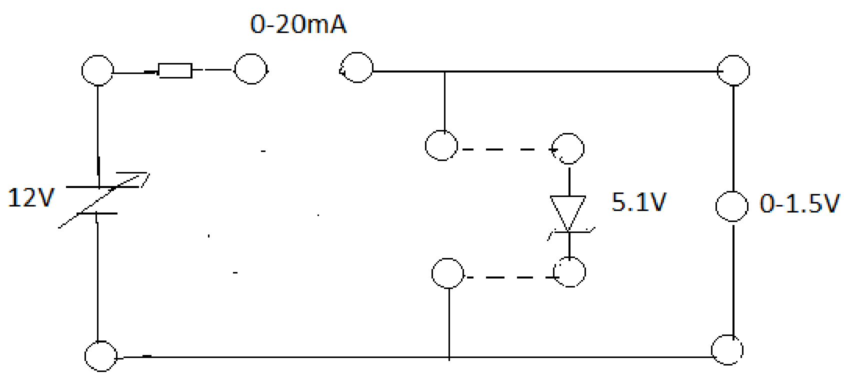
a. Zener Diode Characteristics Trainer kit
b. Manual
c. Patch cards

Theory: An ideal P-N Junction diode does not conduct in reverse biased condition. A **zener diode** conducts excellently even in reverse biased condition. These diodes operate at a precise value of voltage called break down voltage.

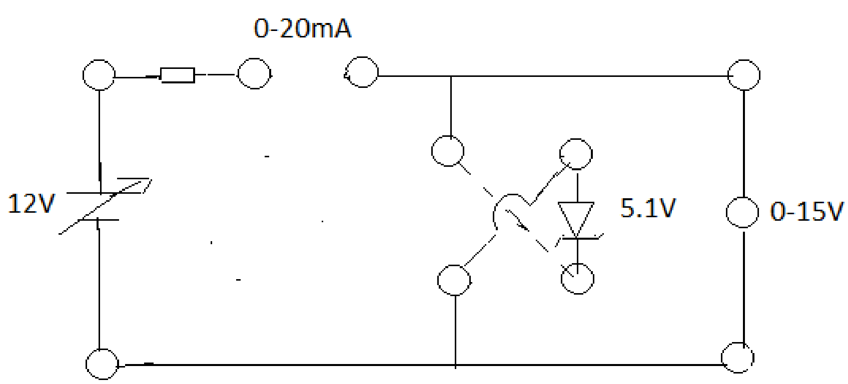
A **zener diode** when forward biased behaves like an ordinary P-N junction diode.

A **zener diode** when reverse biased can either undergo ***avalanche break down*** or ***zener break down***.

Circuit Diagram: Forward bias



Connection Diagram – Reverse Bias



Procedure:

Forward biased condition:

1. Connect the circuit as shown in fig (1).

1. Vary Vz_f gradually and note down the corresponding readings of Iz_f.
2. Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e. if output variation is more, decrease input step size and vice versa).
2. Tabulate different forward currents obtained for different forward voltages.

Reverse biased condition:

1. Connect the circuit as shown in fig (2).
2. Vary Vzr gradually and note down the corresponding readings of Izr.
3. Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e. if output variation is more, decrease input step size and vice versa).
4. Tabulate different reverse currents obtained for different reverse voltages.

Observations:

Zener diode in Forward biased condition:

Forward Voltage across the diode Vz_f (volts)	Forward current through the diode Iz_f (mA)

Zener diode in reverse biased condition:

Reverse Voltage Across diode Vzr (volts)	Reverse current through the diode Izr (mA)

Graph (Instructions):

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark +ve x-axis as V_{Zf}

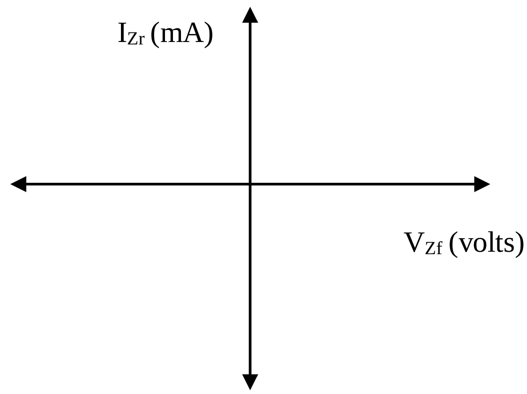
   -ve x-axis as V_{Zr}

   +ve y-axis as I_{Zf}

   -ve y-axis as I_{Zr}

3. Mark the readings tabulated for zener diode forward biased condition in first Quadrant and zener diode reverse biased condition in third Quadrant.

Calculations from Graph:



Static forward Resistance $R_{dc} = V_f/I_f$

Dynamic forward Resistance $r_{ac} = \Delta V_f/\Delta I_f$

Static Reverse Resistance $R_{dc} = V_r/I_r$

Dynamic Reverse Resistance $r_{ac} = \Delta V_r/\Delta I_r$

Result : Verifies Zener Diode Characteristics

EXPERIMENT 5
BJT-COMMON EMITTER CONFIGURATION

Objective: To study the input and output characteristics of a transistor in common emitter configuration.

Equipment:

a. Transistor Characteristics Trainer (CE) kit
b. Manual
c. Patch cards

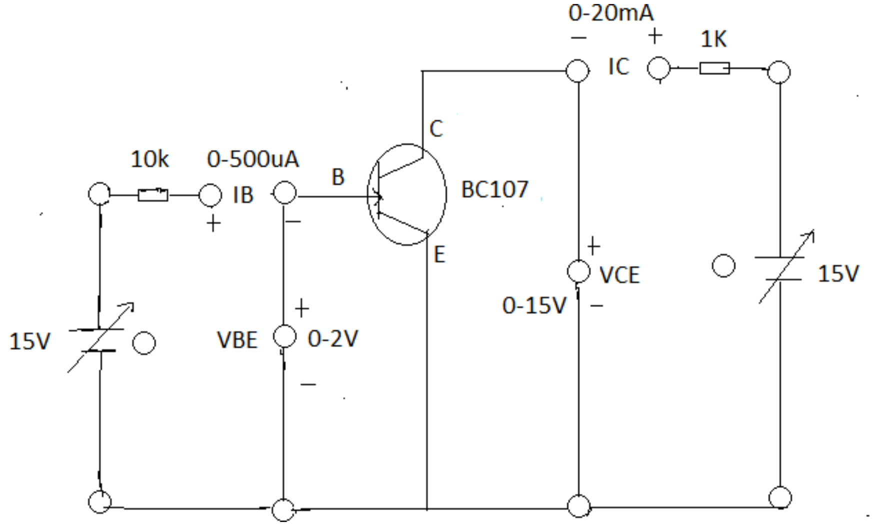
Specifications:

For Transistor **BC 107 -**

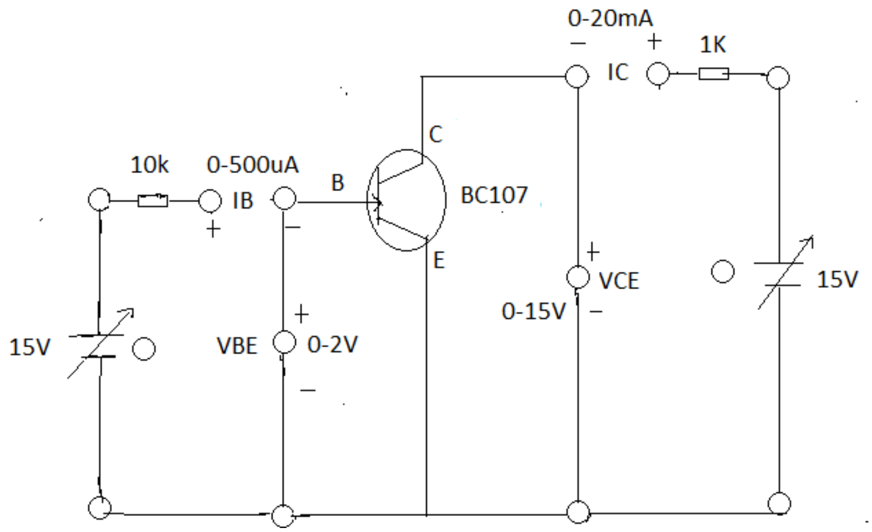
Max. Collector Current = 0.1A

$V_{CEO\ max}$ = 50

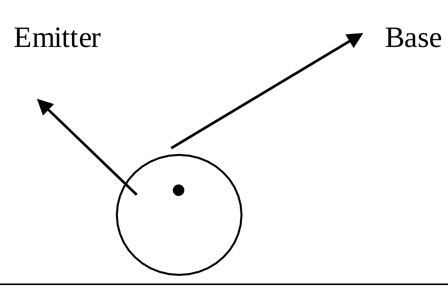
Circuit Diagram: **1) INPUT CHARACTERISTICS**

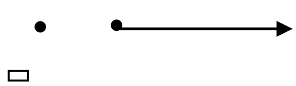


Output Chaarcteristics



Pin assignment of Transistor:





Theory: The basic circuit diagram for studying input and output characteristics are shown in fig (1) & fig (2). In this the input is applied between base and emitter and the output is taken from collector and emitter. Here emitter is common to both input and output and hence the name common emitter configuration.

Input characteristics are obtained between the input current and input voltage taking output voltage as parameter. It is plotted between V_{BE} and I_B at constant V_{CE} in CE configuration.

Output characteristics are obtained between the output voltage and output current taking input current as parameter. It is plotted between V_{CE} and I_C at constant I_B in CE configuration.

Procedure: **Input Characteristics**

1. Make the connections as per circuit diagram fig (1).
2. Keep output voltage V_{CE} = 0V by varying V_{CC}.
3. Varying V_{BB} gradually, note down both base current I_B and base - emitter voltage (V_{BE}).
4. Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e if output variation is more, decrease input step size and vice versa).
5. Repeat above procedure (step 3) for V_{CE} =5V.

Output Characteristics

1. Make the connections as per circuit diagram fig (2).
2. By varying V_{BB} keep the base current I_B = 20μA.
3. Varying V_{CC} gradually, note down the readings of collector-current (I_C) and collector-emitter voltage (V_{CE}).
4. Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e if output variation is more, decrease input step size and vice versa).
5. Repeat above procedure (step 3) for I_E=40μA.

V_{CE} = 0 V	V_{CE} = 5 V

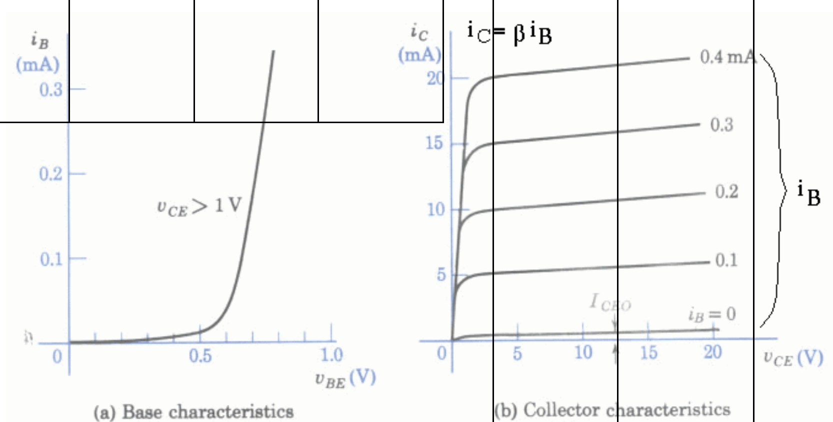
Observatio

Input Characteristics

I_B (μA)	V_{BE} (V)	I_B (μA)	V_{BE} (V)

Output Characteristic

$I_B = 20\mu A$		$I_B = 40\mu A$	
V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)



Calculations from graph:

1. **Input resistance:** To obtain input resistance find ΔV_{BE} and ΔI_B at constant V_{CE} on one of the input characteristics. Then $R_i = \Delta V_{BE} / \Delta I_B$ (V_{CE} constant)

2. **Output resistance:** To obtain output resistance, find ΔI_C and ΔV_{CE} at constant I_B.

   $R_o = \Delta V_{CE} / \Delta I_C$ (I_B constant)

Result: Verified Input & out put characteristics of Transsitor in CE Configuration.

EXPERIMENT 6(a)

LIGHT EMITTING DIODE

AIM : To study of V/ I (Electrical) characteristics and L/ I (optical) characteristics ofLight Emitting Diode.

APPRATURS :

Mikron /Micro Light emitting Diode Characteristics board comprising of:

1. *Light emitting diode*
2. *0-5V variable Supply for Light emitting diode*
3. *20mW Digital Optical power meter to measure optical power of Light emittingdiode*
4. *20V Digital Voltmeter to measure voltage across Light emitting diode*
5. *200mA DC Digital Ammeter to measure Light emitting diode Current*

THEORY: -

When a PN junction diode is forward biased , the potential barrier is lowered and themajority charge carriers start crossing the junction. A PN junction diode, which emitslight on forward biasing, is known as light emitting diode. The emitted light may be inthe visible range or invisible range and the intensity of light depends on the applied potential.

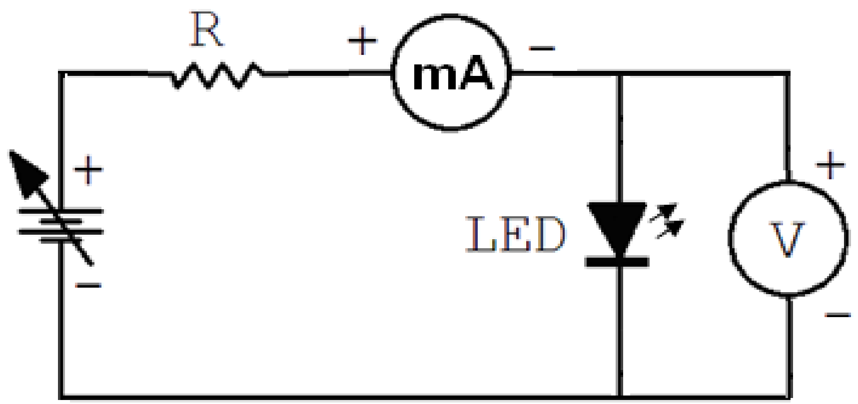
PRINCIPLE: -

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-sidewhile holes are in the valence band on the p-side. The conduction band has a higher energy level compared to the valence band and so when the electrons recombine with ahole the difference in energy is given out in the form of heat or light. In case of silicon orgermanium, 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. But this light is in the invisibleregion & so these materials cannot be used in the manufacture of LED. Hence gallium –arsenide phosphide which emits light in the visible region is used to manufacture an LED.

CONSTRUCTION: -

An n-type layer is grown on a substance and a p-type layer is grown over it bydiffusionprocess. The P-layer is kept at the top because carrier recombination takes place in it. The terminals anode and cathode are taken out of the n-layer and P-layer respectively. The anode connections are made at the edge in order to provide more surface area for the emission of light. A metal film is applied to the bottom of substance to reflect light to the surface of the device and also to provide connection for the cathode terminal. Finally the structure are provided with an encapsulated (cover) to protect them from destruction.

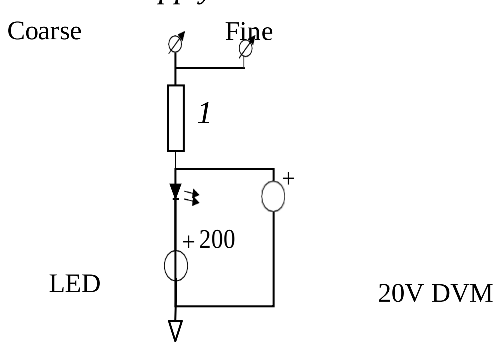
CIRCUIT DIAGRAM:



Procedure for V/I characteristics of a Light emitting diode:

1. *Connect the Light emitting diode circuit as shown below*
2. *Slowly increase supply voltage using variable Power supply using coarse and fineknobs.*
3. *Note down current through the Light emitting diode at increasing values of Lightemitting diode voltage of 0.5V, 1.0V, 1.5V, 2.5 V.*
4. *Do not exceed current limit of 30mA else the Light emitting diode may get damaged.*
5. *Plot a graph of Light emitting diode voltage Vs Light emitting diode current .0-5V*

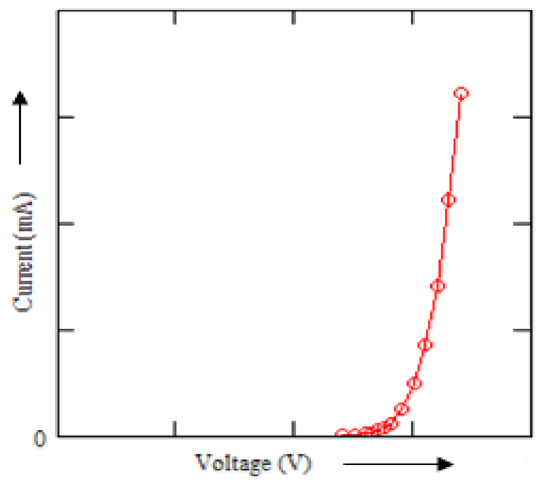
Variable Supply



TABULAR FORM FOR V/I CHARACRISTICS :

S.No	*Voltage in (mV)*	*Current in (mA)*

MODEL GRAPH:

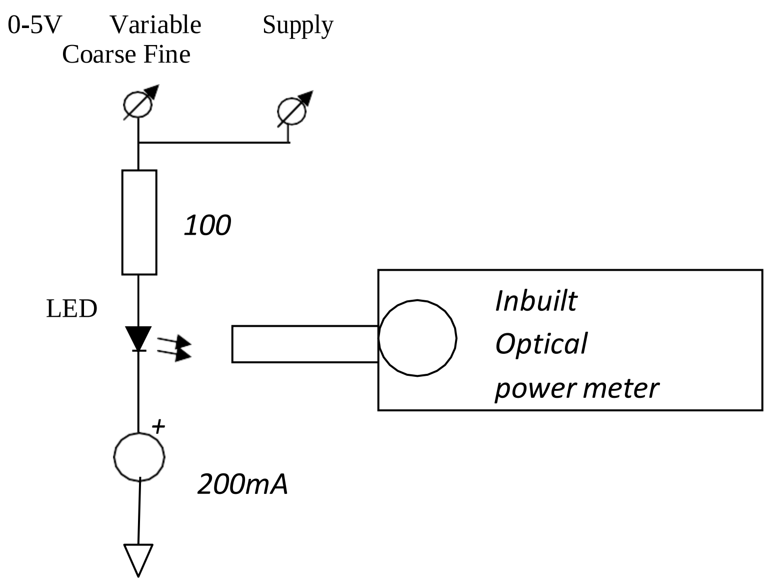


Procedure for L/I characteristics of a Light emitting diode:

1. *Connect the Light emitting diode circuit as shown below:*

2. *Slowly increase supply voltage using variable Power supply coarse and fine knobs.*

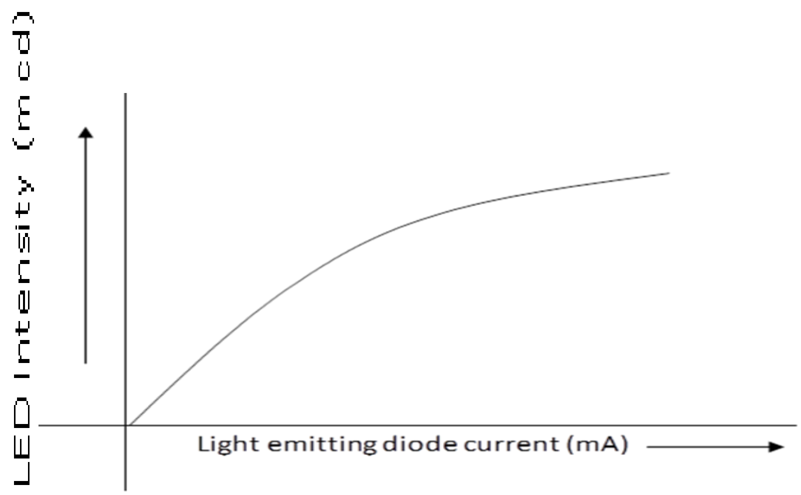
3. *Note down the optical power measured by the optical power meter in mW at increasing current through the Light emitting diode of 1mA to 20 mA at 1 mA step.*
4. *Do not exceed current limit of 30mA else the Light emitting diode may get damaged.*
5. *Plot a graph of Light emitting diode intensity V/s Light emitting diode current asshown in figure2*



TABULAR FORM:

S.NO	*Current in (mA)*	*Power in (mcd)*

MODEL GRAPH :



PRECAUSTIONS:

1. *1 Make sure that the connections are tight.*
2. *After the completion of experiment switch off the power supply.*
3. *Avoid parallax error*

RESULT :

We studied V/ I (Electrical) characteristics and L/ I (optical) characteristics of Light Emitting Diode.

VIVA QUESTIONS:

1. *How LED is fabricated?*
2. *What is a Lighting Emitting Diode and how it works?*
3. *What if LED?*
4. *What happens when LED in reverse biased?*
5. *what material is used in LED manufacture?*
6. *What are the characteristics of LED?*
7. *What symbol we use for Light Emitting Diode?*
8. *what is the difference between ordinary diode and Led?*
9. *What are the I-V Characteristics Light Emitting Diodes*

EXPERIMENT 6(b)

SOLAR CELL

AIM:

To study the characteristics of a Solar cell

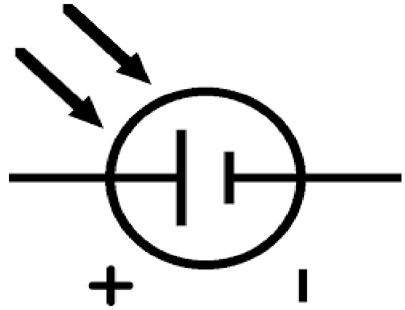
APPARATUS:

Trainer board, solar cell, source of light and patch cords

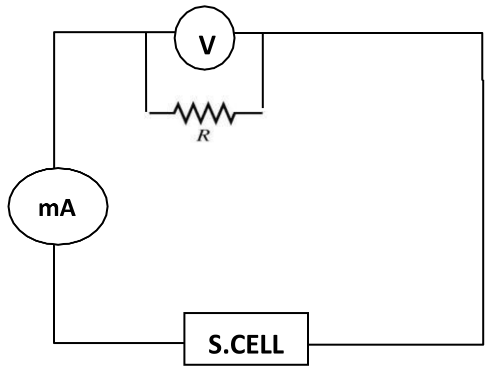
THEORY:

Solar cell is basically a PN junction diode which converts light energy into electrical energy. When a p-n junction diode IS exposed to light, photons are absorbed and electron hole pairs are generated in both the p-side and n-side of the junction. The electron-hole pairs are then separated by the strong barrier field that exists across the junction. The electron in the p-side slide down the barrier potential and move to the n- side while the holes in the n-side move towards the p-side. The accumulation of electrons and holes on the two sides of the junction gives rise to open circuit voltage when the diode is open circuited. If a resistance is connected across the diode, current flows in the circuit. This current flows as long as the diode is exposed to sunlight and the magnitude of the current is proportional to the light intensity.

SYMBOL OF SOLAR CELL:



CIRCUIT DIAGRAM :



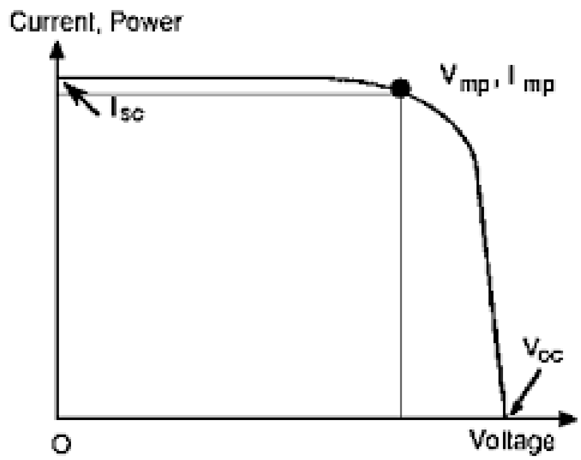
PROCEDURE:

1. Connect 10k Ohms between the (-) and (+) terminals of the solar cell.
2. Focus bright light on the solar cell.
3. Measure the voltage between the terminals of the solar cell and also the current through the resistance.
4. Repeat steps 2 & 3 for different values of the resistors provided on the trainer.
5. Note the effect of increased resistance in series with the solar cell.
6. Plot graph with voltage on X-axis and current on Y-axis

OBSERVATION TABLE:

S.No.	For R = Ω		For R = Ω	
	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)

MODEL GRAPH:



PRECAUTIONS:

1. Make the connections properly.
2. Make sure that the solar cell is properly biased while connecting in the circuit.

RESULT:

The V-I characteristics of solar cell is obtained practically.

VIVA VOICE QUESTIONS:

1. What is a solar cell?
2. What is the working principle of solar cell?
3. What is open circuit voltage and short circuit current?

1. Expected Value or Theoretical Values
2. Achieved Value or Experimental Value
3. Error Value
4. Reasons For Error

5. Suggestions For Error

EXPERIMENT 7

ENERGY GAP OF THE MATERIAL OF P-N JUNCTION

AIM:

To determine the energy band gap of a junction diode

EQUIPMENT & COMPONETS

1. D.C. Power supply -1 (0-15V)
2. Junction diode -1 (Germanium or Silicon)
3. Thermometer -1
4. Heating arrangement to heat the diode-1
5. Voltmeter -1 (0-10V)
6. Micro-ammeter -1(0-100 μA)

FORMULA

Eg = slope of the straight line (m) /5.036 e V

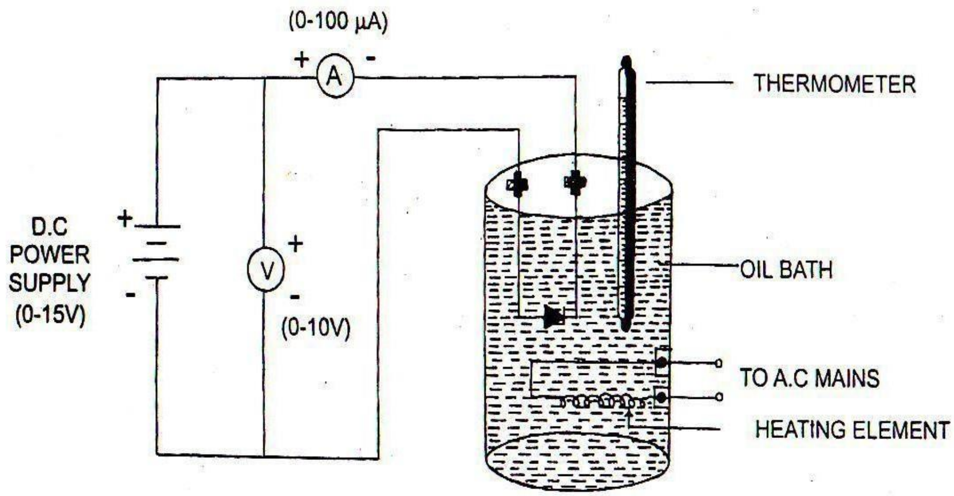
Where Eg = energy band gap of the given semiconductor diode

m = slope of the straight line plot obtained for log10 Is and 10^3/ T

Where Is = reverse saturation current (μA) T = absolute temperature (K)

DESCRIPTION

The experimental arrangement comprises an oil bath which is provided with sockets at its mouth. The sockets are used to insert the to insert the thermometer and the semiconductor diode in the oil bath as shown in the fig.5.1. A heating element is fixed inside the oil bath which is used to raise the temperature of the oil bath by connecting to the A.C. main supply. The reverse biasing voltage can be adjusted by means of the voltmeter and the reverse saturation current can be measured with the help of a micro- ammeter.



PROCEDURE

1. Identify the anode and cathode terminals of the given junction diode.
2. Connect the two terminals of the given junction diode (German or silicon) to the
   D.C. power supply and micro ammeter in such a way that the
   diode is reverse biased.
3. Immerse the diode in the oil bath.
4. Insert the thermometer in the oil bath at the same level as that of the diode.
5. Switch ON the D.C. power supply and adjust the reverse bias voltage to 5 volt.
6. Switch ON the A.C. main supply, then the temperature of the oil bath gradually increases. Consequently, the current through the diode also increases.
7. When the temperature of the oil bath reaches to about 65°C, then switch OFF the
   A.C supply . Stir the oil by means of a stirrer.
8. Consequently, the temperature of the oil bath will rise and stabilizes at about 70°C.
9. Note down the temperature of the oil bath and the current through the diode.
10. After few minutes, the temperature of the oil bath will begin to fall and the current through the diode decreases.
11. Note down the value of the current for every 5°C decrease of the temperature, the temperature of the oil bath falls to the room temperature.
12. Note down the observations in table

Note:

1. When the Germanium diode is employed in the experiment, the temperature should not be increased beyond 80°C. This is because at higher temperatures, the Fermi level moves towards the centre of the forbidden energy gap and the junction

properties are destroyed.

2. When silicon diode is employed, then the temperature should not exceed 200°C.

GRAPH

1. Draw a graph with 10^3 / T on X-axis and log10 Is on Y-axis.
2. The graph will be a straight line as shown in the fig.
3. Find the slope of the straight line, m from the graph.
4. Calculate the energy band gap of the given junction diode by substituting the value of the slope(m) in equation 5.1.
5. Compare the calculated value of Eg, with the standard value.

Note:

This experiment can also be performed for different reverse biasing voltages

OBSERVATIONS:

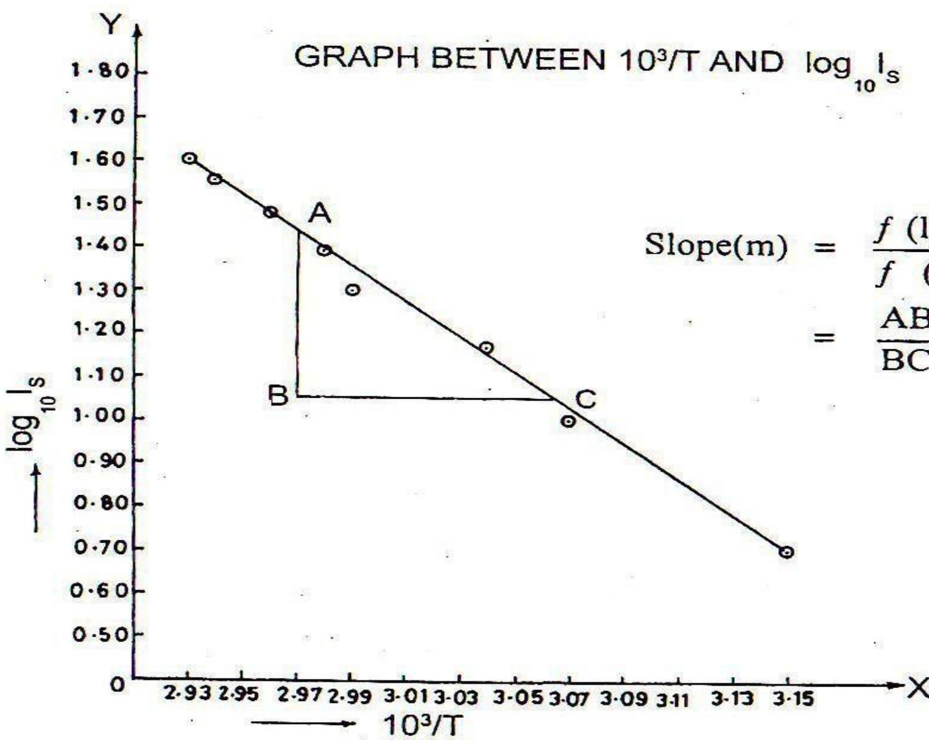


Fig. 5.2

To determine the reverse saturation current at

different temperatures Type of the diode:

Biasing voltage = 5 volt **Room temperature =**

S.NO	Temperature		Current Is (μA)	10^3 /T (k-1)	$\log_{10}$ Is
	T (°C)	T=t+273 ((K)			
1	55				
2	50				
3	45				
4	40				
5	35				

CALCULATIONS:

$$\text{Slope of the straight line,} \quad m = \frac{f\ (\log_{10} I_S)}{f\ (10^3\ /T)} = \frac{AB}{BC} =$$

$$\therefore\ E_g = \frac{\text{Slope of the straight line.}\ (m)}{5.036}$$

$$= \qquad \text{eV.}$$

PRECAUTIONS:

1. The diode and the thermometer should be immersed at the same level in the oil bath.
2. The temperature and the current should be noted simultaneously.
3. This experiment should be performed by connecting the reverse biased position.

RESULT:

The energy band gap of the given semiconductor material is =................eV

VIVA QUESTIONS:

1. What is Forbidden energy gap?
2. What are intrinsic and extrinsic semiconductors?
3. Why do we prefer semiconductors to conductors when conductors have got better conductivity?
4. What is positive temperature coefficient and negative temperature coefficient?

1. Expected Value or Theoretical Values
2. Achieved Value or Experimental Value
3. Error Value
4. Reasons For Error
5. Suggestions For Error

EXPERIMENT 8

TWO PROBE METHOD

Aim: Two Probe Method for the Resistivity Measurement of High Resistive Samples (near Insulators) at Different Temperatures.

INTRODUCTION

Electrical Resistivity of Materials and its dependence on temperature is one of the most important characterstic of materials. It provides important information about its structure and possible use in various applications in the field of engineering and technology. The present set-up is designed to measure the resistivity of highly resistive materials (near insulators).

BRIEF DESCRIPTION OF THE APPARATUS

1. Probe Arrangement

It has two spring loaded probes. These probes move in pipes and are insulated by teflon bushs, which ensure a good electrical insulation. The probe arrangement is mounted in a suitable stand, which also holds the sample plate and RTD sensor. The RTD is mounted in the sample plates such that it is just below the sample, separated by a very thin sheet of mica. This ensures the correct measurement of sample temperature. This stand also serves as a lidof the oven. The leads are provided for connecting the RTD to the controller, and sample tothe voltage source and ammeter.

2. PID Controlled Oven

This is high quality temperature controlled oven suitable for the Two Probe set-up. The oven has been designed for fast heating and cooling rates, which enhances the effectiveness of the controller. While the basic design of the controller is around the PID configuration for its obvious advantages, wastage of power is avoided by using a Pulse Width Modulated (PMW) switch. This combination has the advantages of both on-off controller and linear PIDcontroller. The result is a good stable and accurate temperature control.

Platinum RTD has been used for sensing the temperature. A wheatstone bridge and an instrumentation amplifier are used for signal conditioning. Feedback circuit ensures offset and linearity trimming to a great degree of accuracy. The set and measured temperatures aredisplayed on 3½ digits DPM through selector switch.

Specifications of the Oven

Temperature range	: Ambient to 200 °C
Resolution	: 0.1°C
Short Range stability	: ± 0.2°C
Long Range stability	: ± 0.5°C
Measurement accuracy	: ± 0.5°C (typical)
Oven	: Specially designed for Two Probe Set-Up
Sensor	: RTD
Display	: 3½ digit, 7 segment LED with auto polarity and decimal indication
Input mains	: 220V ±10%, 50Hz
Power	: 150W

Controls

(1) DPM would display the actual reading.

(2) ON/OFF the oven by using switch.

(3) DPM - display the temperature in SET or MEASURE mode in Celsius

(4) TEMPERATURE CONTROL - this is to set the oven at desired temperature.

3. High Voltage Power Supply

This is a fully solid state power supply designed to meet the power requirements ofbroad range of applications.

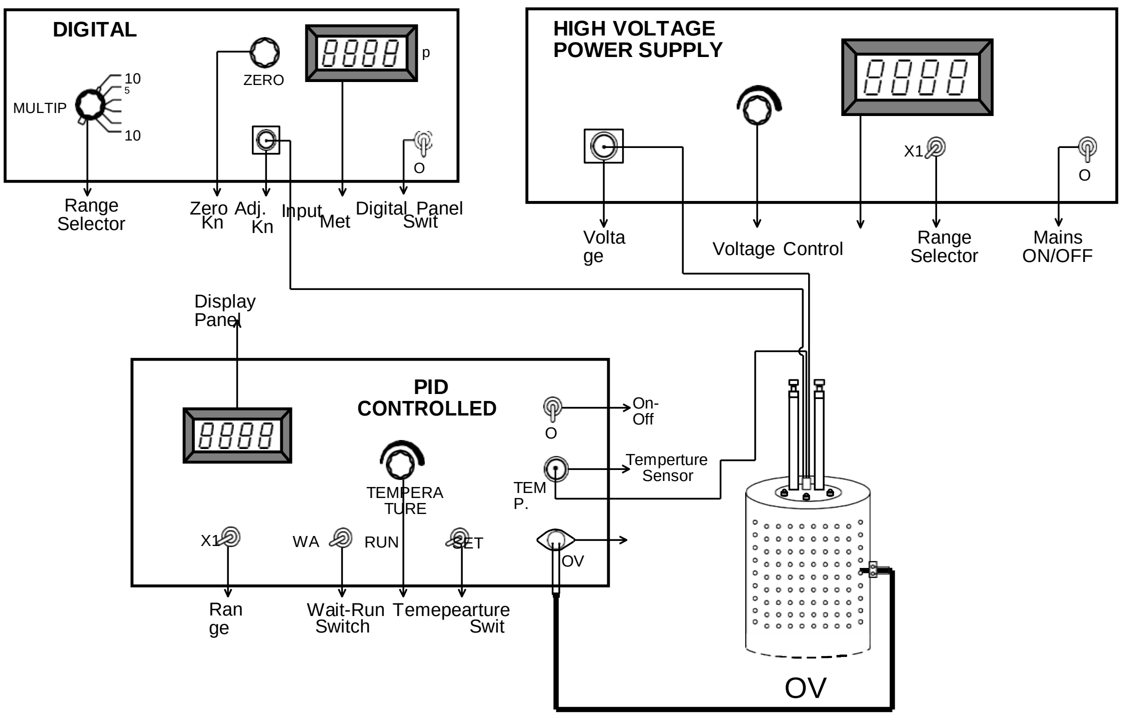
Output	: 0 - 200 V continuously adjustable
Current	: 1 mA (max.)
Polarity	: Negative
Regulation	: 0.5 C
Display	: 3½ digit 7 segment LCD with autopolarity
Input mains	: 220V ±10%, 50Hz

For detailed specifications, and operational instructions please see our manual on 'HighVoltage Power Supply.

4. Digital Picoammter

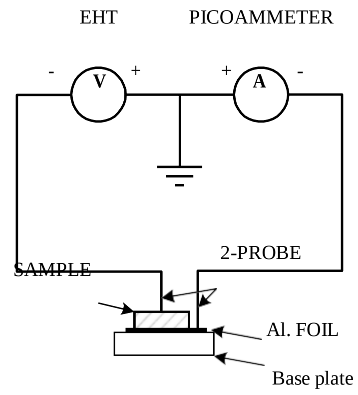
This is very versatile and general purpose instrument. The unit is specially suited forthe measurement of current down to 1 pA.

Multiplier	: x1, x10, $x10^2$, $x10^3$, $x10^4$, $x10^5$
Accuracy	: 0.2% for all ranges
Resolution	: 1pA, 10pA, 100pA, 1nA, 10nA, 100nA
Input resistance	: 2.5K, 0.25K, 25, 2.5, 0.25, 0.025
Display	: 3½ digit 7 segment LED (12.5mm height) with auto polarity and decimal indication
Input mains	: 220V ±10%, 50Hz



DIGITAL
MULTIP
10
5
10
ZERO
p
O
Range Selector
Zero Kn
Adj. Kn
Input
Met
Digital Panel Swit
HIGH VOLTAGE POWER SUPPLY
X1
O
Volta ge
Voltage Control
Range Selector
Mains ON/OFF
Display Panel
PID CONTROLLED
O
On-Off
TEMPERA TURE
TEM P.
Temperture Sensor
X1
WA
RUN
SET
OV
Ran ge
Wait-Run Switch
Temepearture Swit
OV

EXPERIMENTAL PROCEDURES



SCHEMATIC

1. Put a small piece of Al foil on the base plate. Pull the spring loaded probes upward, insert the Aluminium foil and let them rest on it. Put the sample on the foil. Again pull the top of one of the probe and insert the sample below it and let it rest on it gently. Now one of the probes would be in contact with upper surface of the sample, while the other would be with lower surface through Al foil.
2. Connect the leads with amphenol connectors to EHT and Digital Picoammeter.
3. Switch "ON" the EHT and Digital Picoammeter. Please make sure that the EHT is at the 000 position and DigitalPicoammeter at X10^5 range before these instruments are switched "ON".
4. Increase the voltage slowly to say 10V and switch the Digital Picoammeter to more sensitive range till some reading is obtained.
5. In case, there is small reading even at most sensitive range. Increase the voltage of EHT gradually and take the corresponding readings of current and check for ohm's law $\left(\frac{V}{I} = R\right)$. This would ensure that the system is working properly.
6. Calculate the resistivity of the sample using the resistance and the sample dimensions. The resistivity (ρ) is given by the formula $\rho = R*A/L$, where A is the cross-sectional area of the sample and L is the length of the sample.
7. For taking the reading at different temperature settings, PID Controlled Oven should be used.
8. Set the PID Controlled oven PID-200 as follows :
   (i) Connect the RTD sensor's 2-pin socket of Two Probe Arrangement and the oven socket to the PID Controller.
   (ii) Switch 'ON' the mains power. Allow about 5 minutes time to stabilize the circuit. The panel meter would read ambient temperature.
   (iii) The panel meter would readthe previously SET temperature, which could be changed to a desired value with the help of TEMPERATURE CONTROL pad provided.
   (iv) Switch on the oven and bring the digital panel meter in MEASURING MODE. Now the meter would display the oven temperature after approximately 1-2 cycles of over shoot andunder shoot.
   (v) Set temperature may be checked any time which is visible in the PID (temperature) display.
   (vi) In case the temp is set at 200° C, switch the RANGE switch to X10 range whenthe display in DPM starts going out of range.

9. To save time, it is recommended to under adjust the ‘Set Temp.” For example, if it is desired to set 90 °C, adjust the ‘SET TEMP’ at 82 °C. the temperature would continue to rise due thermal inertia of oven. When it reaches 90 °C or near about, adjust the ‘SET TEMP’ at 90 °C. It may go up 1 & 2 °C, but would settle down to 90 °C. Since the change in temperature at this stage is very slow and response of RTD and samples is fast, the reading can be taken corresponding to any temperature without waiting for a steady state.

OBSERVATION & CALCULATION

Sr. No.	**Temperature (°C)**	**Voltage (volts)**	**Current (A)**	$\rho = R*A/L$, **(ohm)**

Where R= V/I, L = 26 mm , r = 3.5 mm and Area (A) = $A = \pi*r^2$

PRECAUTIONS

1. The Set-up is designed for high resistance (MΩ to 10^6 MΩ), measurement of low resistance (<MΩ) should be avoided.
2. Keep the Picoammeter range at 10^5 and increase its sensitivity as required to get a reading of about 1000. In case required this may be obtained by increasing the Voltage across the sample.
3. For resistive samples such as ceramics, it is advisable to coat both the surface by a conducting paint.
4. Short circuit and sample break-down should be avoided. As it may damage the Picoammeter, which is meant for very low current

EXPERIMENT 9

B-H CURVE OF A MAGNETIC MATERIAL

Aim: To determine Hysteresis loop for a ferromagnetic material (B-H curve).

Apparatus: Two solenoid coils, S and C, ferromagnetic specimen rod, reversible key (R), ammeter, magnetometer, battery, solenoid, rheostat and transformer for demagnetizing set up.

Theory:

A ferromagnetic rod is magnetized by placing it in the magnetic field of a solenoid. The magnetized rod causes a deflection ( ) in a magnetometer. The deflection is recorded as the current in the solenoid (I) is varied over a range of positive and negative values.

Hysteresis:

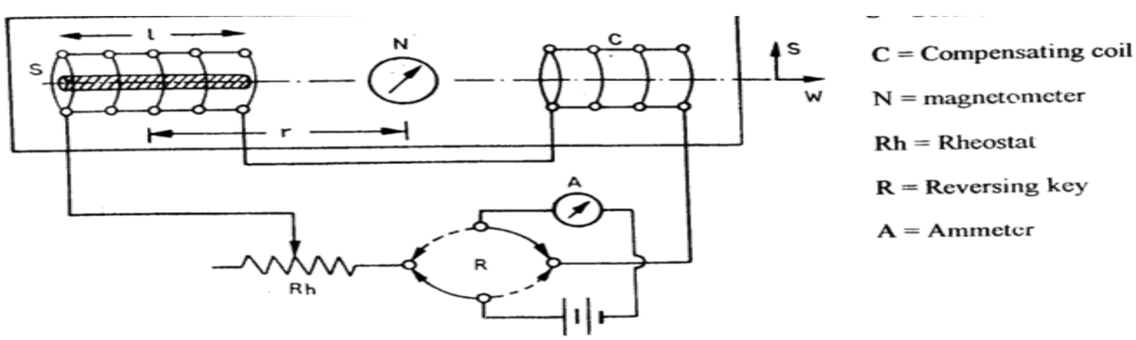
Hysteresis means “remaining” in Greek, an effect remains after its cause has disappeared. Hysteresis, a term coined by Sir James Alfred Ewing in 1881, a Scottish physicist and engineer (1855-1935), defined it as: When there are two physical quantities M and N such that cyclic variations of N cause cyclic variations of M, then if the changes of M lag behind those of N, we may say that there is hysteresis in the relation of M to N. The most notable example of hysteresis in physics is magnetism. Iron maintains some magnetization after it has been exposed to and removed from a magnetic field.

Magnetic Hysteresis Consider a magnetic material being subjected to a cycle of magnetization. The graph intensity of magnetization (M) vs. magnetizing field (H) gives a closed curve called M-H loop

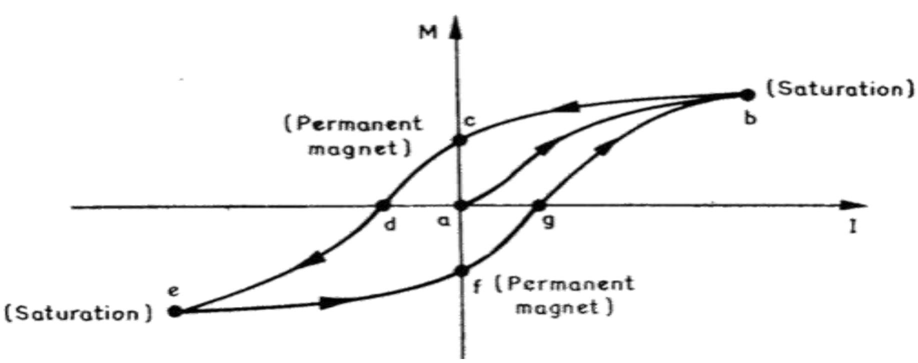
Hysteresis Loop:

An initially un magnetized material is subjected to a cycle of magnetization. The values of intensity of magnetization M and the magnetizing field H are calculated at every stage and a closed loop is obtained on plotting a graph between M and H as shown in the figure. The point O represents the initial un magnetized condition of the material. As the applied field is increased, the magnetization increases to the saturation point A along OA. As the applied field is reduced, the loop follows the path AB. OB represents the intensity of magnetization remaining in the material when the applied field is reduced to zero. This is called the residual magnetism or remanence. The property of retaining some magnetism on removing the magnetic field is called retentivity. OC represents the magnetizing field to be applied in the opposite direction to remove residual magnetism. This is called coercive field and the property is called coercivity. When the field is further increased in the reverse direction the material reaches negative saturation point D. When the field is increased in positive direction, the curve follows path DEF.

CIRCUIT DIAGRAM:



GRAPH



Procedure:

1. Complete the wiring of the apparatus according to the circuit diagram

2. Alignment of apparatus:

Rotate the dial of the magnetometer until ± position is aligned with the axis of the solenoid. Rotate the wooden arm, containing the solenoid, magnetometer and compensating coil, until the magnetic pointer coincides with the 00 ± 00 positions. In this position the wooden arm is along the E ± W position. The horizontal component of earth‟s magnetic field BE (along S-N direction) is then perpendicular to the wooden arm.

3. Begin Measurements:

i). To begin with, the current in the solenoid should be switched off.

ii). Insert specimen rod so that it' s leading tip is at the edge of the solenoid. Note: There should be no deflection of the needle at this point. If deflection is observed, repeat step 3 for demagnetizing rod).

(iii). Keep the reversing key R in a position so that current flows in a given direction. The rheostat position should correspond to maximum resistance

iv). Switch on the current.

v). Vary the current using the rheostat from 0A ± 1.5A and back 1.5A ± 0A in steps of 0.1A and note the deflections 1&2 for each setting of current.

vi). Reverse the position of the reversible key R and vary the current in the reverse direction 0A ± 1.5A, and back 1.5A ± 0A.

vii). Reverse the position of the key R and vary the current from 0 ± 1.5A. Again, note the deflections 1&2

iv). Switch on the current. v). Vary the current using the rheostat from 0A ± 1.5A and back 1.5A ± 0A in steps of 0.1A and note the deflections 1&2 for each setting of current. vi). Reverse the position of the reversible key R and vary the current in the reverse direction 0A ± 1.5A, and back 1.5A ± 0A. vii). Reverse the position of the key R and vary the current from 0 ± 1.5A. Again, note the deflections 1&2

Observations:

1. Distance, r =______________________________m

2. Length of specimen, l =_____________________m

3. No. of turns per unit length of solenoid, n = 1600 turns/m

4. Area of cross-section of rod, S = 1.84 x $10^{-5} m^2$

5. Horizontal component of earth's magnetic field, BE = 3.53 x 10^{-5} T.

Sr. No	Area of B-H loop in term of no. of small square inside the loop (a	Lag a	B max	Log B max
1.				
2.				
3.				
4				

Calculations:

1. Attach graph of Tan vs. I.

2. cf = ________________________

dg = ________________________

3. Calculation of retentivity MO:

Calculation of coercivity BO:

Precautions:

1. All connection should be as per diagram, proper and tight.

2. B-H loop should be clear.

3. CRO should be operated carefully.

4. Knob of horizontal and vertical gains should not be disturbed throughout the experiment.

5. Ac supply should be switched on while taking the observation else it should be switched off.

Results:

Retentivity MO = _________________

Coercivity BO = __________________

EXPERIMENT 10

DIELECTRIC CONSTANT OF A GIVEN MATERIAL

Aim : Measurement of Dielectric Constant of different materials

Apparatus : Dielectric Constant Measurement Trainer (Nvis 6111)

Items Required :

1. Solid Samples
2. Mains Cord
3. Patch Cord

Procedure:

1. Connect the Mains Cord to the trainer & switch ‘On’ the rocker switch.
2. Now rotate the variable resistance knob fully in clockwise direction.
3. Connect variable capacitor to RF output on the trainer.
4. Change the value of capacitance for which maximum value of current is obtained that is the condition of resonance.
5. Note the value of capacitance. Let it be C1.
6. Place the dielectric sample between the plates of test capacitor such that the dielectric sample just touches both the plats with the help of adjusting screw.
7. Now connect the Test Capacitor with dielectric sample with the help of patch cords across the Test Capacitor (marked) on the trainer.
8. Now reduce the value of variable capacitor to obtain the condition of resonance.
9. Note the value of capacitance. Let it be C2.

10. Subtract C1and C2 to determine the value of test capacitance that is C here.

11. Now carefully remove the dielectric material from the test capacitor without changing the distance between the plates.

12. Now determine the distance between both the plates. Note: Take the help of vernier caliper for better result.

13. Determine the value of area of any one plate of test capacitor that is A by using the formula (Length x Breath)

14. Now calculate the value of Dielectric Constant of given material by following formula

15. Repeat the whole experiment for determining the dielectric constant of different material

Where, C=

K = Dielectric Constant

A = Area of plate

d = Distance between two plates

C = Capacitance

Permittivity of free space its value is $\varepsilon_0 = 8.854\times10^{-12}$ F m^{-1}

15. Repeat the whole experiment for determining the dielectric constant of different material.

Observations:

1) Length of plate, l = 134 mm

2) Breath of plate, b = 61mm

3) Area of plates, A = l x b =

4) Distance between both plates for glass dg = 3.1 mm

5) Distance between both plates for Bakelite dB = 6.5 mm

6) Distance between both plates for Teflon dT = 2.8 mm

Observation Table:

Sr No.	Sample	C1 (pF)	C2 (pF)	C = C1 – C2 (pF)
1	Glass			Cg =
2	Bakelite			CB =
3	Teflon			CT =

Calculations:

1. Dielectric constant of glass:

2. Dielectric constant of Bakelite:

3. Dielectric constant of Teflon:

Result:

Dielectric constant of Glass is.......... ,

Dielectric constant of Bakelite is ...., and

Dielectric constant of Teflon is ....

EXPERIMENT 11

NUMERICAL APERTURE

AIM : To determine the numerical aperture (NA) of the given optical fiber.

APPARATUS : One or two meters of the step index fiber, Fiber optics kit, and scale.

THEORY : The numerical aperture of an optical fiber is a measure of the light collected by it. It is defined as the product of the refractive index of the surrounding medium and the Sine of the maximum ray angle (acceptance angle)

Numerical aperture (NA) = $n_0 \sin\theta_a$ --(1)

For air as surrounding medium $n_o = 1$

And NA = Sinθ_a --------------------------**(2)**

For a step index fiber, NA is given by

NA = $[n_{1-}\ n_2]^{1/2}$ --------------- (3)

Where n_1 and n_2 are refractive indices of core and cladding materials.

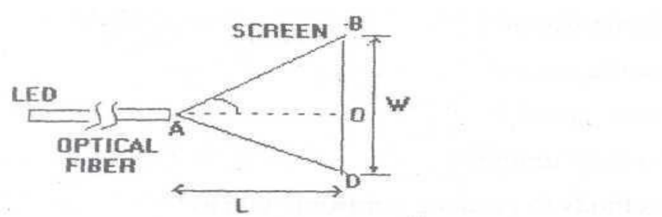


FIG. 1

Light from the fiber end ' A ' falls on the screen BD. Let the diameter of the light falling on the screen BD = w (Fig. 1)

Let the distance between the fiber and the screen AO = L From the triangle AOB

$\sin\theta_a = OB/AB$

$= OB / (OA^2 + OB^2)^{1/2}$

$= (w/2) / (L^2 + w^2 / 4)^{1/2}$

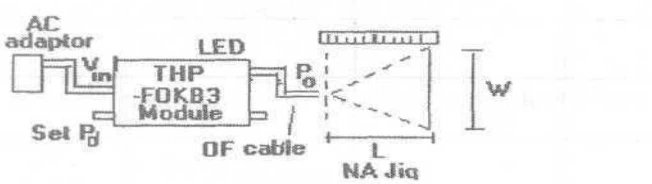
$\sin\theta_a = w / (4L^2 + w^2)^{½}$

NA = Sinθ$_a$ = w/ (4L^2 + w^2)$^{1/2}$ .... (4)

Knowing w and L, the NA can be calculated and substituting this NA value in equation (2) the acceptance angleθ_a can be calculated.

PROCEDURE:

To determine the NA of a optic fiber (OF) make the connection as shown in the fig.2



N A Measurement Set Up :

1. Connect one end of the OF cable to Po and another end to the NA jig (i.e. Landing o/p of LED into OF cable).
2. Connect power adapter into socket V_{in} and plug the AC mains. Red light should appear at the end of the fiber on the NA jig. To set maximum output turn the SET Po/IF Knob clockwise. The red light intensity should increase.
3. Hold the acrylic white screen which has printed scale at a distance of 10 mm (L) from the emitting fiber end and you will view the red spot on the screen. Measure the diameter w of the spot.
4. If the intensity within the spot is not evenly distributed, wind three turns of the fiber on the mandrel. Substitute the measured values L and w in the formula

$$NA = \sin\theta_a = w/(4L^2 + w^2)^{1/2}$$

And calculate the value of the numerical aperture of the fiber.

Repeat the experiment for the distances of 15mm, 20 mm, 25 mm and 30 mm

And note the readings in table.

TABULAR COLUMN:

Sl.No	L (mm)	W (mm)	NA	θ_a (Degrees)
1				
2				
3				
4				
5				

RESULT: Numerical Aperture NA =

MODEL VIVA QUESTIONS:-

1. What is the principal involved in the propagation of light in the optical fibers? Explain.
2. Explain the physical significance of the numerical aperture.
3. Define the core and cladding? Explain the role of the core and cladding in the optical fiber communications.
4. What is optical fiber?
5. What is the reflection and refraction?
6. Define the band width of optical fiber.
7. Why optical fiber is suitable for communication?
8. What is the significance of cladding in optical fibers?
9. How does the fiber core diameter influence the NA?
10. Explain total internal reflection.

EXPERIMENT 12

Torsional pendulum

AIM : To determine the rigidity modulus (n) of the given wire using torsional pendulum.

APPARATUS : A circular disk provided with chuck nut (Torsional pendulum), steel wire, stop watch, screw gauge, vernier calipers and meter scale.

THEORY : A torsional pendulum is a flat disk, suspended horizontally by a wire attached at the top of the fixed support.

When the disk is tuned through a small angle, the wire is twisted. On being released the disk performs torsional oscillations about the axis performs torsional oscillations about the axis of the support. The twist wire will exert a torque on the disk tending to return it to the original position. This is restoring torque. For small twist the restoring torque is found to be proportional to the amount of twist, or the displacement, so that

$$\tau = -k\theta \text{ -- } \mathbf{(1)}$$

Here k is proportionality constant that depends on the properties of the wire is called torsional constant.

The minus sign shows that the torque is directly opposite to the angular displacement θ. Eqn. (1) is the condition for angular simple harmonic motion.

The equation of motion for such a system is

$$\tau = I\,\alpha = I * d^2\theta/dt^2 \text{ -- } \mathbf{(2)}$$

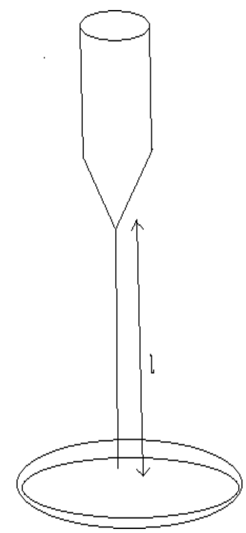
So that, on using the equation (1) we get

$$-k\theta = I * d^2\theta/dt^2$$

$$\frac{d^2\theta}{dt^2} + \frac{k}{I}(\theta) = 0 \text{ -- } \mathbf{(3)}$$

The solution of the equation 3 is, therefore, a simple harmonic oscillation in the angle co-ordinate, namely

$$\theta = \theta_m \cos(\omega t+\delta)$$



Here $\theta_m$is the maximum angular displacement i.e. the amplitude of the angular oscillation

The period of oscillation is given by

$$T= 2\pi\sqrt{\frac{I}{K}}$$

Where, I = rotational mertia of the pendulum

k = torsional constant

If k and I are known, T can be calculated.

FORMULA:

Rigidity modulus (n) of given wire is determine using the formula

$$\eta = \frac{4\pi MR^2 \; [l / T^2]}{a^4} \text{ dyne/cm}^2$$

PROCEDURE:

Torsional pendulum consists of a uniform circular metal (brass or iron) disc of diameter about 10 cm and thickness of 1 cm. Suspended by a metal wire (whose n is to be determined) at the center of the disc. The other end of the wire is griped in to another chuck, which is fixed to a wall bracket. The length (l) of the wire between the two chucks can be adjusted and measured using meter scale. An ink mark is made on the curved edge of the disc. A vertical pointer is kept in front of the disc such that the pointer screens the mark when straight. The disc is set in to oscillations in the horizontal plane, by tuning through a small angle. Now stopwatch is started and time (t) for 20 oscillations is noted.

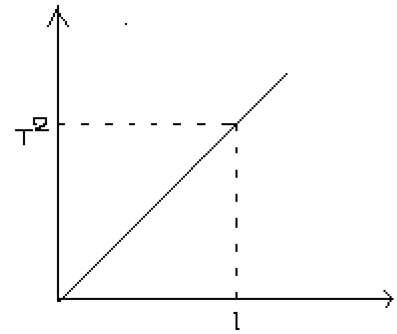
This procedure is repeated foe two times and the average value is taken. The time period T (=t/20) is calculated. The experiment is performed for five different lengths of the wire and observations are tabulated in table.

The diameter and hence the radius (a) of the wire is determined accurately at least at five different places of the wire using screw guage since the radius of the wire is small in magnitude and appears with forth power in the formula of rigidity modulus.

The mass (M) and the radius (R) of the circular disc are determine by using rough balance and vernier respectively.

MODELGRAPH:-

A graph is drawing between " l " on x-axis and T^2 on y-axis



<u>OBSERVATION</u> :

Mass of the disc M = gms

Radius of the disc R = cms

Radius of the wire, a = cms

TABULAR COLUMN:

S.No	MSR	VSR	L.C	MSR + (VSR*LC)	Diameter	Radius(R)

S.No	PSR	HSR	L.C	PSR + (HSR*LC)	Diameter (cm)	Radius, a (cm)

S. No	Length of the wire 'l' between chucks (cm)	Time taken for 20 Oscillations (sec)			Time Period T (sec)	T^2	l/T^2
		Trial	Trial II	Mean			

RESULT: The Rigidity modulus of the given material of wire η =

MODEL VIVA QUESTIONS:-

1. What is Rigidity Modulus?
2. What do you mean by Torsion?
3. What are the units of the torsion constant 'η' in the MKS system and CGS system?
4. Define moment of inertia (I)?
5. What are the units of 'I' in CGS and MKS system?
6. Define time period?
7. What is the definition of torque?
8. State and explain Hook's law?
9. How many types of modulus are there?
10. Two wires made up of the same material, one is thick and other is thin. Which wire has greater rigidity modulus? Explain.
11. What are the main differences between the simple pendulum and torsional pendulum?

ADDITIONAL EXPERIMENT:

TIME CONSTANT OF AN R-C CIRCUIT.

AIM:

To determine the time constant of the given RC circuit

APPARATUS:

RC circuit kit, connecting probes and stop clock

FORMULAE:

(i) Charging:

The voltage across the capacitor, during the charging phase, $V_c = V_0 \left(1 - e^{-\frac{t}{RC}}\right)$

At time t = RC, $V_c = V_0 \left\{1 - \left(\frac{1}{e}\right)\right\} = 0.63\ V_0$

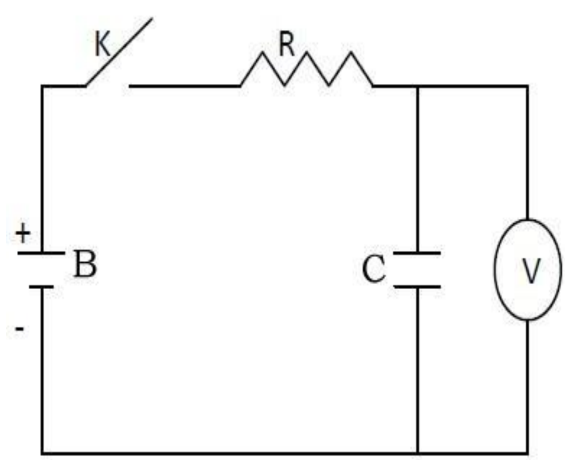
(i) Discharging:

The voltage across the capacitor, during the discharging phase, $V_c = V_o \{\exp[-t/(RC)]\}$

$V_c = V_0 \left(e^{-\frac{t}{RC}}\right)$

At time t = RC, $V_c = V_0 \left(\frac{1}{e}\right) = 0.37\ V_0$

PROCEDURE:



The experimental arrangement for the study of the charging and discharging of a condenser through a resistance is shown in fig. A condenser of capacity C, resistance R, a tap key K are to be connected to a battery B. Connect a voltmeter V, parallel to the condenser, by means of which the potential

differences across the plates of the condenser can be measured. Adjust the voltmeter knob so that it reads zero. Switch on the power supply, press the tap key K and simultaneously start a stop clock. When the tap key K is pressed the current flows and the plates of the condenser get charged. Note the time elapsed at the regular intervals of voltage (say 1.25 V), till the voltage reaches a maximum value V_o , i.e., the condenser gets fully charged. Note the observations in the tabular form. Repeat the experiment for different sets of R and C values.

When the tap key (K) is released, discharging takes place. Reset the stop clock. Release the tap key (K) for discharging and turn on the stop clock simultaneously. Note the time elapsed for the regular decrement of voltage from V_o to zero volt approximately.

Plot a graph between (t) on x – axis and Voltage (V_c) on Y – axis, both for charging and discharging processes. The curves are as shown in the figures. The time corresponding to $0.63V_o$ (during charging) and $0.37V_0$ (during discharging) should be equal to the theoretical value of time constant ie RC (product of the Resistance and Capacitance used in the circuit).

OBSERVATION TABLE:

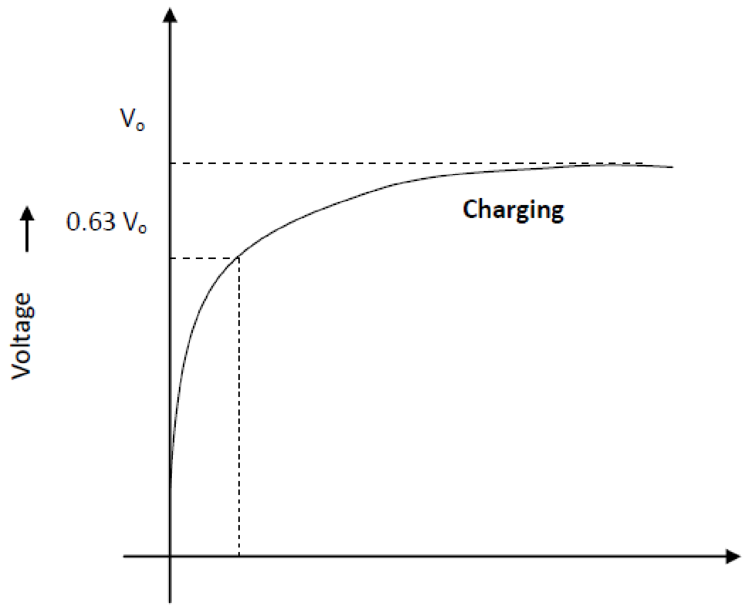
(i) CHARGING:

S. No.	Time required t sec	Voltage across the Capacitor, V_c Volts

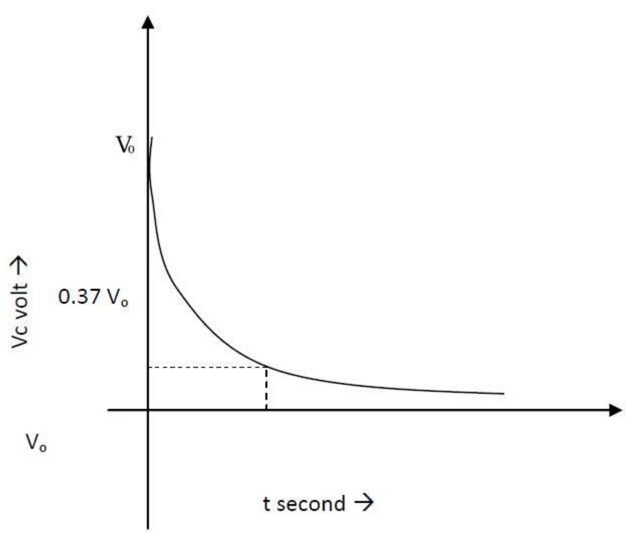
(ii) DISCHARGING:

S. No.	Time required t sec	Voltage across the Capacitor, V_c Volts

MODEL GRAPHS:



Discharging



RESULT:

The exponential decay of current in a circuit containing resistance and capacitance is studied and the RC time constant is determined and found to be
________________________seconds for charging and
________________________seconds for discharging.

VIVA QUESTIONS:

1. What is reactance?
2. What is impedance?
3. What is RC time constant?
4. What is resonance?

1. Expected Value or Theoretical Values
2. Achieved Value or Experimental Value
3. Error Value
4. Reasons For Error
5. Suggestions For Error