Applied Physics Laboratory Manual

(R-18)

By

Mrs B. SANTHI

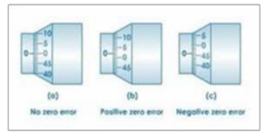
Mr P. SRINIVASA CHARY

Department of Humanities & Sciences

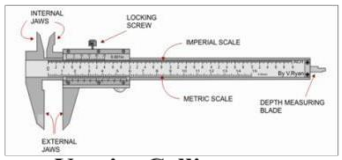
Sri Indu Institute of Engineering & Technology, Ibrahimpatnam.

AP LAB - LIST OF EXPERIMENTS (R-18)

Prism



Screw Gauge



Vernier Calliperse

Stewart and Gee`s experiment

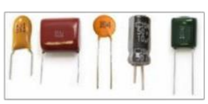
Magneto Meter

Power Supply

Rheostat

Ammeter

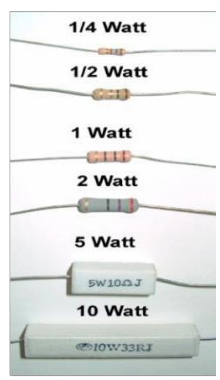
Voltmeter



Resisters

Optical Fiber Cable

Inductors



Resistors

Travelling Microscope

Torsional Pendulum Disc

Diodes

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

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

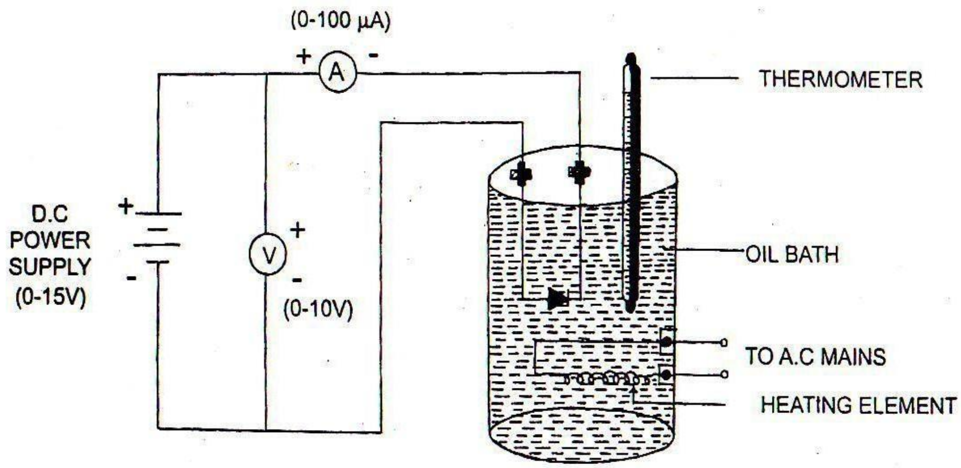
m = slope of the straight line plot obtained for log10 Is and 10^3/ T

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:

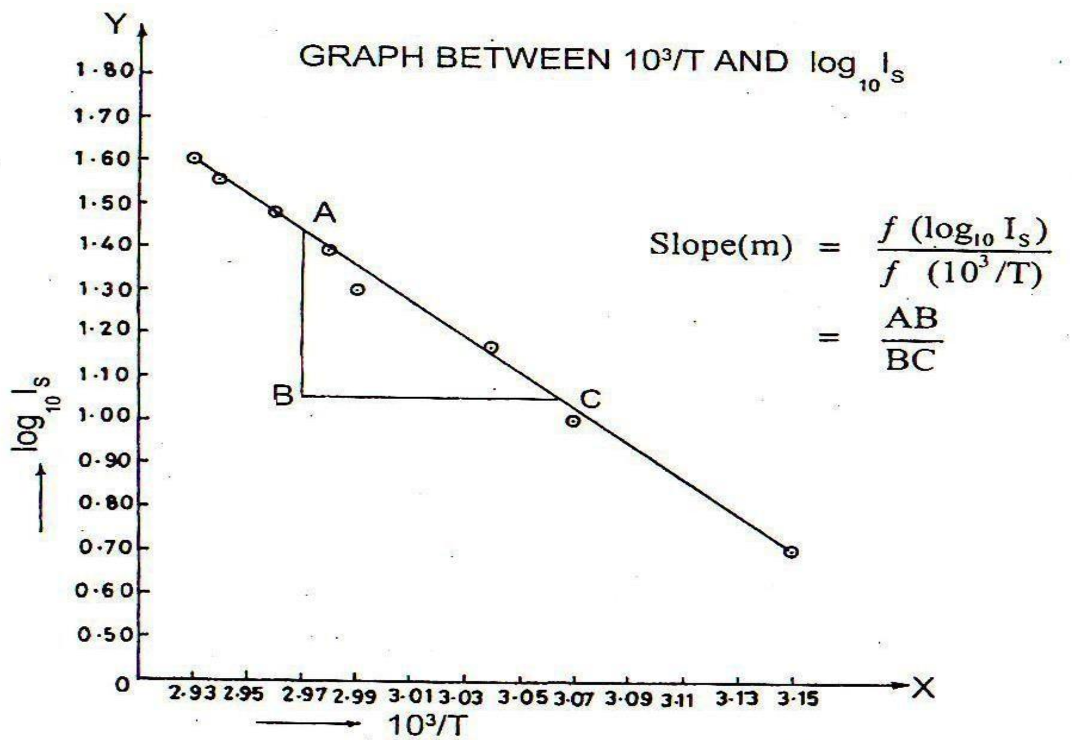


Fig. 5.2

To determine the reverse saturation current at different temperatures

Type of the diode:

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

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

CALCULATIONS:

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

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

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

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 2

V-I CHARACTERISTICS OF A SOLAR CELL

AIM:

To study the characteristics of a Solar cell

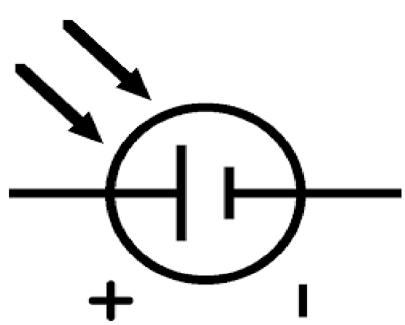
APPARATUS:

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

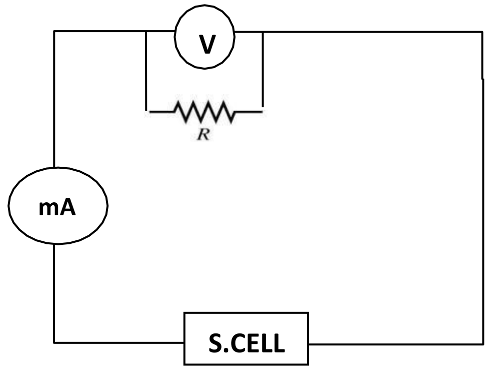
THEORY:

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 :



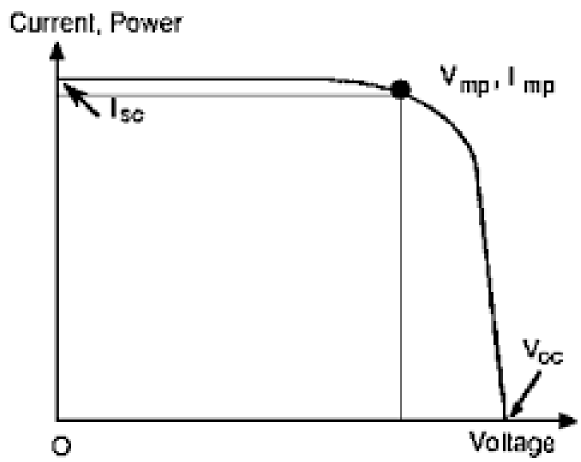
PROCEDURE:

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 3

STUDY THE CHARACTERISTICS OF LED AND LASER DIODE

AIM:

To study the characteristics of light emitting diode

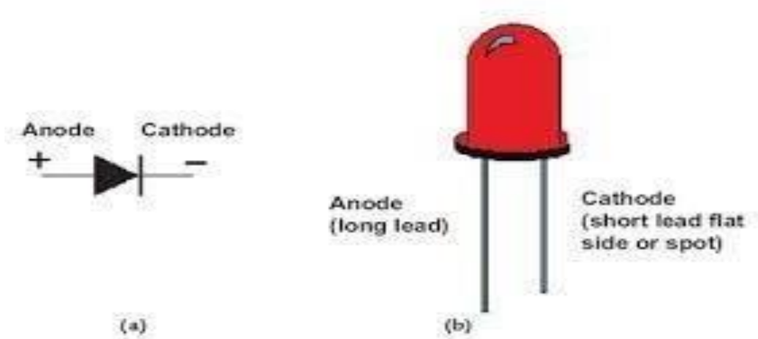
APPARATUS:

Trainer board, LEDS and patch cords

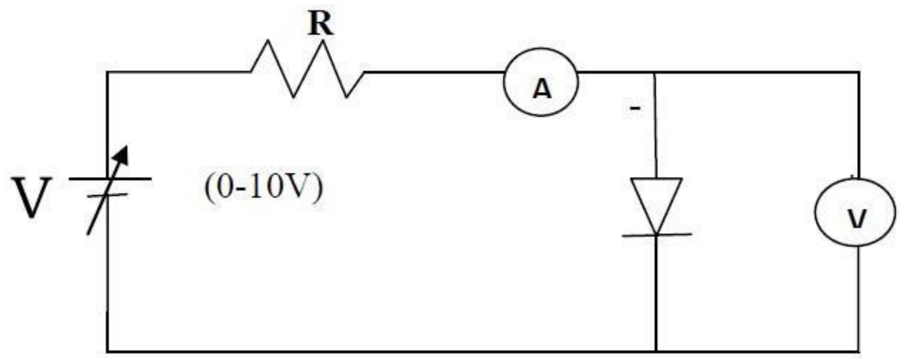
THEORY:

LEDs are Light emitting diodes. They emit light when an electric current passes through them. LED is operates only in forward bias condition. Under forward bias condition, the anode is connected to the positive terminal and the cathode is connected to the negative terminal of the battery. It is like a normal PN junction diode except the basic semiconductor material is GaAs or InP which is responsible for the color of the light. When it is forward biased the holes move from p to n and the electrons move from n to p. In the junction, the carriers recombine with each other and release the energy in the form of light. Thus LED emits light under forward biased condition. Under reverse biased condition, as there is no recombination due to majority charge carriers, so there is no emission of light.

SYMBOL OF LED:



CIRCUIT DIAGRAM: (Forward biased condition**)**



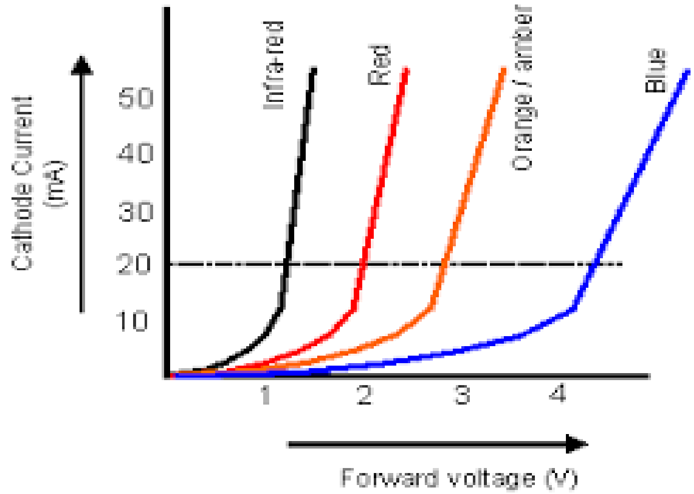
PROCEDURE:

1. Connect the circuit as per the circuit diagram
2. Vary the input voltages and note the corresponding current for the voltages.
3. Plot a graph between voltage and current for forward bias.

OBSERVATION TABLE :

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

MODEL GRAPH



PRECAUTIONS :

1. Make the connections properly.
2. Always connect the LED in the correct way, otherwise the excess flow of current may damage it.

RESULT:

The V-I characteristics of LED are studied under forward biased condition and the cut-off voltage for the given LED is____________ volts.

VIVA VOICE QUESTIONS:

1. What does LED stand for?
2. Why LED emits light?
3. What is forward bias?
4. What is reverse bias?
5. What is cut-off voltage?
6. Why LED is connected only in forward bias and not in reverse biased condition?

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

MAGNETIC FIELD ALONG THE AXIS OF EURRENT CARRYING COIL – STEWART AND GEES METHOD AND TO VERIFY BIOT – SAVART'S LAW

AIM:

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

APPARATUS:

Stewart & Gee type of tangent galvanometer, Battery eliminator, Ammeter, Commutator, Rheostat, plug key, scale, and connecting wires.

DESCRIPTION:

Stewart & Gee apparatus consists of a coil of thick insulated wire of 5 to 500 turns wound on a ring shaped wooden frame of 15cm to 20 cm diameter, as shown in the figure. A wooden plank about 100cm a long and 6cm to 8cm broad is fit horizontally inside the wooden ring with equal lengths projecting to either side of the ring. A scale is fixes to plank along its length and supported at its ends.

THEORY:

When a current of i amps flows through s circular coil of n-turns, each of radius a units, the magnetic induction B at any point P on the axis of the coil is given by

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

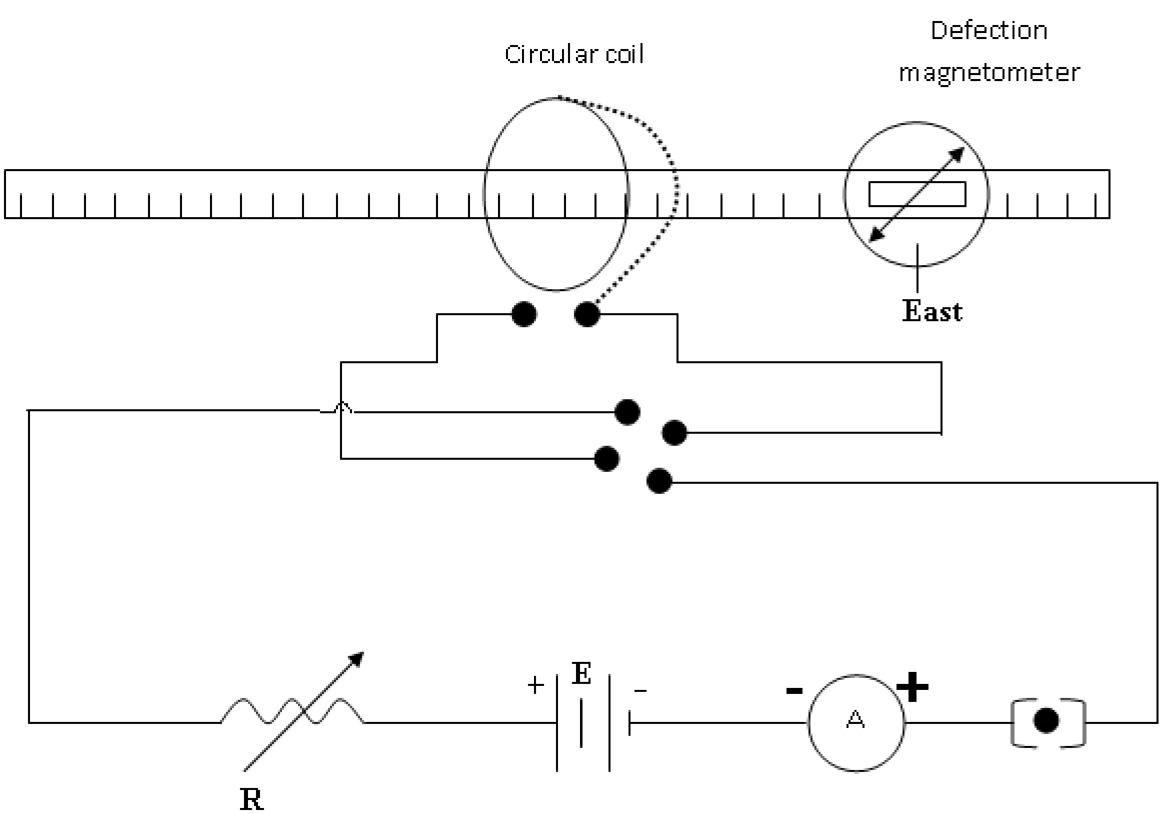
Where x is the distance of the point P from the centre of the coil

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 of the horizontal component of the earth's magnetic 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 up on by the B & B_e which are at right angles to one another. Therefore the needle deflects obeying tangents law,

$$B = B_e \tan\theta$$

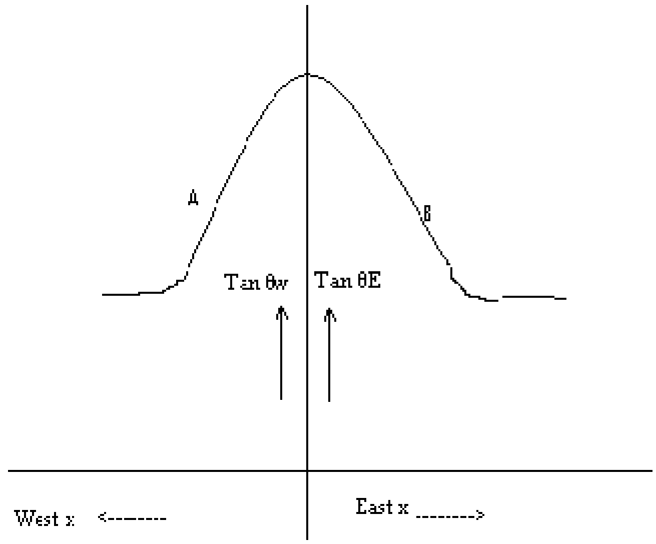
B_e is the horizontal component of the earth's magnetic field is taken from the standard tables. The intensity of the field at any point is calculated from the above equation and verified using the first equation.

CIRCUIT DIAGRAM



R – Rheostat, E – Battery, A – Ammeter

MODEL GRAPH:



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 drawn. Stewart and Gee type of tangent galvanometer is set with its coil in the magnetic meridian, as shown in the fig., 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 effect the magnetometer reading, if they are closed to it.

The magnetometer is set at the centre of the coil and rotated to make the aluminum pointer reads (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 magnetometer is observed. The deflection in magnetometer before and the after reversal of current should not differ much. In case of sufficient difference say about 2^0- 3^0, necessary adjustments are to be made.

Deflection in magnetometer before and after reversal of current is noted when d =

1. The readings are noted in tabular form. The magnetometer is moved towards. East along the axis of the coil in steps of 2 cm at time at each position, the key is closed and the deflection in magnetometer before and after reversal of current are noted. The mean deflection is denoted as θ_E **.** The magnetometer is further moved towards East in steps of 2 cms at each time and the deflection before and the 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 2 cms, each time and the deflection in magnetometer before and after reversal of current is noted. The mean deflection is denoted as θ_w**.**

A graph is drawn between X along x-axis and the corresponding Tanθ_E and Tanθ_w along y-axis. The Shape of the curve is as shown in the figure.

The points A & B marked on the curve line at a distance equal to half the radius of the coil a/2 on either side of the coil.

OBSERVATIONS:

Number of turns in the coil 'n'______________ $B_e = 0.36 \times 10^{-4}$ Tesla

Current through coil *i*=___________Amp $\mu_0 = 4\pi \times 10^{-7}$ Henry/ m

Radius of the coil a =____________________cm 1 Tesla = 1 weber/m

PRECAUTIONS:

2. The line indicating magnetic meridian and its perpendicular line must clearly be drawn on the table
3. The apparatus should not be distributed from its position after it has been arranged in such a way that the coil in the magnetic meridian.
4. Ammeter and Rheostat should be kept away from the magnetometer so that their fields should not influence deflection magnetometer.
5. Deflection in magnetometer should be moved on the groove of the apparatus in steps of 2-3cm and while doing parallax error should be avoided.
6. Keep the key off while moving the magnetometer.

OBSERVATION TABLE:

S.No	Distance of deflection magneto-meter from the centre of the coil (x) meter	Deflection in the magnetometer towards										$\theta = \frac{\theta_E + \theta_w}{2}$	Tanθ	Magnetic Induction weber/m^2	
		EAST side					WEST side								
		θ_1	θ_2	θ_3	θ_4	Mean θ_E	θ_1	θ_2	θ_3	Θ4	Mean θ_w			B=**B$_e$** Tan θ	$B = \frac{\mu_0 n i a^2}{2(x^2 + a^2)^{3/2}}$

RESULT: The magnetic induction at several points is determined.

VIVA QUESTIONS:

1. What is the direction of the magnetic field at the centre of the coil?
2. Where do we expect the field to be maximum in this experiment?
3. What is magnetic meridian?
4. What is the use of Commutator?
5. What is the use of Rheostat?

1. Expected Value or Theoretical Values

2. Achieved Value or Experimental Value

3. Error Value

4. Reasons For Error

5. Suggestions For Error

EXPERIMENT 5

Hall Effect- Determination of Hall coefficient

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

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

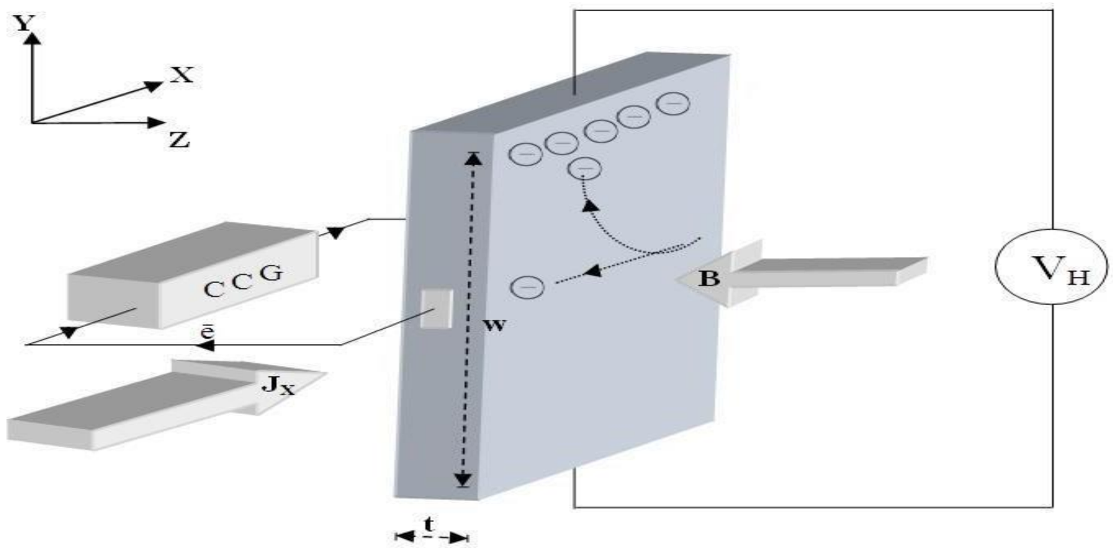


Fig.1 Schematic representation of Hall Effect in a conductor.

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

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

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,

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

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,

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

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

by rearranging eq(4) we get

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

Where R_H is called the Hall coefficient.

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

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 ?

$$R_H = \frac{V_H * t}{I * B}$$

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?

Yes.

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 6

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:

$$h = \frac{e(v2 - v1)\lambda1\lambda2}{C(\lambda1 - \lambda2)}$$

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.

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

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

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

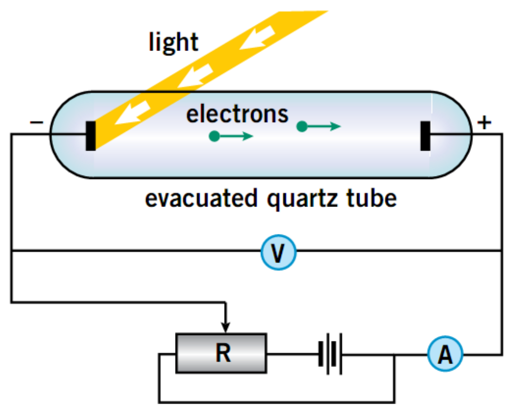
Or $eV_s = h\nu - W_0$

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

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

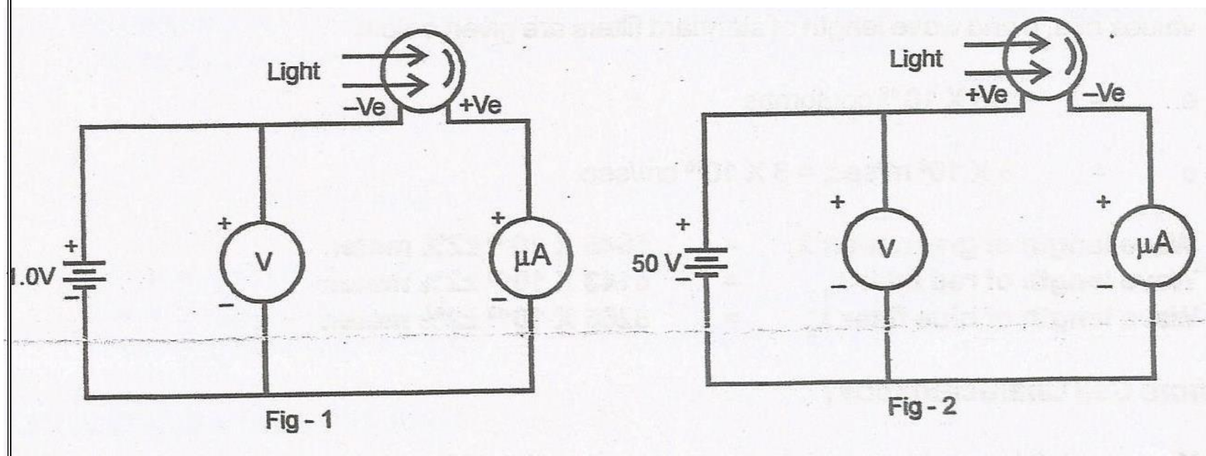
Therefore the slope = h/e

Form above equation ν_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.

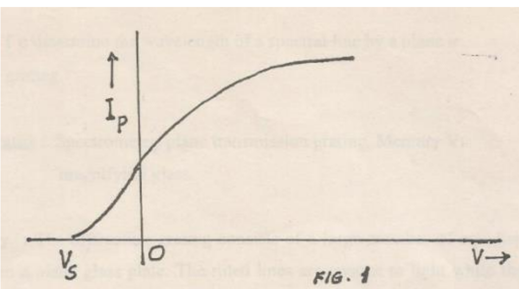
Table1:

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

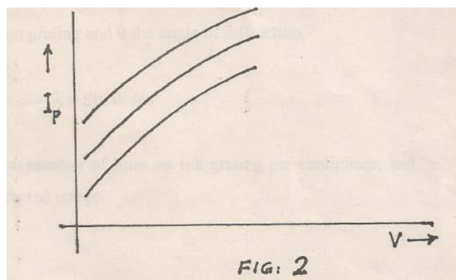
Table2:

S. No	Colour of the filter	Stopping potential V_s	Frequency $\nu = C/\lambda$	Work function $W_o = h\nu - eV_s$
1				
2				
3				

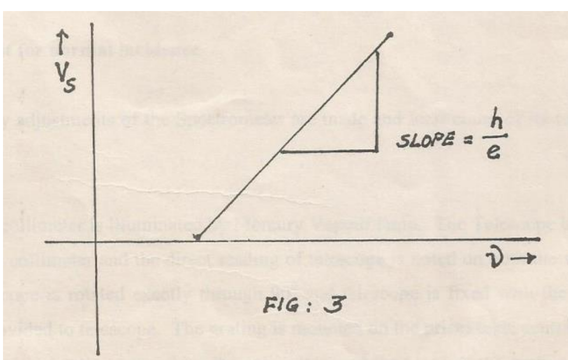
Graph:



Voltage Vs Current



Voltage Vs Current (for filters)



Frequency Vs Stopping Voltage

Calculations:

Work function $W_o = hv - ev_s$

Planck's constant $h = \frac{e(v2-v1)\lambda1\lambda2}{C(\lambda1-\lambda2)}$

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
	$6.62x10^{-34}$		

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 of them.

EXPERIMENT 7

CHARACTERISTICS OF LASER DIODES

AIM:

To study the Optical Power **(Po)** of a Laser Diode vs Laser Diode Forward Current (**I_F**)

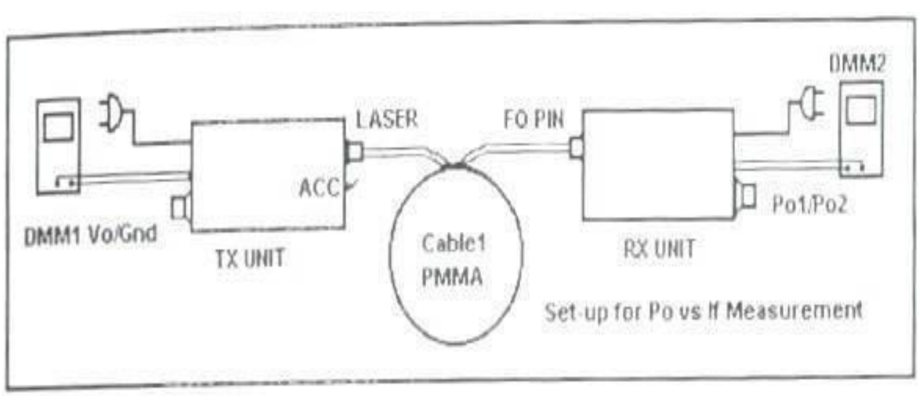
APPARATUS:

(1.) Laser Diode Design Module TNS 20EL-TX **(**2.) Laser Diode Design Module TNS 20EA-RX (3.) Two meter PMMA fiber patch card **(**4.) Inline SMA adaptors

THEORY:

Laser Diodes (LDs) are used in telecom, data communication and video communication applications involving high speeds and long hauls. Most single mode optical fiber communication systems use lasers in the 1300nm and 1550 nm windows. Lasers with very small line-widths also facilitate realization of wavelength division multiplexing (WDM) for high density communication over a single fiber. The inherent properties of LDs that make them suitable for such applications are, high coupled optical power into the fiber (greater than 1 mw), high stability of optical intensity, small line- widths (less than 0.05 nm in special devices), high speed (several GHz) and high linearity (over a specified region suitable for analogue transmission). Special lasers also provide for regeneration/amplification of optical signals within an optical fiber. These fibers are known as erbium doped fiber amplifiers. LDs for communication applications are commonly available in the wavelength regions 650nm, 780nm, 850nm, 980nm, 1300nm and 1550nm.

BLOCKDIAGRAM



PROCEDURE:

The schematic diagram for study of the LD Po as a function of LD forward current IF is shown below and is self explanatory.

1. Connect the 2-metre PMMA FO cable (Cab1) to TX Unit of TNS20EL and couple the laser beam to the power meter on the RX Unit as shown. Select ACC Mode of operation.
2. Set DMM 1 to the 200 mV range and connect it to the **Vo/Gnd terminals.** This will monitor **if in ma**, given by **VO (mV)/100**. Set DMM2 to 2000 mV range and connect it to the **Po1/Po2 terminals**. This will provide Po in dBm when divided by 10.
3. Adjust the **SET Po** knob to extreme counterclockwise position to reduce IF to 0 ma. The power meter reading will normally be below – 50 dBm or outside the measuring limits of the power meter.
4. Slowly turn the **SET Po** Knob clockwise to increase IF and thus Po. Note IF and Po readings. Take closer readings prior to and above the laser threshold. Current, Po will rapidly increase with small increase in IF.

OBSERVATIONS (ACC Mode/PMMA Cable)

Sl No	Vo(mV)	IF=Vo/100(ma)	Po (dBm)
1			
2			
3			
4			

RESULT:

Studied the Optical Power **(Po)** of a Laser Diode vs Laser Diode Forward Current (**I_F**) Characteristics

Viva –voce:

1. What is laser?
2. What is the difference between ordinary light and laser light?
3. What are the characteristics of laser?
4. What are the applications of laser?

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

OPTICAL FIBER - BENDING LOSSES

AIM:

To determine the losses in optical fibers in dB due to macro bending of the Fiber

APPARATUS:

Fiber Optic Kit, Optical cable of length 1m and 5m, mandrel, connecting wire.

THEORY:

The transmission loss or attenuation of an optical fiber is perhaps the most important characteristic of the fiber. Attenuation result from mainly scattering and absorption of light. Attenuation also results from number of effects like, fiber bending, fiber joints, improper cleaving and also splicing due to axial displacement and mismatch of core diameters of fibers. But, here we study the attenuation due to macro bending in fibers.

Attenuation is measured in decibels per kilometer (dB/Km), which is a logarithmic unit.

Loss of optical power = $-10/L \log (P_o/P_f)$ dB/m

Where P_o = Power launched in to the fiber

P_f = Power reached at the end of the fiber

L = Length of the given optical fiber

PROCEDURE:

1. Connect one end of the 1m optical fiber cable (OFC) to output end of the LED and the other end to the photo detector (PIN diode). Switch on the power.
2. Turn the SET P_o knob clock wise a little. Insert the leads of the dB meter at the output terminals of the optical power meter circuit and then note the output power (P_o) in the dB meter.
3. Without disturbing the SET P_o knob, wind the OFC one turn on the mandrel and measure the output power (P_B) in the dB meter.
4. Repeat the above step for II turns, III turns and IV turns and note the corresponding values in table from dB meter.
5. The difference between P_o and P_B gives the bending losses for 1m cable.
6. Repeat the same procedure for 5m OFC.

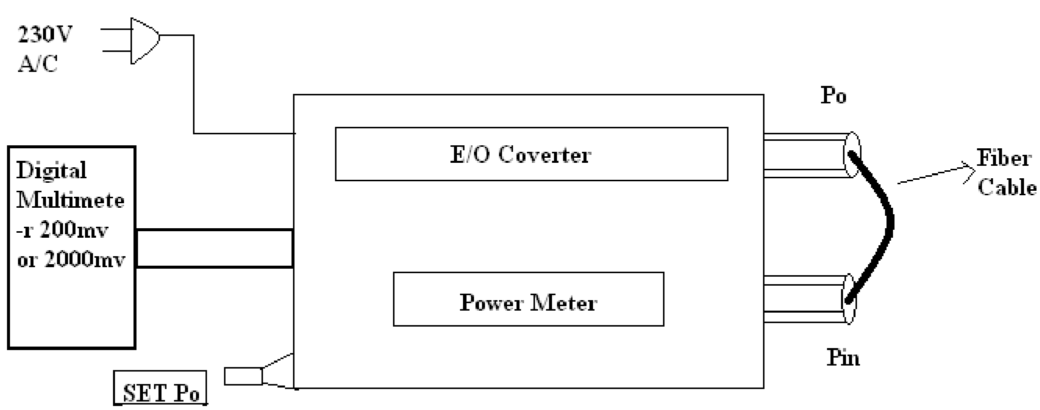


Fig: 1 Bending losses measurement

OBSERVATION TABLE:

<table>
<tr><th>S. No</th><th>Power without bending
P_o</th><th colspan="2">POWER WITH BENDING
P_B</th><th>Bending Loss
$P_o - P_B$</th></tr>
<tr><td rowspan="4">1 m</td><td rowspan="4"></td><td>I TURN</td><td></td><td></td></tr>
<tr><td>II TURN</td><td></td><td></td></tr>
<tr><td>III TURN</td><td></td><td></td></tr>
<tr><td>IV TURN</td><td></td><td></td></tr>
<tr><td rowspan="4">5 m</td><td rowspan="4"></td><td>I TURN</td><td></td><td></td></tr>
<tr><td>II TURN</td><td></td><td></td></tr>
<tr><td>III TURN</td><td></td><td></td></tr>
<tr><td>IV TURN</td><td></td><td></td></tr>
</table>

PRECAUTIONS:

1. Avoid bends in the cable.
2. Avoid cracks in the cable.

RESULT:

The Bending Losses in 1m OFC = --------------------- dB

The Bending Losses in 5m OFC = --------------------- Db

VIVA QUESTIONS:

1. What are the various types of optical fibers?
2. What is meant by numerical aperture?
3. What is acceptance angle?
4. What makes an optical fiber free from EMI
5. What is total internal reflection?
6. What is the importance of cladding in an optical fiber?
7. What are the different types of losses in the optical fibers?

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

EXPERIMENT 9

L-C-R CIRCUIT – RESONANCE & Q-FACTOR

A: SERIES RESONANCE

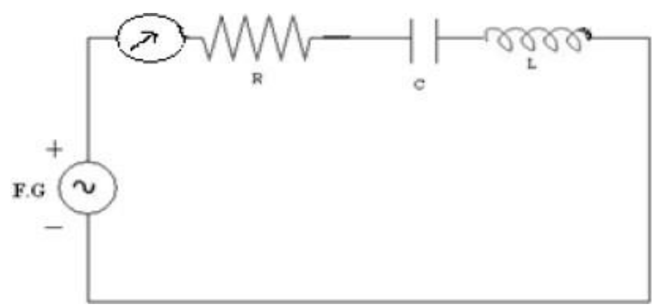
AIM:

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

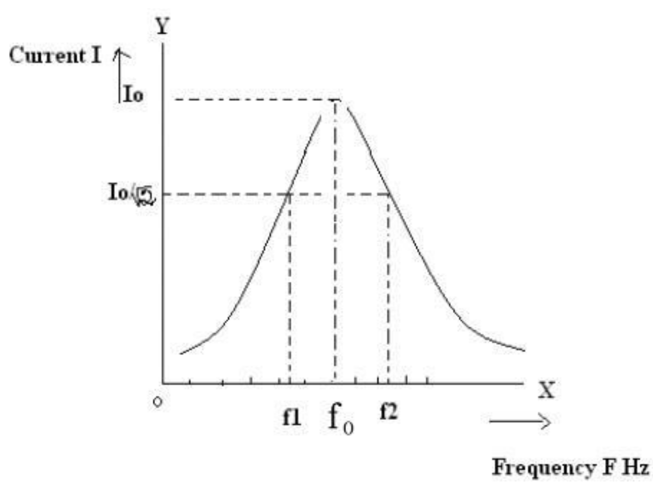
APPARATUS:

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

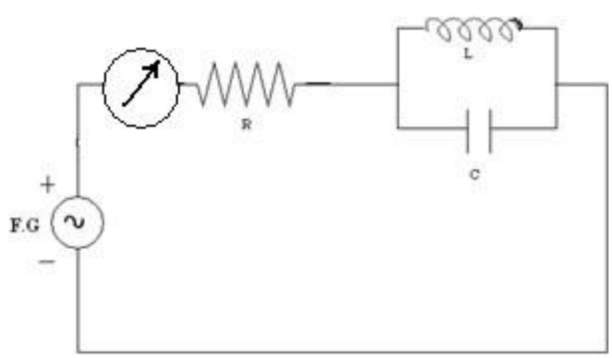
AIM:

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

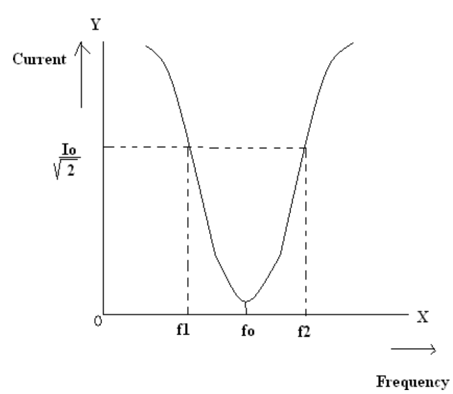
APPARATUS:

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 10
CHARGING, DISCHARGING AND 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, $V_c = V_0 \left\{1 - \left(\frac{1}{e}\right)\right\} = 0.63\ V_0$

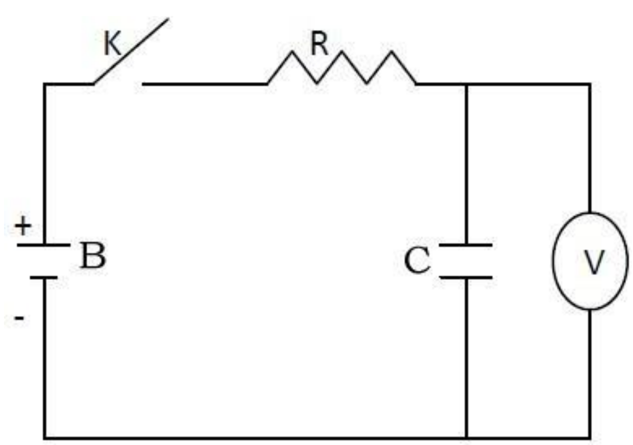
(i) Discharging:

The voltage across the capacitor, during the discharging phase, $V_c = V_0$ {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:

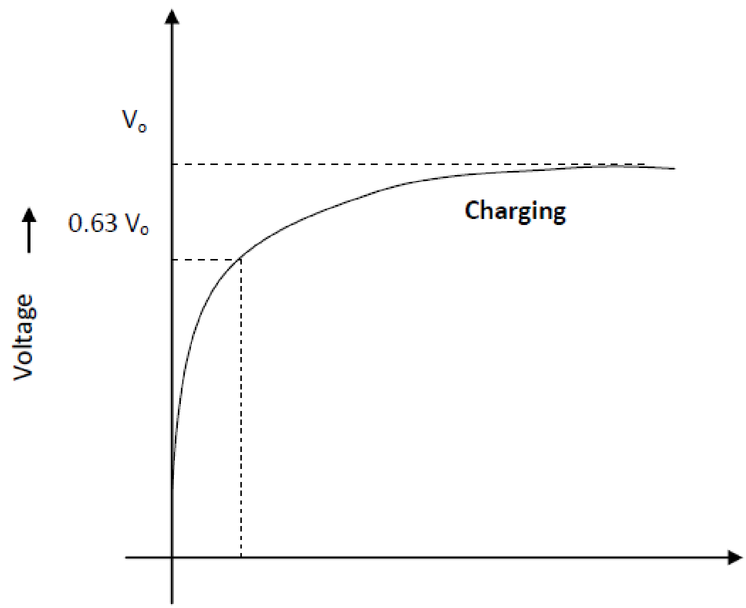
(i) CHARGING:

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

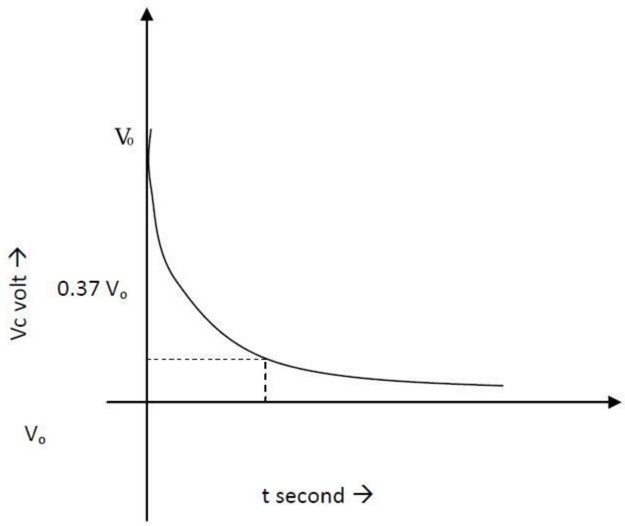
(ii) DISCHARGING:

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