Applied Physics Laboratory

Manual cum Record

DEPARTMENT OF PHYSICS

GOKARAJU RANGARAJU

INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

Bachupally, Hyderabad – 500 090

Preface

The main objective of the laboratory manual entitled “**Applied Physics laboratory manual**” is to make the first year B. Tech students familiar with the physics lab in a more systematic manner. This manual is written according to **GRIET (Autonomous)** syllabus .This book has been prepared to meet the requirements of Applied Physics lab.

This book is written and verified by the faculty of Department of Physics.

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CERTIFICATE

This is to certify that this is a bona fide record of practical work done by ____ of I B. Tech (I / II Semester) Reg. No.______________________________ in the Applied Physics Laboratory during the academic year ________________

Faculty In charge **External Examiner**

GOKARAJU RANGARAJU

INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

APPLIED PHYSICS LAB

(Common to CSE (AIML), CSE (DS), CSE, ECE, EEE & IT)

Course Code: GR20A1012

B. Tech I Year **L: 0 T: 0 P: 3 C: 1.5**

Course Objectives:

1. Outline the characteristics of various semiconducting devices.
2. Identify the behavioral aspects of magnetic and electric fields.
3. Demonstrate the quantum nature of radiation through photoelectric effect.
4. Apply the theoretical concepts of Lasers and optical fibers in practical applications.
5. Recall the basic concepts of LCR and RC circuits through hands on experience.

Course Outcomes:

1. Compare the behavior of p-n junction diode, Solar cells and LED.
2. Analyze the behavior of magnetic and electric fields with the help of graphs.
3. Infer the work function of a material through photoelectric effect.
4. Discuss the characteristics of Lasers and infer the losses in optical fibers.
5. Estimate the time constant of RC circuit and resonance phenomenon in LCR circuit.

List of Experiments:

1. Energy gap of P-N junction diode: To determine the energy gap of a semiconductor diode.

2. Solar Cell: To study the V-I Characteristics of solar cell.

3. Light emitting diode: Plot V-I and P-I characteristics of light emitting diode.

4. Stewart – Gee's experiment: Determination of magnetic field along the axis of a current carrying coil.

5. Hall effect: To determine Hall co-efficient of a given semiconductor.

6. Photoelectric effect: To determine work function of a given material and Planck's constant.

7. LASER: To study the V-I and P-I characteristics of LASER sources.

8. Optical fiber: To determine the bending losses of Optical fibers.

9. LCR Circuit: To determine the resonant frequency and Quality factor of LCR Circuit in series and parallel.

10. R-C Circuit: To determine the time constant of R-C circuit during charging and discharging.

Note: Any 8 experiments are to be performed.

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1. ENERGY GAP OF A p-n JUNCTION DIODE

AIM: To determine the energy gap of semiconductor using a PN junction diode.

APPARATUS: Micro Board Kit consists of Germanium semiconductor diode, micro ammeter, regulated dc power supply, thermometer, oven, copper vessel, Bakelite lid and connecting wires.

FORMULA: Energy gap $E_g = \frac{2 \text{ x } \text{ slope } \text{ x Boltzmann constant (K) x } 2.303 \text{ eV}}{1.6 \text{ x } 10^{-19}}$

Here Boltzmann constant K = 1.38 x 10^{-23} J/K

THEORY:

In a semiconductor there is an energy gap between its conduction and valance band. For conduction process certain amount of energy is to be given and the energy needed is the

measure of energy gap, E_g of the semiconductor. When a P-N junction diode is reverse biased, current is due to minority carriers whose concentration is dependent on E_g. The reverse current I_s is a function of temperature of the junction diode.

The energy band gap of different semiconductor like Si, Ge, Gap, GaAs etc are different, hence by determining the energy gap we can identify the type of semiconductor used to prepare the diode.

Energy Band Diagram:

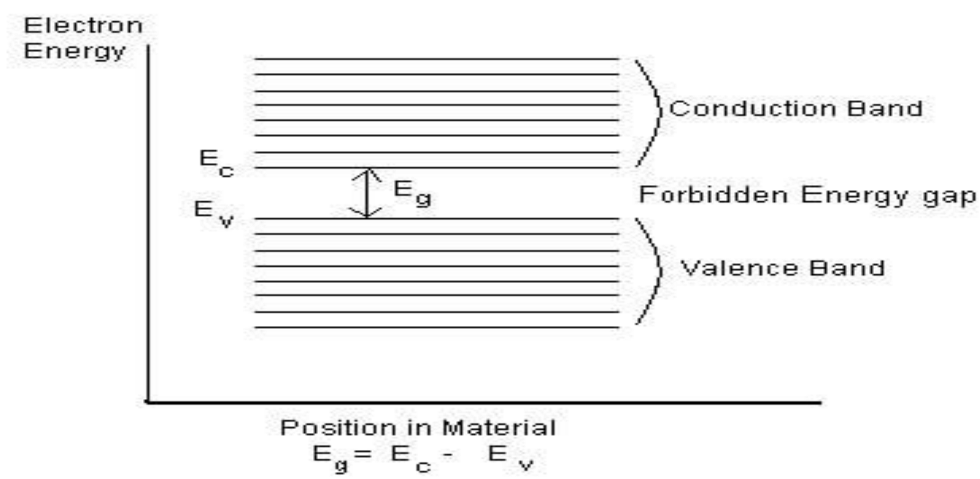
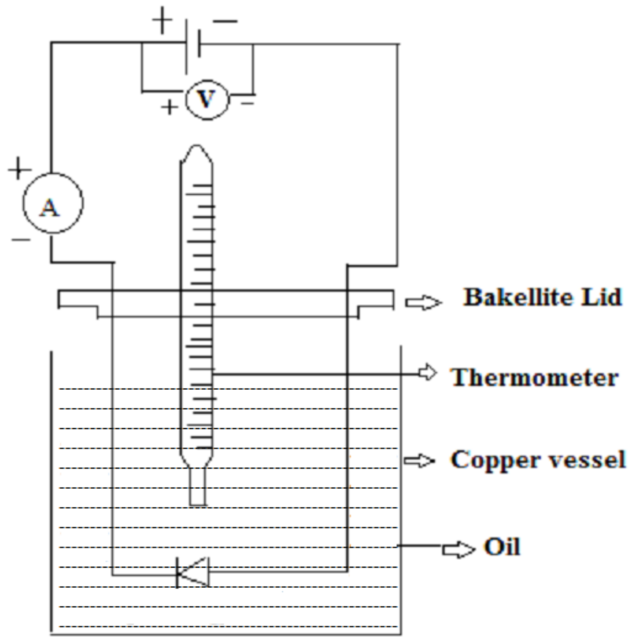


Figure 1

CIRCUIT DIAGRAM:



PROCEDURE:

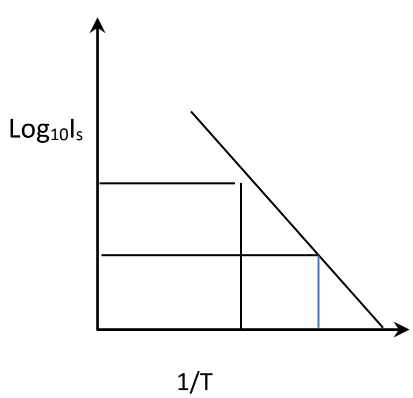
1. Connect all the connections as per the circuit diagram.
2. Kit and heater are to be turned off while making the connections.
3. After making the connections switch on the kit.
4. Pour some oil in the copper vessel.
5. Now fix the voltage at 1.5 V.
6. Insert the thermometer in to the slot provided and switch on the heater.
7. Now allow the temperature to rise up to 60 ^{0}C, and then switch off the heater.
8. Wait until the temperature is raised to 70 ^{0}C or 80^{0}C and becomes stable.
9. After some time, the temperature will begin to fall.
10. Note down the current value (in μA) using ammeter for every 5 ^{0} C fall of temperature.
11. This value of current will be known as saturation current I_s for that specific temperature.
12. Note down the readings until the temperature reaches 30 ^{0} C.
13. Note down all the observations in the tabular form given below.

Observations:

S.No.	Current(I_s) μA	Temperature(t) ^0C	Temperature(T) Kelvin (t+273)	1/T K^{-1}	$Log_{10}I_s$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

GRAPH:

A graph is drawn between $Log_{10}I_s$ and 1/T. It is a straight line for which slope is measured.



CALCULATIONS:

Energy gap $E_g = \frac{2 \text{ x slope x Boltzmann constant (K) x 2.303 eV}}{1.6 \text{ x } 10^{-19}}$

Here Boltzmann constant K = 1.38 x 10^{-23} J/K.

Slope (m) = $\frac{y2-y1}{x2-x1}$

RESULT: The energy gap of germanium semiconductor diode is_______________eV

VIVA VOCE

1. **What is a semiconductor?**

   A semiconductor is a material which has energy gap between that of conductor such as copper and insulator such as glass.

2. **What is forward and reverse biasing?**

   Forward bias: When the positive terminal of the battery is connected to the p-type material and the negative terminal of the battery is connected to the n-type material.

   Reverse bias: When the positive terminal of the battery is connected to n-type material and the negative terminal of the battery is connected to the p-type material.

3. **What is energy gap?**

   The gap between valance band and conduction band in any material.

4. **What is intrinsic and extrinsic semiconductor?**

   Intrinsic semiconductor: A pure semiconductor is known as intrinsic semiconductor.Extrinsic semiconductor: A pure semiconductor after doping is called extrinsic or impure semiconductor. Trivalent and pentavalent impurities are added to form p type and n type extrinsic semiconductors respectively.

5. **Define P-type and N-type semiconductors respectively**.

   N-type: It is a extrinsic semiconductor which is obtained by doping the pentavalent impurity like As, Sb, Bi to pure semiconductor. P-type:It is an extrinsic semiconductor which is obtained by doping the trivalent impurity like Ga, I, B to pure semiconductor.

6. **What is doping?**

   The process of adding impurities to a pure semiconductor is called doping, the material added as impurity is called as dopant.

7. **Why are readings taken only while cooling?**

   Because heating is non-linear where as cooling is linear and it follows Newton's law of cooling.

8. **Why is the diode reverse biased in this experiment?**

   Reverse bias diode equation $I_d = I_s\left[\exp\left(\frac{ev}{kT}\right) - 1\right]$

   Reverse saturation current I_s dependent on temperature T, hence we choose reverse bias to determine energy gap.

9. **Why can't we use water instead of coconut oil?**

Water has high specific heat, it will take longer times to heat and longer times to Cool. Specific heat of coconut oil is less, which means that coconut oil quickly heat up and quickly cools down.

SPACE FOR GRAPH SHEET

2. SOLAR CELL

AIM: To study the V-I characteristics of solar cell.

APPARATUS: Trainer Board, Solar Cell, Source of light and connecting wires.

DESCRIPTION:-

Solar cell is basically a two terminal p-n junction device designed to absorb photon absorption through the electrical signal or power in the external circuits. Therefore it is necessary to discuss the physics of semiconductor p-n junction diode, which converts the optical energy into electrical signals.

It is well known that doped semiconductors are of two types, p and n- types semiconductors depending upon the nature of the charge carriers. In n-type semiconductor the free carriers are electrons and in p-type semiconductor, the free charge carriers are holes. Since the semiconductors are electrically neutral, in a doped semiconductor the number of free carriers is equal to the lattice ions present in the semiconductor

A solar cell is illuminated by light having photon energy greater than the band gap energy of the solar cell. Then, using a proper circuit, the open circuit voltage, short circuit current and power drawn from the solar cell are measured.

The solar cell is a semiconductor device, which converts the solar energy into electrical energy. It is also called a photovoltaic cell. A solar panel consists of numbers of solar cells connected in series or parallel. The number of solar cell connected in a series generates the desired output voltage and connected in parallel generates the desired output current. The conversion of sunlight (Solar Energy) into electric energy takes place only when the light is falling on the cells of the solar panel. Therefore in most practical applications, the solar panels are used to charge the lead acid or Nickel-Cadmium batteries. In the sunlight, the solar panel charges the battery and also supplies the power to the load directly. When there is no sunlight, the charged battery supplies the required power to the load.

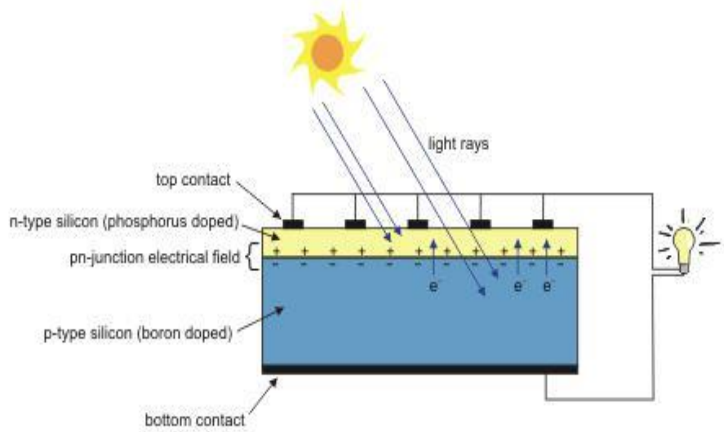
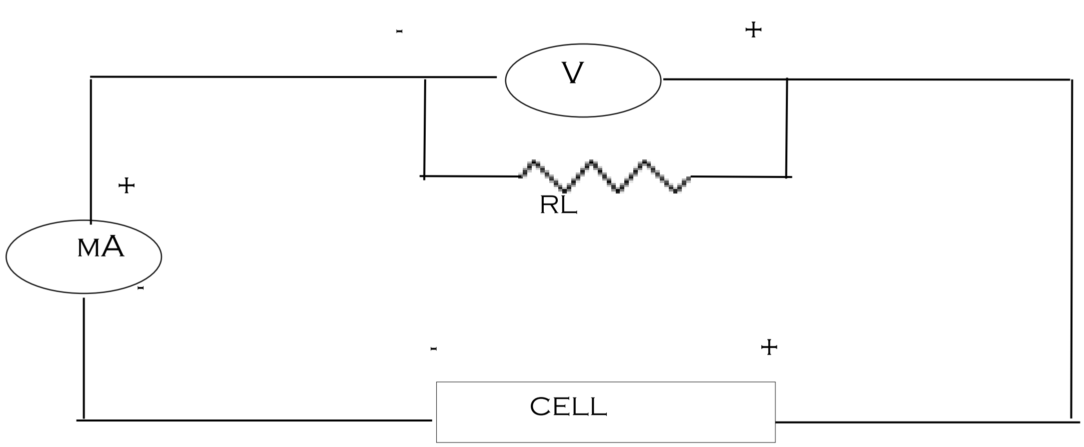


Fig. 1 working principle of a solar

A solar cell operates in somewhat the same manner as other junction photo detectors. A built-in depletion region is generated in that without an applied reverse bias and photons of adequate energy create hole-electrons pairs. In the solar cell, as shown in Fig. 1, the pair must diffuse a considerable distance to reach the narrow depletion region to be drawn out as useful current. Hence, there is higher probability of recombination. The current generated by separated pairs increases the depletion region voltage (Photovoltaic effect). When a load is connected across the cell, the potential causes the photocurrent to flow through the load.

CIRCUIT DIAGRAM:



PROCEDURE:-

1. Complete the circuit as shown in circuit diagram.

2. Illuminate the solar cell. Adjust the R_h position for resistance so that the voltmeter reads zero & ammeter reads a value of max value. This is the short circuit connection. Note down the value of the current as short circuited current, I_{sc}

3. Increase the resistance by varying the Rh slowly and note down the readings of current and voltage till a maximum voltage is read. Ensure to take at least 5 – 10 readings in this region

4. Disconnect the R_h and note down the voltage. This is the open circuit voltage, V_{oc}.

5. Repeat the experiment for another intensity of the illumination source

6. Tabulate all readings in Table 1. Calculate the power using the relation, $P = V \times I$

7. Plot I Vs V with I_{sc} on the current axis at the zero volt position and V_{oc} on the voltage axis at the zero current.

8. Identify the maximum power point P_m on each plot. Calculate the series resistance of the solar cell using the formula as follows: $R_s = [\Delta V/\Delta I]$.

9. To see the performance of the cell calculate fill factor (FF) of the cell, which can be expressed by the formula, $FF = [P_m/I_{sc}V_{oc}]$.

10. Repeat the experiment with distance varying from source to solar cell for example say 50 Cm.

11. Note the reading of Voltmeter, Ammeter & also R_h Load resistance value by varying knob provided on Board. Tabulate all readings in Table 2

Observations:

Table: 1

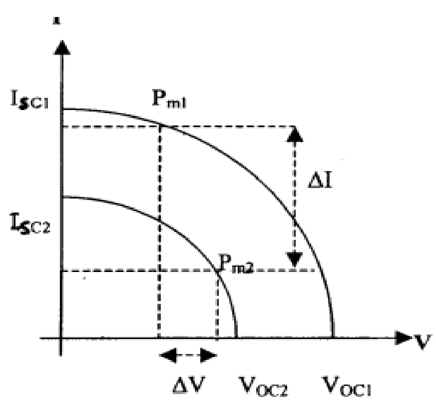
Voltage (V)	**Current (mA/µA)**	**P=V*I**

Table: 2

Voltage (V)	**Current (mA/µA)**	**P=V*I**

Graph:

Graph is drawn between voltage and current. Output voltage is taken on x-axis and output current is taken on y-axis.



RESULT: The V-I characteristics of solar cell are studied.

VIVA VOCE

1. **What is a solar cell?**

   A solar cell or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect.

2. **Does the presence of photon result in photoelectric effect?**

   Yes it does .The photon's energy transfer to the valence electron of an atom in the n-type Si layer. That energy allows the valence electron to escape its orbit leaving behind a hole. In the n-type silicon layer, the free electrons are called majority carriers whereas the holes are called minority carriers. As the term "carrier" implies, both are able to move throughout the silicon layer of the solar cell, and so are said to be mobile.

   Inversely, in the p-type silicon layer, electrons are termed minority carriers and holes are termed majority carriers, and of course are also mobile.

3. **Which type of materials is used in solar cells?**

   The basic component of a solar cell is pure silicon

4. **Name an electrical device that converts the energy of light directly into electricity by the photovoltaic effect.**

   Photovoltaic cell or solar cell.

5. **What is the biasing condition of a Solar cell?**

   When under illumination (under the sun), photocurrent in p-n junction solar cells flows in the reverse bias direction. In the dark, the solar cell simply acts as a diode in forward biased.

6.What is short circuit current in solar cell?

The short-circuit current (ISC) is the current through the solar cell when the voltage across the solar cell is zero (i.e., when the solar cell is short circuited).

7.What is open circuit voltage?

The open-circuit voltage, V_{OC}, is the maximum voltage available from a solar cell, and this occurs at zero current. The open-circuit voltage corresponds to the amount of forward bias on the solar cell due to the bias of the solar cell junction with the light-generated current.

SPACE FOR GRAPH SHEET

3. LIGHT EMITTING DIODE

AIM: To plot V-I and P-I characteristics of light emitting diode.

APPARATUS: LED trainer kit, power supply.

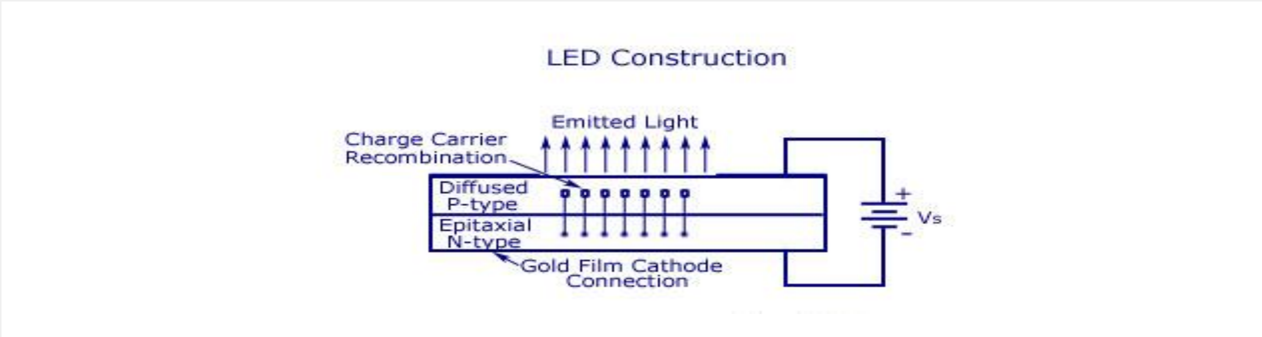
PRINCIPLE: The light emitting diode (LED) works on the principle of electroluminescence.

A light emitting diode (LED) is known to be one of the best optoelectronic devices out of the lot. The device is capable of emitting a fairly narrow bandwidth of visible or invisible light when its internal diode junction attains a forward electric current or voltage. The visible light that an LED emits are usually orange, red, yellow, or green. The invisible light includes the infrared light. The biggest advantage of this device is, its high power to light conversion efficiency. That is, the efficiency is almost 50 times greater than a simple tungsten lamp. The response time of the LED is also known to be very fast in the range of 0.1 microseconds when compared with 100 milliseconds for a tungsten lamp. Due to these advantages, the device has wide applications as visual indicators and as dancing light displays.

We know that a P-N junction can convert the absorbed light energy into its proportional electric current. The same process is reversed here. That is, the P-N junction emits light when energy is applied on it. This phenomenon is generally called electro luminescence, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence band. Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some part of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

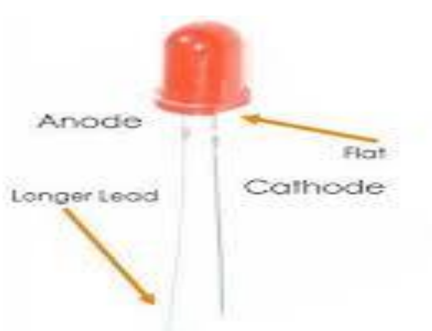
The electrons dissipate energy in the form of heat for silicon and germanium diodes. But in Gallium- Arsenide-phosphorous (GaAsP) and Gallium-phosphorous (GaP) semiconductors, the electrons dissipate energy by emitting photons. If the semiconductor is translucent, the junction becomes the source of light as it is emitted, thus becoming a light emitting diode (LED). But when the junction is reverse biased no light will be produced by the LED, and, on the contrary the device may also get damaged.

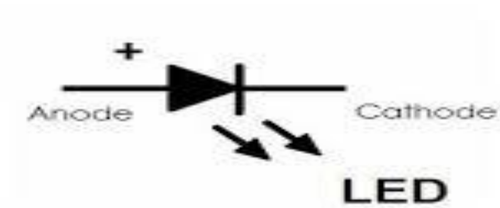
The constructional diagram of a LED is shown below.



All the semiconductors listed above can be used. An N-type epitaxial layer is grown upon a substrate, and the P-region is produced by diffusion. The P-region that includes the recombination of charge carriers is shown. Thus the P-region becomes the device surface. In order to allow more surface area for the light to be emitted, the metal anode connections are made at the outer edges of the P-layer. For the light to be reflected as much as possible towards the surface of the device, a gold film is applied at the bottom of the surface. This setting also enables to provide a cathode connection. The reabsorption problem is fixed by including domed lenses for the device. All the wires in the electronic circuits of the device is protected by encasing the device. The light emitted by the device depends on the type of semiconductor material used. Infrared light is produced by using Gallium Arsenide (GaAs) as semiconductor. Red or yellow light is produced by using Gallium-Arsenide-Phosphorus (GaAsP) as semiconductor. Red or green light is produced by using Gallium-Phosphorus (GaP) as semiconductor.

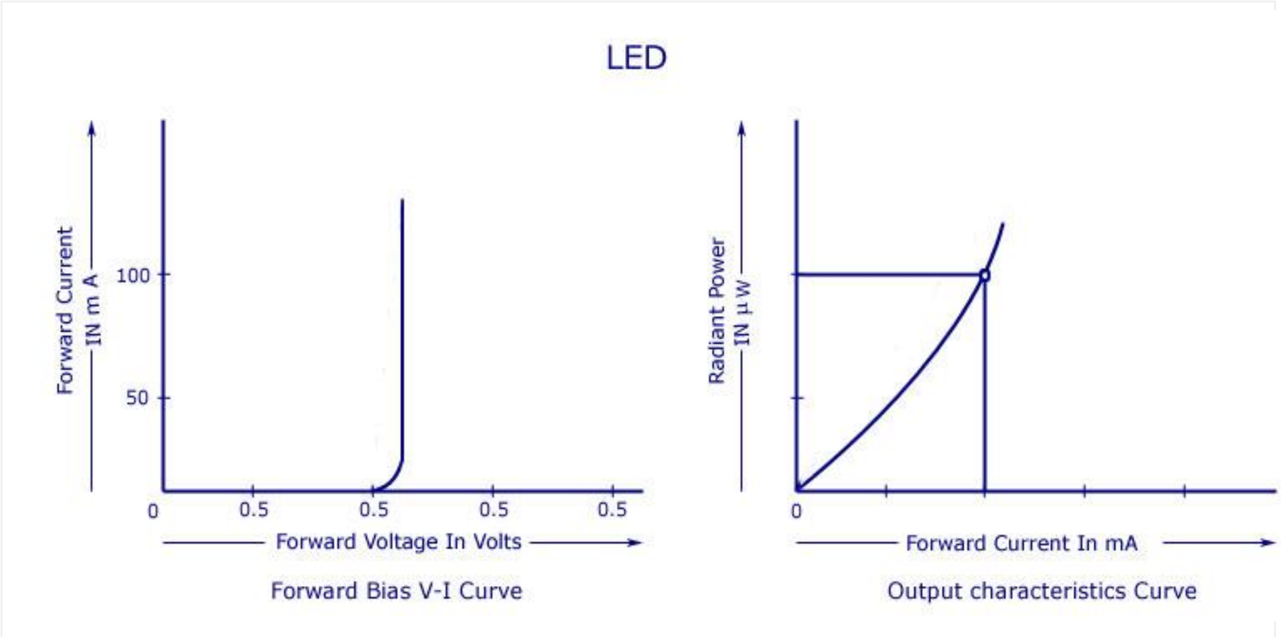
LED Circuit Symbol





The circuit symbol of LED consists of two arrow marks which indicate the radiation emitted by the diode.

LED Characteristics



The forward bias Voltage-Current (V-I) curve and the output characteristics curve is shown in the figure above. The V-I curve is practically applicable in burglar alarms. Forward bias of approximately 1 volt is needed to give significant forward current. The second figure is used to represent a radiant power-forward current curve. The output power produced is very small and thus the efficiency in electrical-to-radiant energy conversion is very less.

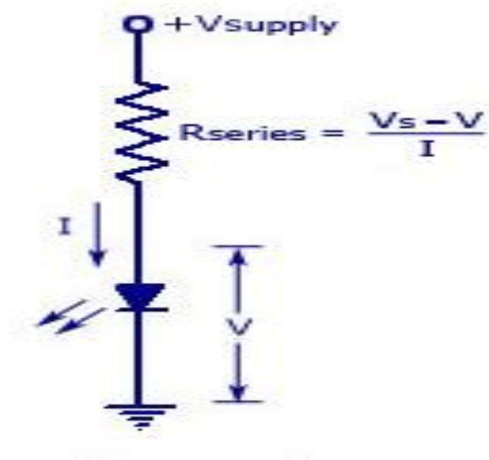
The figure below shows a series resistor R_{series} connected to the LED. Once the forward bias of the device exceeds, the current will increase at a greater rate in accordance to a small increase in voltage. This shows that the forward resistance of the device is very low. This shows the importance of using an external series current limiting resistor. Series resistance is determined by the following equation.

$$R_{series} = (V_{supply} – V)/I$$

V_{supply} is Supply Voltage

V is LED forward bias voltage

I is Current



The commercially used LED’s have a typical voltage drop between 1.5 Volts to 2.5 Volts or current between 10 to 50 milliamperes. The exact voltage drop depends on the LED current, colour, tolerance, and so on.

PROCEDURE:

V-I characteristics of LED

1. Switch on the power supply.
2. Adjust the set P_o Knob to extreme anti clock position to give minimum output power and observe the power in the power meter.
3. Slowly turn set P_o knob clockwise a little and then note load voltage (V_L) across the LED, also note the current (I_L) readings in ammeter
4. Repeat step 3 for noting various values of voltage and current
5. Plot graph of V_L and I_L.

P-I characteristics of LED

1. Adjust the set P_o knob to extreme anticlockwise position to give the minimum output in the power meter and observe the output power in the power meter.
2. Slowly turn the set P_o knob clockwise a little and then note current (I_L) through the LED terminals. Also note the reading in the power meter (P_o).
3. Repeat step 2 for noting various values of I_L and P_o.

4. Plot a graph between I_L and P_o take closer reading to plot a fine graph.

OBSERVATIONS:-

V-I characteristics of LED

S.NO.	Voltage (V)	Current (I) mA

P-I characteristics of LED:

S.NO.	Current (I) mA	Optical power (mW)

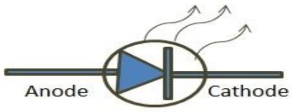
RESULT: Studied theV-I and P-I characteristics of LED

.

VIVA VOCE

1. **What is the material used in LED, Symbol of LED?**

   Light Emitting Diodes are made from exotic semiconductor compounds such as Gallium Arsenide (GaAs), Gallium Phosphide (GaP), Gallium Arsenide Phosphide (GaAsP), Silicon Carbide (SiC) or Gallium Indium Nitride (GaInN) all mixed together at different ratios to produce a distinct wavelength of colour.



2. **If you are given 2 LEDs in series, then how will the resultant intensity of light be affected?**

   First it will increase the resistance as it is connected in series, therefore the current will decrease and intensity depends on current, thus less current so less intensity.

3. **If you are given 2 LEDs in parallel, then how will the resultant intensity of light be affected?**

   The intensity will remain same, as same voltage across each led is equal and resistance also the same so same current flows.

4. **Name a device, which converts electrical energy to light energy.**

   Light Emitting Diode.

5. **Which material is used in LED?**

   LEDs are comprised of compound semiconductor materials such as GaAs and GaP

6. **How LED works?**

   A light-emitting diode is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons.

7. **What is the difference between a diode and LED?**

   Normal diodes are used as resisting semiconductors in electric circuits, while LEDs are designed specifically to produce light as a result of the extra energy caused by their resistance.

8. **What is the difference between the LASER and LED?**

   A Laser emits converged light while LED emits highly diverged light.

SPACE FOR GRAPH SHEET

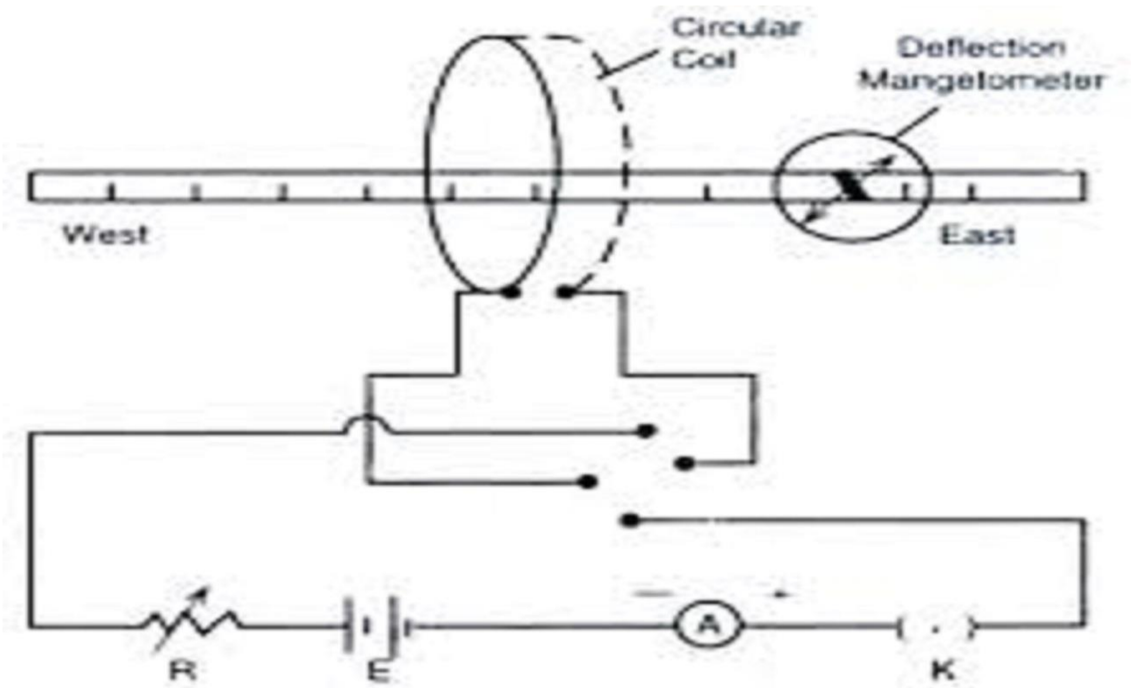
SPACE FOR GRAPH SHEET

4. Stewart –Gee's Experiment

AIM: To determine the magnetic field along the axis of a current carrying coil.

APPRATUS: Stewart & Gees type of tangent galvanometer, battery, key, rheostat, ammeter, commutator and connecting wires.

CIRCUIT DIAGRAM:



DESCRITPITON:

The apparatus consists of a circular frame made up of non-magnetic substance. An insulated copper wire is wounded on the frame. The ends of the wire are connected to the other two terminals. By selecting a pair of terminals the number of turns used can be changed. The frame is fixed to a long base B at the middle in a vertical plane along the breadth side. The base has levelling screws. A rectangular non-magnetic metal frame is supported on the uprights. The plane of the frame contains the axis of the coil and the frame passes through the circular coli. A magnetic compass used in deflection magnetometer is supported on a movable platform. This platform can be moved on the frame along the axis of the coil. The compass is so arranged that the centre of the magnetic needle always lies on the axis of the coil.

The apparatus is arranged so that the plane of the coil is on the magnetic meridian. The frame with compass is kept at the centre of the coil and the base is rotated so that the plane of the coil is parallel to the magnetic needle in the compass. The compass is rotated so that the aluminium pointer reads 0^{o} -0^{o}. Now the rectangular frame is along the east- west directions.

THEORY:

When current flows through coil, the magnetic field produced is in perpendicular direction to the plane of the coil. The magnetic needle in the compass is under the influence of two magnetic fields.

'B' due to the coil carrying current given by

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

And the earth's magnetic field 'B_e'. Both are mutually perpendicular. The needle deflects through an angle 'θ' satisfying the tangent law.

$$B = B_e \tan\theta$$

Biot savart law is basic law of electricity and magnetism.

.

It states that magnetic field produced due to small conductor of length dl carrying current I at point at distance r is:

$$dB = K\frac{Idl\sin\theta}{r^2}$$

PROCEDURE:

1. Keep the deflection magnetometer in magnetic meridian position. (The wooden arms of the deflection magnetometer should be parallel to the axis of the magnetic needle of deflection magnetometer).
2. The magnetometer is kept at the center of the coil and rotated so that the aluminum pointer reads 0º-0º.
3. Two terminals of the coil having proper number of turns are selected and connected to the two opposite terminals of the commutator.
4. A battery, key, ammeter, and rheostat are connected in series with the other two terminals of the coil.
5. The rheostat is adjusted so that the deflection is about 60º.
6. The ammeter reading 'i' is noted.
7. The two ends of the aluminum pointer are read (θ_1, θ_2).
8. Then the current through the coils are reversed using commutator and the two ends of aluminum pointer are read (θ_3, θ_4).
9. The average deflection 'θ' is calculated.
10. The magnetometer is moved towards east in steps of 2 cm each time and the deflections before and after reversal of current are noted, until the deflection falls to 30º.
11. The experiment is repeated by shifting the magnetometer towards west from the center of the coil insteps of 2 cm, each time and deflection are noted before and after reversal of current.

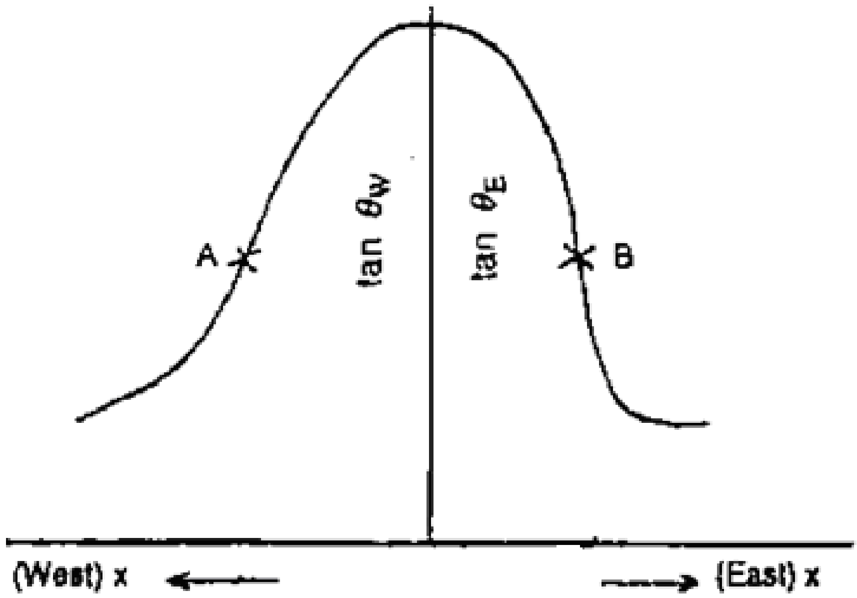
Observations:

n = number of turns of the coil =
i = current passing through the coil =
a = radius of the coil =
B_e = earth's magnetic field = $0.38\times\ 10^{-4}\ tesla$
μ_0 = permeability = $4\pi \times 10^{-7} H/m$

Distance from centre of the coil(x) meters	Deflections on East						Deflections on West						$\theta = \frac{\theta_E + \theta_W}{2}$	Tan(θ)	B= B_e tan θ	B= $\frac{\mu_0 nia^2}{2\,(x^2+a^2)^{3/2}}$
	θ_1	θ_2	θ_3	θ_4	θ_E	tan(θ_E)	θ_1	θ_2	θ_3	θ_4	θ_W	tan(θ_W)				

CALCULATIONS:

GRAPH: A graph is drawn between the distance (x) and the magnetic field (or) tanθ. It gives the variation of the magnetic field.



RESULT: The variation of magnetic field along the axis of circular coil carrying current is studied

VIVA VOCE

1. **What is magnetic field induction (B)?**
   Total number of magnetic lines of force crossing unit area in perpendicular direction Unit is Weber/meter^2 or tesla. CGS units are GAUSS

2. **What is Oersted experiment?**
   Oersted discovered connection between electricity and magnetism. Current carrying conductor behaves like a magnet and can attract iron filling and can induce permanent magnetism in small magnetic needle.

3. **What is Ampere's Law?**
   Ampere's Law specifically says that the magnetic field created by an electric current is proportional to the size of that electric current with a constant of proportionality equal to the permeability of free space.

4. **What is Tangent Law?**
   Tangent Law: If a small bar magnet is suspended in two mutually perpendicular uniform magnetic field, B and B_H , such that it come to rest making an angle Θ with direction of field B_H, then $B = B_H \tan\theta$

5. **How magnetic field is produced in this experiment?**
   When current flows through a coil, magnetic field is produced around it.

6. **In what direction magnetic field is developed?**
   The magnetic field produced are in perpendicular direction to the plane of the coil.

7. **What is the use of commutator in this experiment?**
   It consists of four keys used to change the direction of current.

8. **What is the direction of magnetic field at the centre?**
   At the centre of the circular coil the field is maximum and is perpendicular to the coil.

9. **How does magnetic field vary with distance?**
   Field decreases on either side of the coil.

10. **What is the use of rheostat in this experiment?**
    A rheostat is a variable resistor which is used to control current.

SPACE FOR GRAPH SHEET

5. HALL EFFECT

AIM: To determine Hall coefficient of a given semiconductor.

APPRATUS: Electromagnet, digital gauss meter, constant current power supply, Hall effect setup

THEORY: L, W and t are the length, width and thickness of a semiconductor rectangular strip. A current 'I' flows along the length of the strip. A magnetic field 'H' is applied along the thickness of the strip. An electric field E_H (Voltage V_H) is developed along the width of the strip. This electric filed E_H is known as Hall electric field (Voltage developed is called Hall Voltage V_H) and this effect is called as HALL EFFECT.

This effect is very useful in determining

a) Type of semiconductor (Whether P-Type or N-Type)
b) Carrier concentration(N)
c) Mobility of charge carriers(μ)

$E_H = \frac{\mathbf{I}}{t \times W} \frac{1}{Ne} H$

Due to E_H a voltage V_H is developed across 1 and 2.

$V_H = E_H \times w = \frac{\mathbf{I}}{t} \frac{1}{Ne} H$

Hall coefficient (R_H) $= \frac{\mathbf{1}}{\boldsymbol{Ne}} = \frac{V_H \times \boldsymbol{t}}{\boldsymbol{I} \times \boldsymbol{H}}$

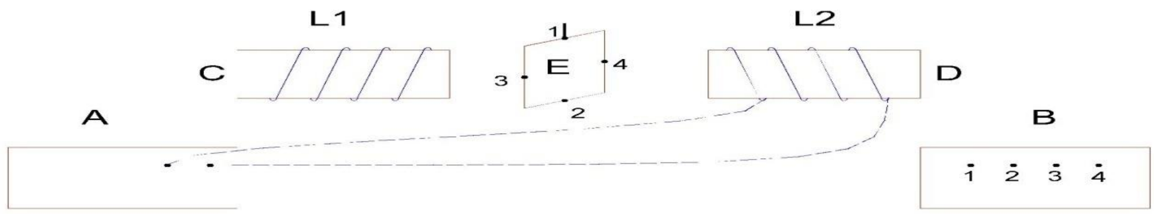
V_H is Hall voltage

t is thickness of sample

I is current passing through the Hall probe and

H is applied magnetic field strength

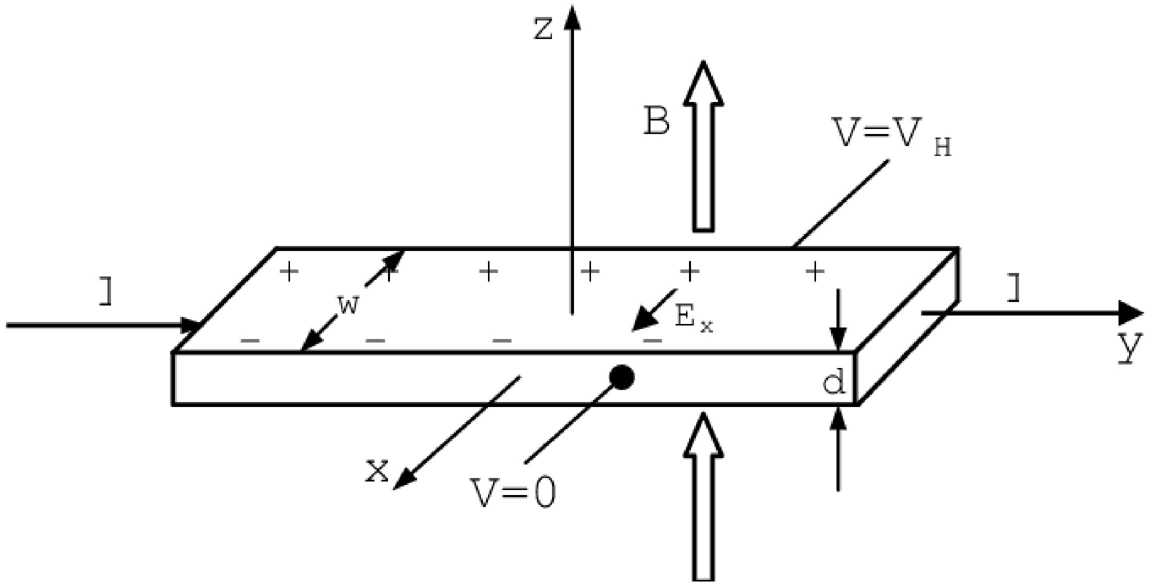
EXPERIMENTAL ARRANGMENT



1. ELECTROMAGNET: C and D are two soft iron cylinders. L_1 and L_2 are two coils (Energizing) wound on iron cylinders.
2. Power supply for electro magnet: A is a power supply that drives constant current through the coils L_1 and L_2, the current can be varied from 0 - 4 amp.
3. Hall probe: E is a germanium crystal. Current is passed through the opposite faces 1 and 2(red and black leads).Hall voltage is developed across the faces 3 and 4(yellow and green leads).
4. Hall Effect set up: B is a Hall Effect set up. 1 and 2 are the terminals of digital milli ammeter while 3 and 4 are the terminals of digital milli voltmeter. The digital milli voltmeter measures Hall voltage.
5. Digital Gauss meter: The magnetic field in the space between C and D is measured using digital Gauss meter.

PROCEDURE:

1. Keep the probe of Gauss meter in the space between C and D and adjust the current from A until the Gauss meter shows a magnetic field strength of 1000 Gauss. Remove the Hall probe.
2. Insert the Hall probe E in the space CD .Connect the Red and Black leads of the Hall probe to the terminals 1 and 2 of milli ammeter.
3. Connect the Yellow and Green leads of the Hall probe to 3 and 4 of milli voltmeter.
4. Adjust the current and note the Hall voltage. Change the magnetic field to a different value and note the Hall voltage. Thus by changing the magnetic field note the Hall voltage.



Current through Hall probe (I) =_______mA

S.No	**Magnetic field strength (H) Gauss**	**Hall voltage(V_H) mV**

RESULT: Hall coefficient (R_H) of the given semiconductor is =___________Cm^3/Coulomb

VIVA VOCE

1. **What is Hall Effect?**

   When a current carrying specimen (semiconductor/conductor) is placed in a transverse magnetic field, a voltage is developed which is perpendicular to both, direction of current and magnetic field. This phenomenon is known as Hall Effect

2. **Why is Hall potential developed?**

   When a current carrying conductor is placed in a transverse magnetic field the magnetic field exerts a deflecting force (**Lorentz Force**) in the direction perpendicular to both magnetic field and drift velocity. This causes charges to shift from one surface to another thus creating a potential difference.

3. **What is the significance of this experiment?**

   We can distinguish N-type semiconductor from P-type semiconductor, we can measure Carrier concentration (n) and mobility (μ) of the charge carriers.

4. **If Hall coefficient (R_H) is positive, what is the conclusion?**

Given Semiconductor is P-type.

5. **If Hall coefficient (R_H) is negative, what is the conclusion?**

Given Semiconductor is N-type.

6. **What are the majority charge carriers in P-type and N-type semiconductors?**

In P-type holes are majority carriers i.e. current conduction is due to holes.

In N-type electrons are majority carriers i.e. current conduction is due to electrons.

7. **What is the Unit of hall coefficient (R_H)?**

Cm^3/ Coulomb

8. **What is the Unit of magnetic field?**

Weber/$meter^2$ or Tesla / Gauss (CGS)

9. What is the use of different apparatus used in this experiment?

Electromagnet: To produce desired value of magnetic field by passing current.

Constant current power supply: To supply constant value of current for electromagnet to produce desired value of magnetic field.

Gauss meter: To measure the strength of magnetic field between two poles of electromagnet.

Hall Effect setup: To pass desired value of current through Hall probe and to measure Hall voltage (V_H)

10. List out some Real time Applications of Hall effect?

Hall probes are often used as magnetometers, i.e. to measure magnetic fields, or inspect materials (such as tubing or pipelines) using the principles of magnetic flux leakage.

A **Hall Effect sensor** is a transducer that varies its output voltage in response to a magnetic field.

Hall effect sensors are used for proximity switching, positioning, speed detection, and current sensing application.

6. PHOTO ELECTRIC EFFECT

AIM: To determine work function of a given material and Planck's constant.

APPARATUS: Photo emissive cell mounted in a box provided with a wide slit D.C Power supply, set of filters, filters stand, light source

FORMULA: Planck's constant $h = \frac{e(V_2 - V_1)\lambda_1\lambda_2}{c(\lambda_1 - \lambda_2)}$

e = Electronic charge

V_2 = Stopping potential * corresponding to wave length 2

V_1 = Stopping potential * corresponding to wave length 1

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

λ_1 and λ_2 = wave length of colour filters (blue,green,yellow,orange)

$$W_0 = h\vartheta - eV$$

h= Planck's constant

ϑ = frequency

W_0 = Work function

CIRCUIT DIAGRAM:

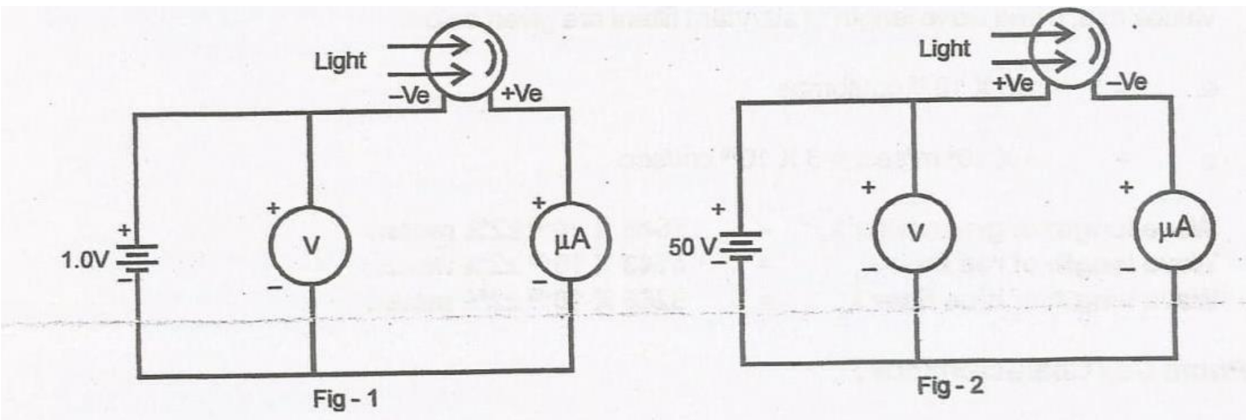


Fig - 1

Fig - 2

PROCEDURE:

1. Keep the left hand side switch on the panel towards sensitive side and right hand side switch towards 1.0 V switch on the unit. Now set the μA reading to zero with the help of potentiometer marked with zero adjustment.

2. The circuit connections are made as shown in the diagram (Fig-1). Be careful about the polarity shown in diagram.

3. A light source is arranged. The light is allowed to fall on the tube. The distance between tube and light source is adjusted such that there is a deflection of about 8 to 10 div. in μA. Now a suitable filter (Say green) of known wave length is placed in the path of light (in the slit provided) say it is wave Length λ_2.

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

5. A small -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 wave length λ_2

7. The experiment is repeated after replacing the green filter with blue and red filters. Say with wave length λ_2 and λ_3 respectively and stopping potential V_1 and V_3 are noted.

8. Taking negative anode potential on x-axis and corresponding deflections in micro-ammeter on y-axis, graphs are plotted for difference filters.

9. By using above values Plank's Constant 'h' is calculated by formula given. Standard values of e, c and wave length of standard filters are given below.

$$e = 1.6 \times 10^{-19}\ C$$

$$C = 3 \times 10^{8}\ m/sec$$

Wave length of blue filter $\lambda_1 = 4850 \times 10^{-10} \pm 2\%$ meter

Wave length of green filter λ_2 = 5650 x 10^{-10} ± 2% meter

Wave length of yellow filter λ_3 = 5900 x 10^{-10} ± 2% meter

Wave length of orange filter λ_4 = 6250 x 10^{-10} ± 2% meter

$W_0 = h\gamma - eV$ = work function

S. No.	**Colour of the filter**	**Frequency (γ)**	**Stopping Potential (V)**	$W_0 = h\gamma - ev$
1	Blue			
2	Green			
3	Yellow			
4	Orange			

CALCULATION:

RESULT: Planck's constant of given photo metal (h) is____________J-S and work function (w_0) is eV

VIVA VOCE

1. **What is photo electric effect?**

   The photoelectric effect is the emission of electrons or other free carriers when light shines on a material. Electrons emitted in this manner can be called photo electrons. This phenomenon is commonly studied in electronic physics, as well as in fields of chemistry, such as quantum chemistry or electrochemistry.

2. **What is meant by threshold frequency?**

   Threshold frequency is defined as the minimum frequency of incident light which can cause photo electric emission i.e. this frequency is just able to eject electrons without giving them additional energy.

3. **What do you mean by work function?**

   The photoelectric work function is the minimum photon energy required to liberate an electron from a substance, in the photoelectric effect. If the photon's energy is greater than the substance's work function, photoelectric emission occurs and the electron is liberated from the surface.

4. **Can all monochromatic light sources are able to eject electrons from the surface of the photo metal?**

   Monochromatic light is used in the experiment. Lower the wavelength of light, the higher the energy of the emitted electrons.

5. **Even for zero applied anode voltage, ammeter shows the current. How can you explain this situation?**

   Consider a situation in which the voltage across the plates is zero. Photons of sufficient frequency strike the outermost surface of the cathode, emitter plate. Electrons become free from the attraction of nucleus as their net energy becomes positive.

6. **What is the difference between the photo electronic cell, photo conductivity cell and photo voltaic cell?**

   Light sensors are more commonly known as “Photoelectric Devices” or “PhotoSensors” because they convert light energy (photons) into electricity (electrons).Thus, more light increase the current for a given applied voltage. The most common photoconductive material is Cadmium Sulphide used in LDR photocells.

Space for the graph

7. LASER

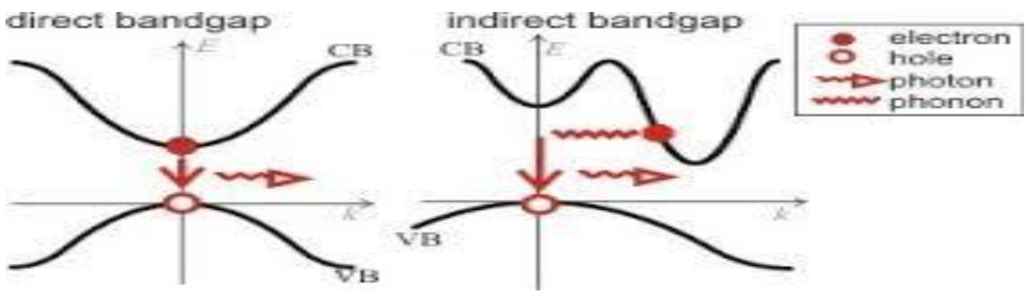
AIM: To study the V-I and P-I characteristics of the LASER sources**.**

APPARATUS: Micro Laser Diode Characteristics board comprising of:

1. Laser diode.
2. 0-5 V variable supply for laser diode.
3. 20 mW digital optical power meter to measure optical power of Laser diode.
4. 20 V digital voltmeter to measure voltage across laser diode.
5. 200 mA dc digital ammeter to measure laser diode current.

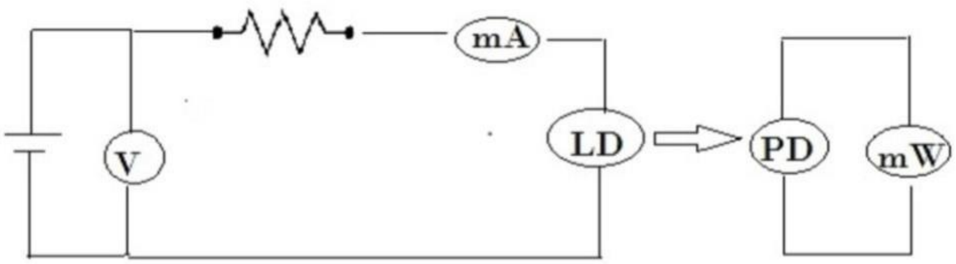
THEORY: Laser diodes are electronic devices which work on the principle of electroluminescence.

These are made up of direct band gap materials (materials for which maximum of valence band and minimum of conduction band lie for same value of K) Example: GaAs, In P etc.



Materials for which maximum of valence band and minimum of conduction band do not occur at same value of K are called indirect band gap materials. Example: Si and Ge

CIRCUIT DIAGRAM:



Electrical Characteristics:

The V-I curve: The voltage drop across the laser is often acquired during electrical characterization. This characteristic is similar to the analogous characteristic of any other type of semiconductor diode and is largely invariant with temperature, as depicted in Figure. The typical voltage drop across a laser diode at operating power is 1.5 volts. V/I data is most commonly used in derivative characterization techniques.

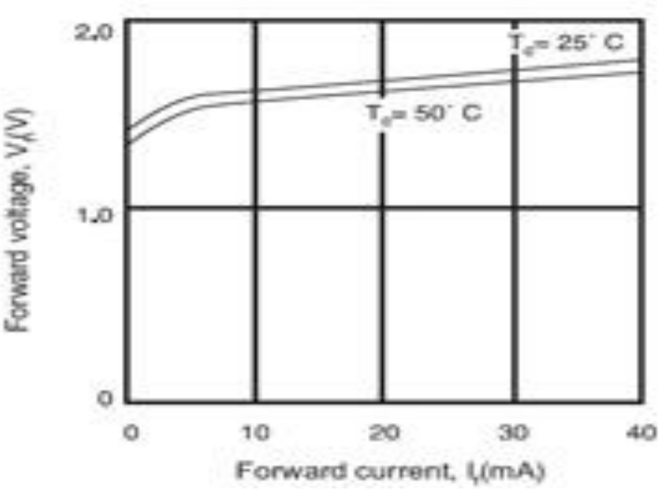
Procedure for V-I characteristics of a laser diode:

1. Connect the circuit as per the circuit given.
2. Slowly increase supply voltage using variable power supply using coarse and fine knobs.
3. Note down the current through the laser diode at increasing values of laser diode voltage of 0.5 V, 1.0 V, 1.5 V, 2.5 V.
4. Do not exceed current limit of 30 mA else the laser diode may get damaged.
5. Plot a graph of laser diode voltage V_s laser diode current as shown in figure (As this experiment is conducted at room temperature, only one graph for a single temperature will be obtained.

Observations:

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

GRAPH:



The P-I Curve.

The most common of the diode laser characteristics is the P-I curve .It plots the drive current applied to the laser against the output light intensity. This curve is used to determine the laser's operating point (drive current at the rated optical power) and threshold current (current at which lasing begins). The efficiency of a diode laser is also derived from the P-I curve. It is most commonly expressed as slope efficiency and measured in units of mW/mA.

We know that,

Power (P) α I^2R

Where, I is current and
R is resistance.
As, voltage increases current increases (V α I) and as current increases the intensity of laser diode increases and as a result the number of electrons which are coming out of the laser diode increases. Hence the reading of wattmeter will also increases.

Procedure for P-I characteristics of laser diode:

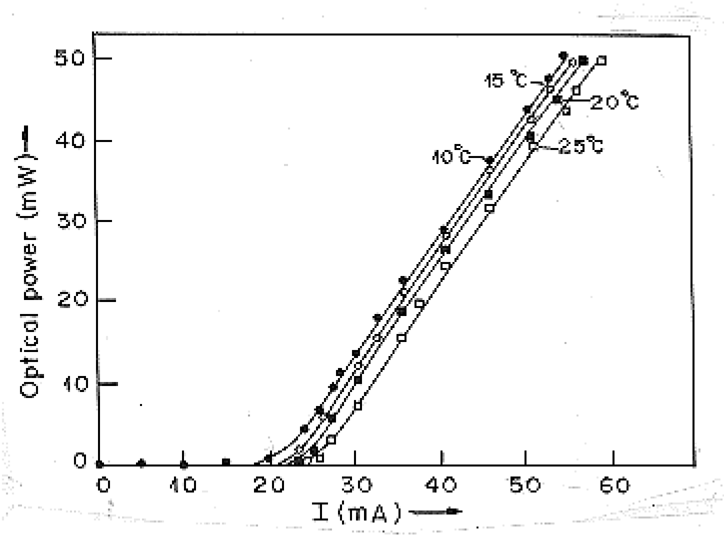
1. Connect the laser diode circuit as shown below.
2. Slowly increase supply voltage (current) using variable power supply coarse and fine knobs.
3. Note down the optical power measured by the optical power meter in mW at increasing current through the laser diode from 5 mA to 26 mA at 1 mA step.
4. Do not exceed current limit of 30mA else the laser diode may get damaged.

5. Plot a graph of laser diode optical power Vs laser diode current as shown in figure 2. (As this experiment is conducted at room temperature, only graph for a single temperature will be obtained.

Observations:

S.No	Voltage(v)	Power(mW)

GRAPH:



RESULT: ______ and ______ characteristics of laser diode are studied.

VIVA VOCE

1. **What are n-type and p-type semiconductors?**
   An n-type semiconductor is created by adding pentavalent impurities like phosphorus (P), arsenic (As), or antimony (Sb). A pentavalent impurity is called a donor because it is ready to give a free electron to a semiconductor. P-type Semiconductor is created due to addition of trivalent impurities such as boron, aluminum or gallium to an intrinsic semiconductor creates deficiencies of valence electrons called "holes".

2. **Explain the working of a laser diode?**
   Forward biasing to cause population inversion and hence stimulated emission.

3. **What do you understand from V-I characteristics of a laser diode?**
   After Knee voltage, as the voltage increases the current increases i.e.; V α I

4. **What do you understand from P-I characteristics of a laser diode?**
   As, voltage increases current increases (V α I) and as current increases the intensity of laser diode increases as a result the number of electrons which are coming out of the laser diode increases. Hence the reading of wattmeter will also increases. i.e.; V α L

5. **What type of biasing is used in this experiment?**
   Forward biasing to cause population inversion and hence stimulated emission.

6. **What are the real time applications of laser diode?**
   CD and DVD players,
   Barcode scanners,
   Remote control applications
   Fiber optic communication
   Integrated circuits
   High speed long distance communications.

SPACE FOR GRAPH SHEET

SPACE FOR GRAPH SHEET

8. OPTICAL FIBER

AIM: To determine the bending losses of optical fibers.

APPARATUS: Optical fiber kit, one-meter optical fiber cable, Mandrel, patch cards.

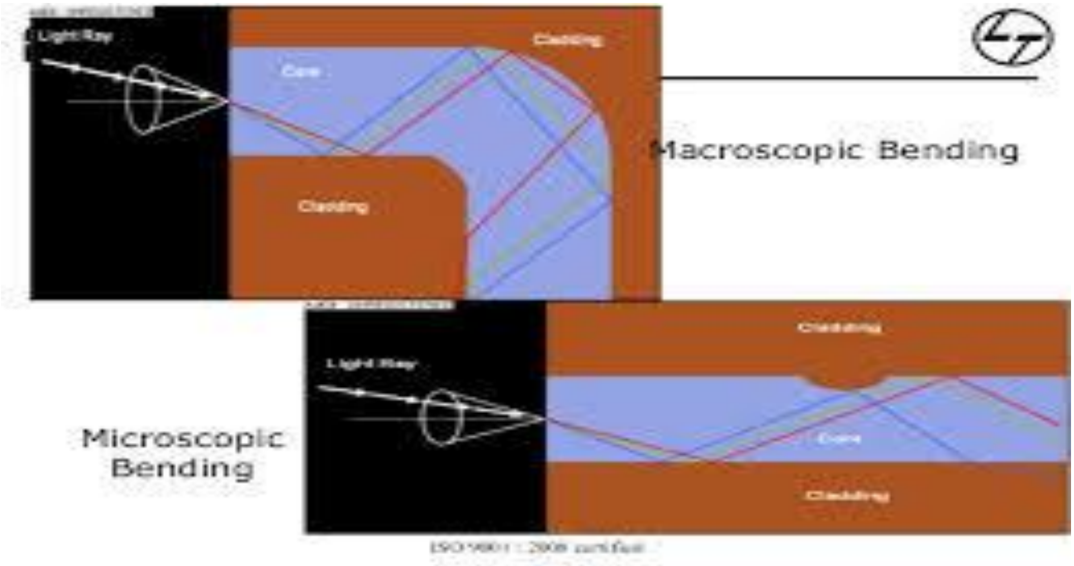
THOERY:

Attenuation:

Attenuation or loss in optical fibers basically refers to the loss of power. During transit, light pulse loses some of their photons, thus reducing their amplitude. Attenuation for a fiber is usually specified in decibels per kilometre. The degree of attenuation depends on the wavelength of light transmitted.

- The various losses in optical fiber cable are due to
  1. Absorption
  2. Scattering
  3. Bending
  4. Dispersion
- The loss which exists when an optical fiber undergoes bending is called bending loss.
- There are two types of bending

1) **Macroscopic Bending:** Bending in which complete fiber undergoes bends which causes certain modes not to be deflected and therefore causes loss to the cladding.
2) **Microscopic Bending:** Either the core or cladding undergoes slight bends at its surface . It causes light to be reflected at angles when there is no further reflection.



FORMULA:

Attenuation is defined as the ratio of the optical input power to the output power in the fiber of length L.

$$\propto = -\frac{\mathbf{10}}{\boldsymbol{L}} \boldsymbol{log}\left(\frac{\boldsymbol{P_{in}}}{\boldsymbol{P_{out}}}\right) \boldsymbol{dB/km}$$

Where, P_{in} = Input Power (Transmitted)

P_{out}=Output Power (Received)

α is Attenuation constant

L is length of optical fiber = 1 meter cable

Therefore LOSS = P_{in}-P_{out} dB/km

A decibel (dB) is a unit used to express relative differences in signal strength.

A decibel is expressed as the base 10 logarithm of the ratio of the power of two signals

(P_{in} and P_{out}).

dB = 10 × Log_{10}(P1/P2)

Where Log_{10} is the base 10 logarithm, and P1 and P2 is are the powers to be compared.

PROCEDURE:

1. Connect one end of optical fiber to the reference light source and the second end to the optical power meter. Make sure that the optical fiber is straight and no bends or loops are present.

2. Connect the optical power meter terminals to power display unit through patch cards (Red to Red, Black to Black terminals).

3. By using the variable knob select certain amount of power to be transmitted through the optical fiber.

4. Hold the optical fiber straight and note the power reading displayed in the power meter as P_{in}.

5. Bend the optical fiber for one turn with the help of mandrel and note the power meter reading.

6. Repeat the same procedure for four turns and note the readings.

7. Take the mean of all these readings as P_{out}.

8. The difference of P_{in} and P_{out} is the loss of power due to bending of optical fiber.

9. Take the average of all the readings and divided by 10 to measure the bending loss of given optical fiber.

To Determine bending losses in optical fiber:

S.No	Output power Without bending of Optical Fiber(P_{in})	Out power with bending of Optical Fiber(P_{out})dB					Loss= P_{in}-P_{out} (dB)
		1 turn	2 turn	3turn	4turn	Mean	

CALCULATION:

RESULT: The Bending loss is determined in the given optical fiber is_________dB/meter

VIVA VOCE

1. **What are various parts of optical fiber?**
   Core – Thin glass center of fiber where light travels
   Cladding - Outer optical material surrounding the core
   Buffer jacket - Coating that protects the fiber.

2. **How should be the refractive index of core and cladding?**
   Refractive index of core should be high compared to cladding for TIR.
3. **What is the basic principle behind the propagation of light through optical fiber?**
   Total Internal Reflection.
4. **What is Total Internal Reflection?**
   When the light rays launched from denser medium at an angle of incidence greater than the critical angle, then all the light rays are reflected back into the denser medium.
5. **What is critical angle?**
   The incidence angle in denser medium for which the angle of refraction is 90° in rarer medium.
6. **Define Attenuation in optical fiber?**
   Attenuation in an optical fiber is caused by absorption, scattering, and bending losses. Attenuation is the loss of optical power as light travels along the fiber.
   Signal attenuation is defined as the ratio of optical input power (P_i) to the optical output power (P_o).

7. **Define Numerical aperture?**

   The sin of acceptance angle is called as Numerical Aperture.

8. **What is the significance of Numerical aperture?**

   It gives the Light gathering ability of an optical fiber.

9. **What is Acceptance angle?**

   Acceptance angle (θ_a) is the maximum angle made by the light ray with the fiber axis, so that light can propagate through the fiber after total internal reflection.

10. **What is Acceptance cone?**

    Acceptance cone is derived by rotating the acceptance angle about the fiber axis.

11. **What are various attenuations present in optical fiber?**

    The various losses in optical fiber cable are due to

Absorption

Scattering

Bending

Dispersion

12. **Losses in optical fibers are measured in ___________unit?**

    dB/kilometer

9. LCR - CIRCUIT

AIM: To determine the resonant frequency and quality factor of LCR circuit in series and parallel.

APPARATUS: Capacitor, resistor, voltmeter, ammeter, frequency, generator, inductor, connecting wires

PRINCIPLE: If the value of the frequency of applied signal is so adjusted that the impedance of the circuit becomes minimum. The current flowing through the circuit will be maximum. This particular frequency at which the impedance of the circuit becomes minimum and therefore the current becomes maximum is called the resonant frequency.

FORMULA: Quality factor $Q = \frac{f_r}{|f_1 - f_2|}$

Resonant frequency for LCR circuit in series and parallel connections

Where, $f_r = \frac{1}{2\pi\sqrt{LC}}$

f_r = Resonant frequency in Hz

L = Inductance in henrys

C = capacitance in faradays'

THEORY: We know that inductive reactance $X_L = 2\pi fL$ means inductive reactance is directly proportional to frequency (X_L and prop f). When the frequency is zero or in case of DC, inductive reactance is also zero, the circuit acts as a short circuit; but when frequency increases; inductive reactance also increases. At infinite frequency, inductive reactance becomes infinity and circuit behaves as open circuit. It means that, when frequency increases inductive reactance also increases and when frequency decreases, inductive reactance also decreases. It is clear from the formula of capacitive reactance $X_C = 1 / 2\pi fC$ that, frequency and capacitive reactance are inversely proportional to each other. In case of DC or when frequency is zero, capacitive reactance becomes infinity and circuit behaves as open circuit and when frequency increases and becomes infinite, capacitive reactance decreases and becomes zero at infinite frequency, at that point the circuit acts as short circuit. The inductive and capacitive reactance becomes equal and the frequency at which these two reactance

become equal, is called resonant frequency, f_r. At resonant frequency, $X_L = X_C$

At resonance f = f_r and on solving above equations we get

$$, \quad f_r = \frac{1}{2\pi\sqrt{LC}}$$

PROCEDURE:

1. Connect the circuit as shown in figure. Connect resistance R, capacitor C and inductor L in the circuit.
2. Connect function generator across input of the circuit as shown in figure.
3. Switch ON the function generator using ON/OFF switch provided on the front panel. Set the output of function generator to sine wave signal of approximately 3VAC RMS and set the frequency at 100Hz.
4. Increase the frequency in small steps towards 10 KHz and every time note down the observations in the table no.1. At a particular frequency, current starts decreasing. The frequency at which current starts decreasing is the Resonance Frequency.
5. Repeat the procedure for different values of R and C.
6. Plot a graph between frequency Vs current by taking frequency on X-axis and current aY-axis as shown in plot.

Circuit for LCR Series:

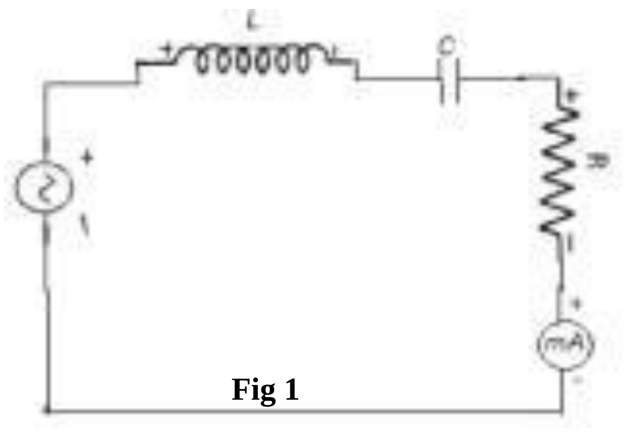


Fig 1

model graph:

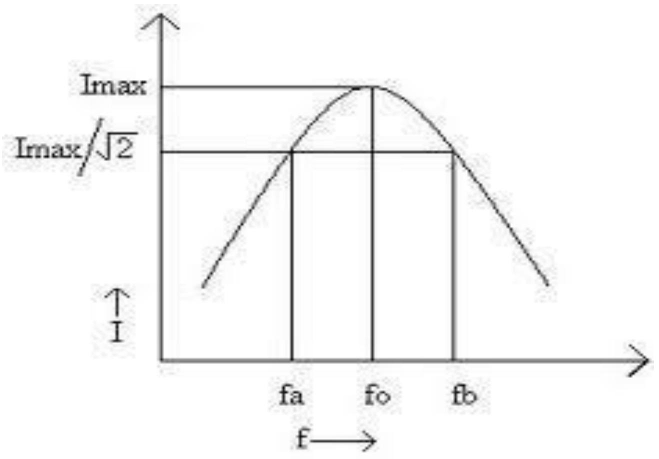


figure 2

SERIES LCR CIRCUIT

S.No	Frequency (Hz)	Current (mA)

L = --------------------- mH

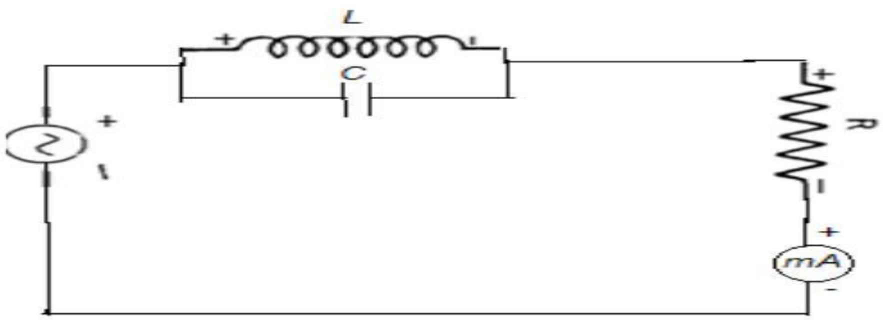
C = --------------------- μF.

R= ---------------------- Ω

CALCULATIONS:- Calculation from the graph(series resonant circuit)

1. Band width Δf = $|f_1 - f_2|$
2. Quality factor $Q = \frac{f_r}{|f_1 - f_2|}$
3. Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$

CIRCUIT FOR LCR PARALLEL:



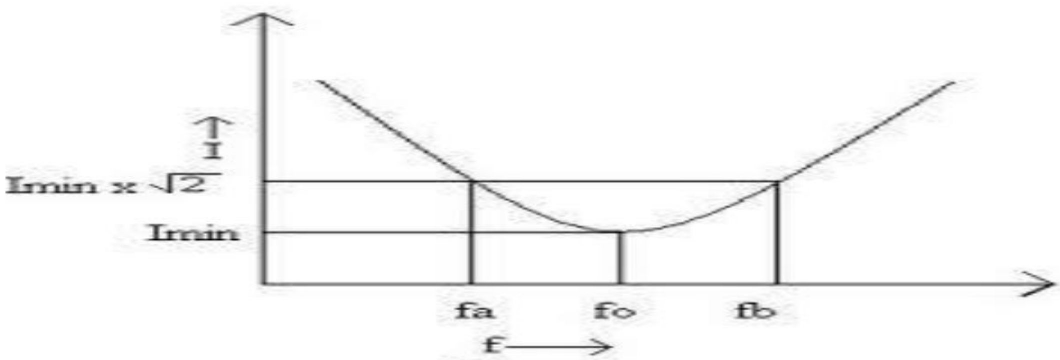


figure 4

Parallel LCR Circuit

. **L = --------------------- mH**

C = --------------------- μF.

R= ---------------------- Ω

S.No	Frequency (Hz)	Current (mA)

Calculation from the graph (parallel resonant circuit)

1. Resonant frequency ($\boldsymbol{f_r}$)=
2. Band width Δf = $|f_1 - f_2|$
3. Quality factor $Q = \frac{f_r}{|f_1 - f_2|}$

Result: Resonant frequency for LCR Series Circuit ($\boldsymbol{f_r}$) = ________ Hz

Resonant frequency for LCR Parallel Circuit ($\boldsymbol{f_r}$) = ________ Hz

Quality factor for LCR Series Circuit (Q) =____________

Quality factor for LCR Parallel Circuit (Q) = ____________

VIVA VOCE

1. **What is the function of A.F. oscillator?**

   An A.F oscillator is a device which can produce sinusoidal waveforms of any desired frequency ranging from 20Hz to 20 KHz.

2. **What do you mean by sharpness of resonance?**

   It is a measure of the rate of fall of current amplitude from its maximum value at resonance frequency to on either side of it.

3. **What is resonance frequency?**

   The frequency at which the resonance occurs is called resonance frequency.

4. **What is meant by resonance?**

   When the applied frequency matches with the natural frequency of a body, the amplitude of vibration becomes maximum. This phenomenon is called resonance.

5. **What is bandwidth of series circuit?**

   The range of frequencies between the cut-off frequencies is called bandwidth.

6. **Define quality factor of a series circuit.**

   The ratio of a resonant frequency of a circuit to its bandwidth is called quality factor.

7. **Why is the series circuit called as acceptor circuit?**

   Because it accept one frequency component out of the input signals having different frequencies. The accepted frequency is equal to its own resonance frequency.

8. **Why parallel resonance circuit is called a rejecter circuit?**

   Because it rejects the signal having same frequency as its own frequency.

9. **What is the importance of series resonance circuits?**

   For high frequency A.C in radio communications, a series resonance circuit is used.

   LCR circuits are used in frequency filter circuits like high pass filter, low pass filter and band pass filter.

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10. R-C CIRCUIT

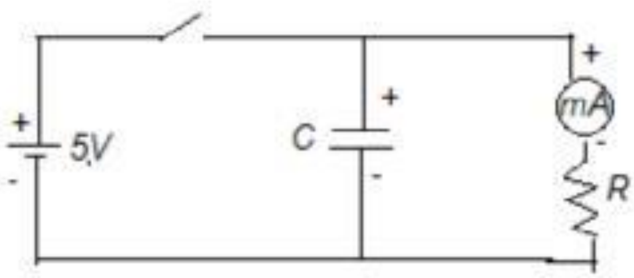
AIM: To determine the time constant of R-C circuit during charging and discharging

APPARATUS: D.C. Voltage source, resistors, a capacitor, digital micro ammeter, Charge and discharge key.

FORMULA: $\tau = R \times C$

Where τ is time constant

CIRCUIT DIAGRAM:



THEORY: When a condenser 'C' is charged through a resistance 'R' then charge increases exponentially in accordance with the formula.

$$Q = Q_O \left(1 - e^{\frac{t}{RC}}\right)$$

Where Q is the charge in time t; and

Q_0 is the maximum charge.

The product 'RC' is called time constant. It is the time taken to establish (l – e) part of the maximum charge in the condenser. It is equal to the time taken to establish 0.632 part of the total charge.

When a condenser is discharged through a resistance, the charge falls in accordance with the formula.

$$Q = Q_O e^{\frac{-t}{RC}}$$

The time constant in this case is equal to the time, taken to decrease the charge of ‘e’ part of the maximum charge. It is equal to the time taken to discharge to a value of 0.368 part of maximum charge.

i.e. we can say that

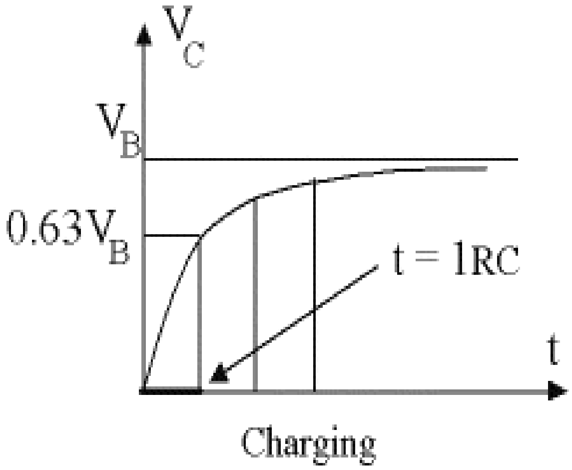
$$I = \frac{dQ}{dt}$$

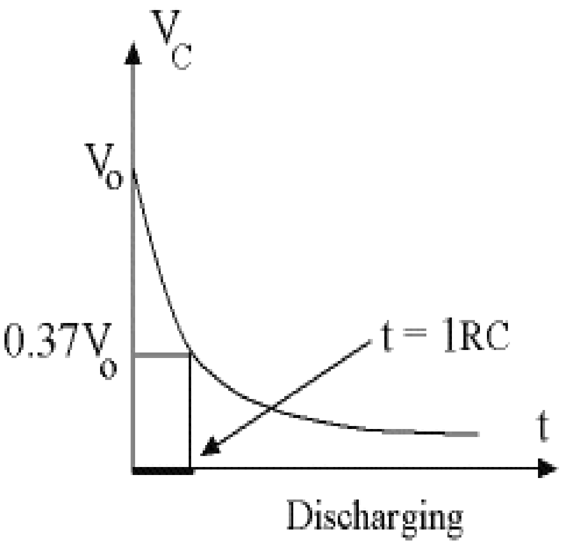
$$= -t_0\, e^{\frac{-t}{RC}}$$

Where C = capacitor in farad R = resistance in ohm I = current in the circuit

When I = 0.36 Io then t = RC

GRAPH:





PROCEDURE: -

1. The circuit is connected as shown in figure, taking one set of R and C. The capacitor C is charged for a short time till the deflection in the galvanometer is maximum, but within the scale.
2. The tap key is then released. The capacitor now starts discharging through the resistor R. The deflection decreases steadily the stop clock is started at a suitable

initial point (need not be maximum) and the deflection is noted at suitable intervals of time.

3. It is continued till the deflection falls below 0.36 of starting value. The experiment is repeated for the other sets of R and C and the observations are tabulated in Table.
4. The time constant is calculated theoretically from the values of R & C used, and also from the graphs;

Observations and results:

<table>
<tr><th rowspan="2">S.No.</th><th rowspan="2">Time sec</th><th colspan="2">Set1R1 = Ω
C1 = μf</th><th rowspan="2">Time sec</th><th colspan="2">Set 2 R2 = Ω
C2 = μf</th></tr>
<tr><th>Voltage(v) Charging</th><th>Voltage(v) discharging</th><th>Voltage(v) Charging</th><th>Voltage(v) discharging</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

RESULT:

RC Time Constant	Theoretical = R×C	Practical (Graph)
R_1 = Ω C_1 = μF		
R_2 = Ω C_2 = μF		

VIVA VOCE:

1. **What is the definition of time constant in R-C circuit?**

   Time constant is the time in seconds required to charge a capacitor to 63.2% of the applied voltage. This period is referred to as onetime constant. After two time constants, the capacitor will be charged to 86.5% of the applied voltage.

2. **Why does a capacitor discharge?**

   When a voltage is placed across the capacitor the potential cannot rise to the applied value instantaneously. As the charge on the terminals builds up to its final value it tends to repel the addition of further charge. The resistance of the circuit through which it is being charged or is discharging.

3. **Why does current decreases when discharging a capacitor?**

   The reason that it often is not constant is that we are discharging the capacitor through a resistor. And since the capacitor is discharging, the voltage across it is decreasing, and thus, because of Ohm's Law (V = I R), when the voltage decreases, the current must also decrease, while the resistance remains constant.

4. **How does a capacitor stores energy?**

   The energy stored in a capacitor is almost entirely in the electric field produced between the plates. It takes energy from a battery or some other power source to move electrons to one of the plates and away from the other. This makes one plate positively charged and the other negatively charged.

5. **Why capacitor does not allow DC?**

A capacitor allows no current to flow "through" it for DC voltage (i.e. it blocks DC). The voltage across the plates of a capacitor must also change in a continuous manner, so capacitors have the effect of "holding up" a voltage once they are charged to it, until that voltage can be discharged through a resistance.

6. **When the capacitor is fully charged?**

Once the Voltage at the terminals of the Capacitor, v_c, is equal to the Power Supply Voltage, $v_c = V$, the Capacitor is fully charged and the Current stops flowing through the circuit, the Charging Phase is over.

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