Parul University

FACULTY OF ENGINEERING AND TECHNOLOGY

BACHELOR OF TECHNOLOGY

ENGINEERING PHYSICS (03192101)

B. Tech. 1st year

Applied Science and Humanity

Laboratory Manual

Instructions to students

1. The main objective of the Engineering Physics laboratory is: ***Learning Engineering Physics through the Experimentation***. ***All the experiments are designed to illustrate various phenomena in different areas of* Engineering Physics *and also to expose the students to various instruments and their uses***.
2. Be prompt in arriving to the laboratory and always come well prepared for the experiment.
3. Be careful while working on the equipment's operated with high voltage power supply.
4. Work quietly and carefully. Give equal opportunity to all your fellow students to work on the instruments.
5. Every student should have his/her individual copy of the Engineering Physics *Practical Book.*
6. Every student has to prepare the notebooks specifically reserved for the Engineering Physics practical work:" *Engineering Physics Practical Book"*
7. Every student has to necessarily bring his/her *Engineering Physics Practical Book*, *Engineering Physics Practical Class Notebook* and *Engineering Physics Practical Final Notebook*, when he/she comes to the Practical to perform the experiment.
8. Record your observations honestly. Never makeup reading or doctor them either to get a better fit on the graph or to produce the correct result. Display all your observations on the graph (if applicable)
9. All the observations have to be neatly recorded in the *Engineering Physics Practical Class Notebook* (as explained in the *Engineering Physics Practical Book*) and verified by the instructor before leaving the laboratory.
10. If some of the readings appear to be wrong then repeat the set of observations carefully.
11. Do not share your readings with your fellow student. Every student has to produce his/her own set of readings by performing the experiment separately.
12. After verification of the recorded observations, do the calculation in the *Engineering Physics Practical Class Notebook* (as explained in the *Engineering Physics Practical Book*) and produce the desired results and get them verified by the instructor.
13. Never forget to mention the units of the observed quantities in the observation table. After calculations, represent the results with appropriate units.
14. Calculate the percentage error in the results obtained by you if the standard results are available and also try to point out the sources of errors in the experiment.
15. Find the answers of all the questions mentioned under the section '*Find the Answers*' at the end of each experiment in the *Engineering Physics Practical Book.*
16. Finally record the verified observations along with the calculation and results in the *Engineering Physics Practical Notebook.*
17. Do not forget to get the information of your next allotment (the experiment which is to be performed by you in the next laboratory session) before leaving the laboratory from the Technical Assistant.
18. The grades for the Engineering Physics practical course work will be awarded based on your performance in the laboratory, regularity, recording of experiments in the *Engineering Physics Practical Final Notebook*, lab quiz, regular viva-voce and end-term examination.

CERTIFICATE

This is to certify that

Mr./Ms.…………………………………………………

with enrolment no. …………………………has successfully

completed his/her laboratory experiments

In Engineering Physics laboratory during the academic

year………….

Date:

Signature of HOD: *Signature of lab teacher:*

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EXPERIMENT NO. 1

LIGHT EMITTING DIODE

OBJECTIVE: To study the I-V characteristic of LED and determine Knee voltage and dynamic resistance of LED.

APPARATUS: Circuit board comprises 0-10 V D.C. at 10 mA, continuously variable regulated power supply, integral current limiting resistor, Digital voltmeter, digital current meter, LED, Patch chords.

THEORY: Light Emitting Diodes

Light Emitting Diodes or **LED´s** are among the most widely used of all the different types of semiconductor diodes available today. They are the most visible type of diode that emit a fairly narrow bandwidth of either visible light at different coloured wavelengths, invisible infra-red light for remote controls or laser type light when a forward current is passed through them. A "**Light Emitting Diode**" or **LED** as it is more commonly called, is basically just a specialized type of PN junction diode, made from a very thin layer of fairly heavily doped semiconductor material.

When the diode is forward biased, electrons from the semiconductors conduction band recombine with holes from the valence band releasing sufficient energy to produce photons which emit a monochromatic (single colour) of light. Because of this thin layer a reasonable number of these photons can leave the junction and radiate away producing a coloured light output. Then we can say that when operated in a forward biased direction **Light Emitting Diodes** are semiconductor devices that convert electrical energy into light energy.

LED Construction

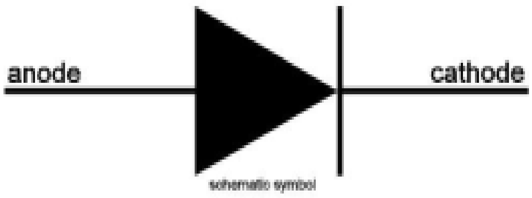
The construction of a light emitting diode is very different from that of a normal signal diode. The PN junction of an LED is surrounded by a transparent, hard plastic epoxy resin hemispherical shaped shell or body which protects the LED from both vibration and shock.

By mixing together a variety of semiconductor, metal and gas compounds the following list of LEDs can be produced

- **Gallium Arsenide (GaAs)** - infra-red
- **Gallium Arsenide Phosphide (GaAs P)** - red to infra-red, orange
- **Aluminium Gallium Arsenide Phosphide (Al Ga As P)** – high-brightness red, orange-red, orange, and yellow
- **Gallium Phosphide (Ga P)** - red, yellow and green
- **Aluminium Gallium Phosphide (Al Ga P**) - green
- **Gallium Nitride (Ga N)** - green, emerald green
- **Gallium Indium Nitride (Ga In N)** – near ultraviolet, bluish-green and blue
- **Silicon Carbide (Si C)** - blue as a substrate
- **Zinc Selenide (Zn Se)** - blue
- **Aluminium Gallium Nitride (Al Ga N)** – ultraviolet

SIMPLE DIODE:

A simple diode is a two terminal electrode device consisting of p – n junction, formed either from germanium (Ge) or silicon (Si) crystal. The circuit symbol of a p – n junction diode or semiconductor diode is shown in Fig.



LIGHT EMITTING DIODE:

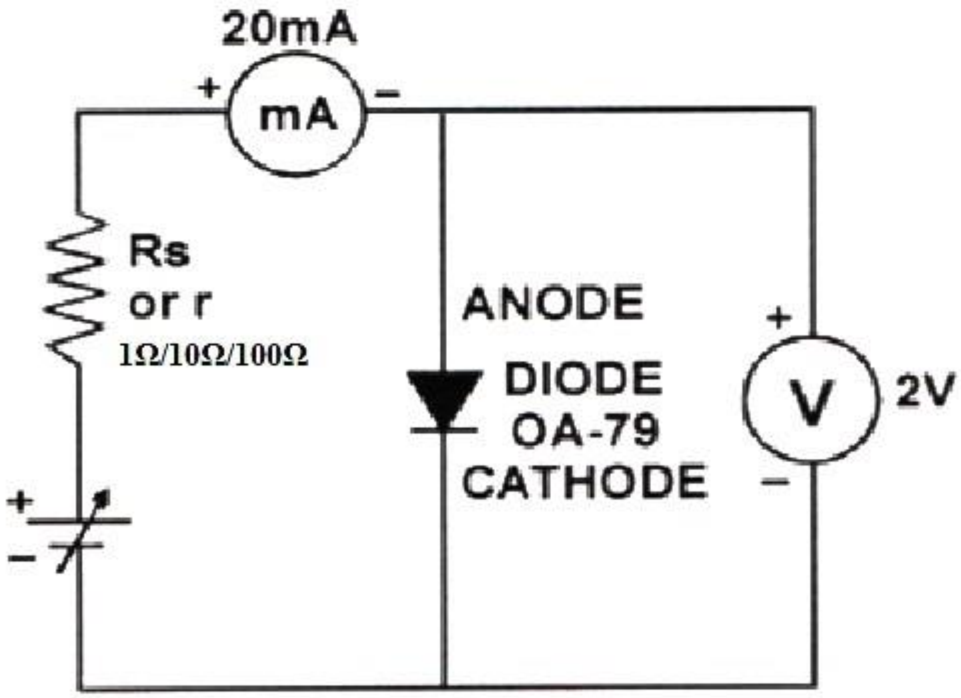
The operation of light emitting diode (LED) is based on the phenomenon of electroluminescence, which is the emission of light from a semiconductor material under the influence of an electric field. LEDs are the best known optoelectronic devices which emit a fairly narrow bandwidth of visible light; usually red, orange, yellow, blue or green. A light emitting diode is a simply a p – n junction diode. It is usually made from semiconductor materials such as aluminium gallium arsenide (Al Ga As) or gallium arsenide phosphide (Ga As P).

FORWARD BIASING:

When the positive end of the battery is connected to the anode of the diode and negative to cathode of the diode, the connection is called forward biasing.

When the p – n junction diode is forward biased and if the applied voltage is gradually increased in steps, at some forward voltage, 0.3 V for Ge and 0.7 V for Si, the potential barrier is altogether eliminated and current starts flowing. This voltage is known as threshold voltage (V_{th}) or knee voltage or cut in voltage. The mill ammeter readings are noted at various steps of applied voltage and a graph is plotted between voltage and current, as shown in Fig(ii). From the graph it is seen that practically no current flows until the barrier voltage (V_B) is overcome. When the external voltage exceeds the barrier potential or the threshold value, the current increases exponentially. This portion is known as linear operating region of the diode. If the forward voltage is increased beyond a safe limit, damage is likely to occur to the diode due to overheating.

CIRCUIT DIAGRAM:



PROCEDURE:

- Set – up the circuit as shown in figure.
- Set the current limiter suitably, e.g. 100 mA for rectifiers and 20 mA for LED, Zener diode and small signal diodes.
- Vary the voltage in small steps and measures the current in terms of the voltage drop across the resistance. The current in mA is obtained by dividing it by the value of resistance. Also, the actual voltage across the diode should be corrected for by taking into account the drop across the current measuring resistance, i.e., $V_D = V_M - V_R$ where V_D is the voltage across diode; V_M is the measured voltage; V_R is the voltage across current measuring resistance. Tabulate the readings.
- Sketch the V – I characteristics with voltage on X-axis and current on Y-axis and extend the linear portion of the curve downward to obtain the cut-in voltage V_c. The slope of the linear portion gives the dynamic resistance r_d of the diode.

OBSERATION TABLE:

(Value of series resistance R=_____________ ohm)

Sr. No.	Applied Voltage V_{in}(volt)	Resistive Voltage (V_R) (mV)	Current (mA) $I=V_R/R$	Voltage across Diode $V_L= V_{in}- (V_R*10^{-3})$

CALCULATION:

PRECAUTIONS:

- Set the current limit switch properly. An incorrect setting may damage the device under test.
- To sketch the characteristics accurately near the sharp bends (around the cut-in and breakdown points) a larger number of readings may be necessary. Choose suitable resistances, as suggested, for current measurements in these portions

RESULT: The forward biased characteristics curve is plotted in the graph.

The knee voltage of given LED is found as________ volt.

The dynamic resistance of LED is found as ___________ ohm.

QUESTIONS: -

1] What do u mean by knee voltage?

Ans: -____
____
____

2] What is depletion region in PN junction?

Ans: -____
____
____

3] What is barrier potential?

Ans: -____
____
____

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EXPERIMENT NO.2

ZENER DIODE

OBJECTIVE: To study the reverse bias characteristics of a ZENER diode and determine its Break down voltage and dynamic resistance.

APPARATUS: Circuit board comprises 0-10 V D.C. at 10 mA, continuously variable regulated power supply, integral current limiting resistor, Digital voltmeter, digital current meter ZENER diode, Patch chords.

THEORY: The circuit diagram to plot the *VI* characteristics of a Zener diode is shown. Zener diode is a special diode with increased amounts of doping. This is to compensate for the damage that occurs in the case of a *p-n* junction diode when the reverse bias exceeds the breakdown voltage and thereby current increases at a rapid rate.

Applying a positive potential to the anode and a negative potential to the cathode of the Zener diode establishes a forward bias condition. The forward characteristic of the Zener diode is same as that of a *p-n* junction diode i.e. as the applied potential increases the current increases exponentially. Applying a negative potential to the anode and positive potential to the cathode reverse biases the Zener diode.

As the reverse bias increases, the current increases rapidly in a direction opposite to that of the positive voltage region. Thus under reverse bias condition breakdown occurs. It occurs because there is a strong electric filed in the region of the junction that can disrupt the bonding forces within the atom and generate carriers. The breakdown voltage depends upon the amount of doping. For a heavily doped diode depletion layer will be thin and breakdown occurs at low reverse voltage and the breakdown voltage is sharp where as a lightly doped diode has a higher breakdown voltage. This explains the Zener diode characteristics in the reverse bias region.

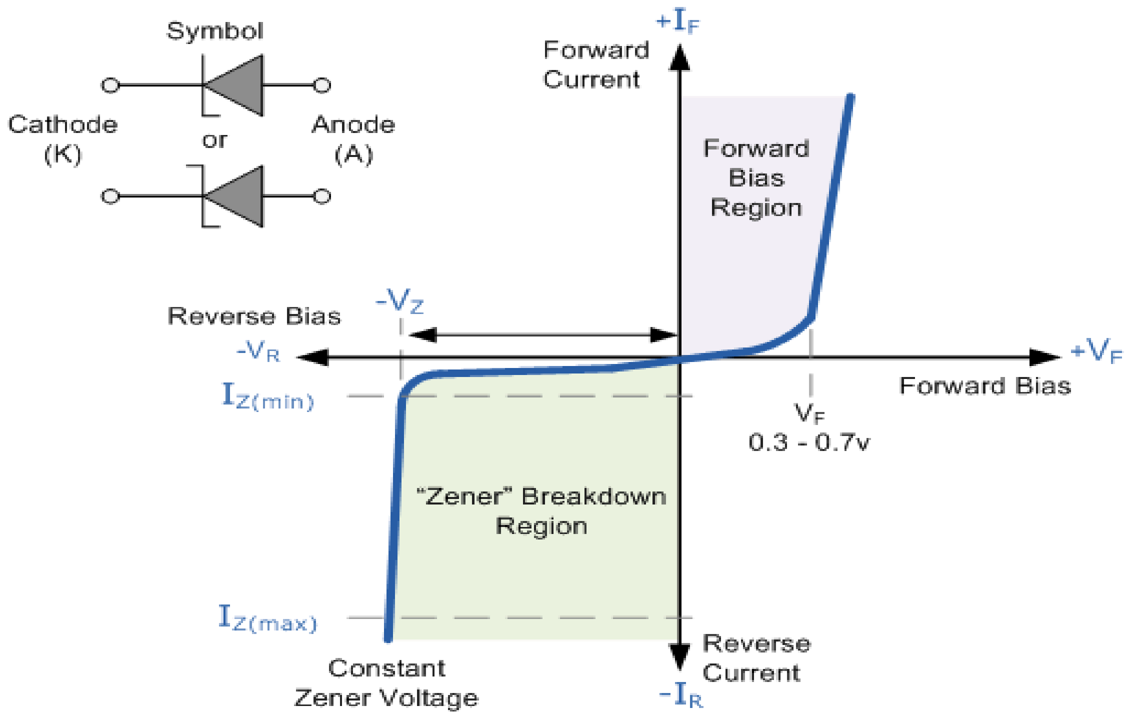
The maximum reverse bias potential that can be applied before entering the Zener region is called the Peak Inverse Voltage referred to as PIV rating or the Peak Reverse Voltage Rating (PRV rating).

REVERSE BIASED CHARACTERISTICS OF A DIODE.

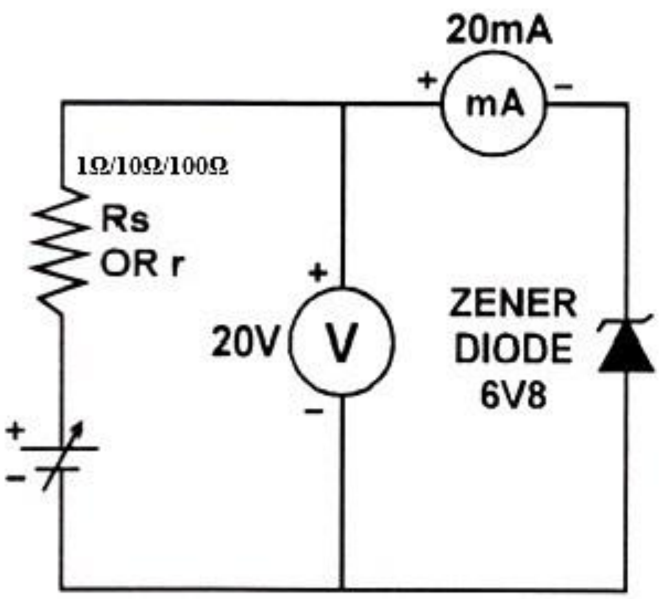
The **Zener Diode** is used in its "reverse bias" or reverse breakdown mode, i.e. the diodes anode connects to the negative supply. From the I-V characteristics curve above, we can see that the Zener diode has a region in its reverse bias characteristics of almost a constant negative voltage regardless of the value of the current flowing through the diode and remains nearly constant even with large changes in current as long as the Zener diodes current remains between the breakdown current $I_{Z(min)}$ and the maximum current rating $I_{Z(max)}$.The fact that the voltage across the diode in the breakdown region is almost constant turns out to be an important application of the Zener diode as a voltage regulator.

If the reverse bias applied to a p-n junction diode is increased, a point will be reached at which the junction breaks down and the current flowing in the reverse voltage at which this occurs and the breakdown mechanism involved, depends on the construction of the diode. In a conventional rectifier diode, reverse breakdown should not occur within the voltage rating of the diode (which may be several hundred volts). When reverse breakdown occurs in rectifier it destroys the diode. Such breakdown is also known as “AVALANCHE BREAKDOWN’. The “avalanche breakdown” mechanism predominates in diodes having reverse breakdown voltages above about 8V.

Devices can be made with reverse breakdown voltages below about 3 V. This type of breakdown is known as “ZENER BREAKDOWN”. When reverse breakdown occurs at voltages in the range 3 to 8, then both Zener and avalanche breakdown mechanism are involved. It is customary to describe diodes that are continuously operated in the reverse breakdown mode as ZENER diode, even though the actual breakdown mechanism may be of the avalanche type. Breakdown voltages of commercially available diodes range from about 1 to 1000. Zener diodes are used in the reverse biased mode to give stable fixed voltage references in practical circuits.



CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit for reverse bias of Zener diode as shown in the figure Fig.
2. Switch ON the board. Slowly increase the 0-10 V supply and note down the readings of voltmeter for the supply voltage and voltage across the diode.
3. Plot the voltage and current readings on a graph paper by taking voltage on the negative X-axis and current on the negative Y-axis. The plot will look like the reverse bias characteristics shown in Fig.
4. We observe that negligible current flows through the Zener diode till the Zener voltage i.e. 6V is reached. Thereafter on increasing the applied voltage there is almost no variation in the voltage across the Zener diode.

OBSERVATION TABLE:

Value of series resistance R= _____________ ohm

Sr. No.	Applied Voltage V_{in}(volt)	Resistive Voltage (V_R) (mV)	Current (mA) $I=V_R/R$	Voltage across Diode $V_Z = V_{in} - (V_R*10^{-3})$

CALCULATION:

RESULT: The revere biased characteristics of Zener diode has been plotted in the graph.

The breakdown voltage of Zener diode is found as ________ volt

The dynamic resistance of Zener diode is found as __________ohm.

QUESTIONS: -

1] What is meant by biasing a PN junction?

Ans: -____
____
____

2] What is Reverse saturation current?

Ans: -____
____
____

3] What is avalanche break down?

Ans: -____
____
____

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EXPERIMENT NO. 3

ULTRASONIC INTERFERROMETER

OBJECTIVE: To measure the velocity of ultrasonic waves in water and determine the Compressibility of water

APPARATUS: Frequency Generator 1 & 3 MHz, Co-axial cable, Ultrasonic interferometer with micrometer screw and Measuring Cell, Base to hold the Cell & the given liquid.

THEORY: An ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity in liquids with a high degree of accuracy.

The principle employed in the measurement of velocity (v) is based on the accurate determination of the wavelength (l) in the medium. Ultrasonic waves of known frequency (f) are produced by a quartz crystal fixed at the bottom of the cell. These waves are reflected by a movable metallic plate kept parallel to the quartz crystal. If the separation between these two plates is exactly a whole acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and the anode current of the generator becomes a maximum. If the distance is now increased or decreased and the variation is exactly half the wavelength ($\lambda/2$) or multiple of it, anode current becomes maximum. Using the value of λ, the velocity (v) can be obtained by the relation

Velocity = wavelength x frequency

$$\mathbf{v = \lambda \times f}$$

Where,
V is the velocity of the ultrasonic waves,
λ is the wavelength of the ultrasonic waves &
f is the frequency of the ultrasonic waves.
Compressibility is given as,

Compressibility (β) = $\frac{1}{\rho v^2}$

Where,

β is compressibility of the liquid,

ρ is the density of the liquid &

v is the velocity of the liquid.

EXPERIMENTAL SET UP:

PROCEDURE:

- Unscrew the knurled cap of the cell and lift it away from double walled construction of the cell. In the middle portion of it pour experimental liquid and screw the knurled cap.
- Wipe out excess liquid overflowing from the cell. Insert the cell in the socket and clamp it with the help of a screw provided on its side.
- High frequency generator is connected to the cell using co-axial cables.
- Move the micrometer slowly in either clockwise or anticlockwise direction till the anode current on the ammeter on the high frequency generator shows a maximum or a minimum. Note the readings of micrometer.
- Take readings of a few consecutive maximum or minimum.
- The difference between two consecutive readings will give $\lambda/2$. Take the average of all the differences.
- Once the wavelength (λ) is known the velocity of ultrasonic wave in the liquid can be calculated.
- From the value of velocity, we can calculate the compressibility of liquid.

OBSERVATION TABLE:

Least count of Micro meter screw = pitch/Total no. of divisions on circular scale

= ________mm

Sr. No.	Micro meter Reading(in mm)				Difference between consecutive maxima/minima ($\lambda/2$) (mm)	Average ($\lambda/2$) (mm)
	Main Scale reading [A] mm	Coinciding mark on Vernier scale [B]	Vernier Scale reading C = B X LC mm	Reading Corresponding to maxima/ minima [A+C]		

CALCULATIONS:

Density of the given liquid (water) = 996.458 kg/m^3.

PRECAUTIONS:

- Do not switch on the generator without filling the experimental liquid in the cell.
- Do not tilt the cell after filling the liquid to avoid flow of liquid towards micrometer which may rust/jam the threads of the micrometer heads.
- Remove experimental liquid out of cell after use. Keep it clean and dry.
- Keep micrometer open at 25mm after use.
- Avoid sudden rise or fall in temperature of circulated liquid to prevent thermal shock to the quartz crystal.
- While cleaning the cell, care should be taken not to spoil or scratch the gold plating on the quartz crystal.
- Give your generator 15seconds warming up time before the observation.

RESULT:

The velocity of ultrasonic waves in the given liquid is found as …………………….. m/s.

The compressibility of the liquid is measured as ….................... m^2/N.

QUESTIONS: -

1] Explain the term ultrasonic waves?

Ans: -____

2] What is least count and write the formula?

Ans: -____

3] Write methods for production of ultrasonic waves?

Ans: -____

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EXPERIMENT NO.4

DIELECTRIC CONSTANT

OBJECTIVE: To determine Dielectric Constants of given dielectric samples.

APPARATUS: Dielectric Constant Measurement Trainer kit with in- built standard Capacitors, Dielectric samples (Glass, Bakelite, PZT, Plywood), gold plated Brass plates

THEORY: The dielectric constant (ε) of a dielectric material can be defined as the ratio of the capacitance using that material as the dielectric in a capacitor to the capacitance using a vacuum as the dielectric. Typical values of ε for dielectrics are:

Material	DIELECTRIC CONSTANT (ε)
Vacuum	1.000
Dry Air	1.0059
Barium Titanate	100-1250
Glass	3.8-14.5
Quartz	5
Mica	4-9
Water distilled	34-78
Soil dry	2.4-2.9
Titanium dioxide	100

If C = capacitance using the material as the dielectric in the capacitor,

C_0 = capacitance using vacuum as the dielectric

ε_0 = Permittivity of free space (8.85×10^{-12} F/m)

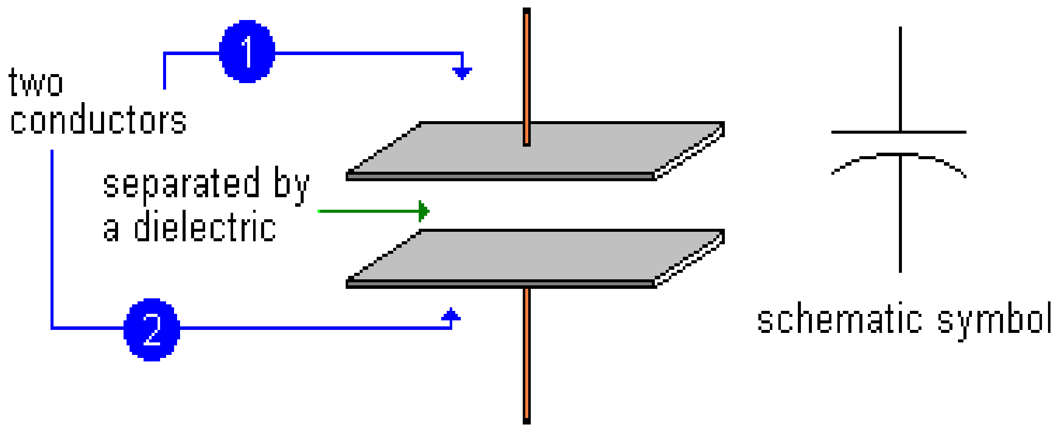
A = Area of the plate/ sample cross section area

t = Thickness of the sample

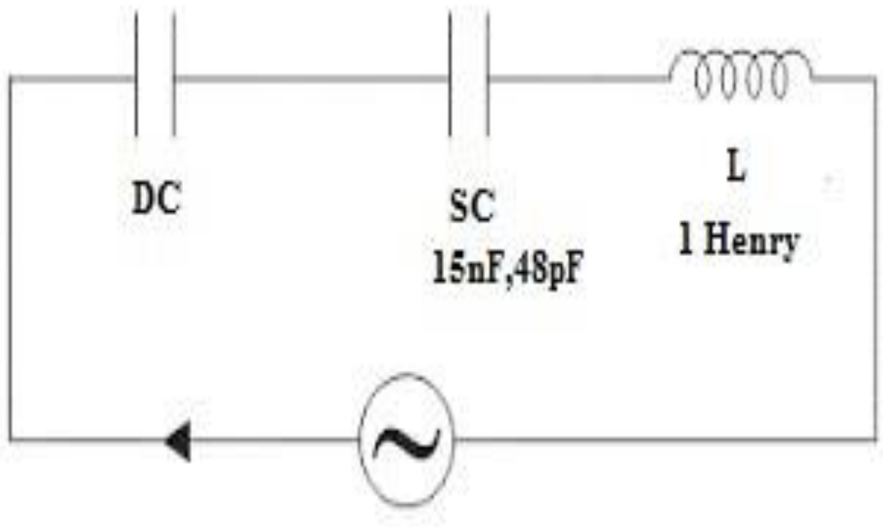
Then,

Dielectric constant is given by

$$\varepsilon = \frac{C}{C_0} \quad \textbf{Where} \quad C_0 = \frac{\varepsilon_0 A}{t}$$



EXPERIMENTAL SET UP:



PROCEDURE:

1) Connect the dielectric cell assembly to the main unit and insert the sample in between plates(SS PLATES)

2) Switch ON the unit.
3) Choose the standard capacitor (with the help of the switch S_2) SC_1 for the material having low dielectric constants (like Bakelite, glass, plywood) and SC_2 for the material having high dielectric constant (like PZT sample)
4) Shift S_1 TOWARDS DC to measure the voltage across dielectric cell say V_{DC} and towards SC to measure voltage across standard capacitor, say V_{SC}. Calculate capacitance C using the formula

$$C= (V_{SC}/V_{DC})*C_{SC}$$

5) Calculate the capacitance of an air capacitor considering the thickness of air between the plates exactly equal to the thickness of dielectric sample using the formula given.
6) Take the ratio of capacitance of capacitor with dielectric to the capacitance of capacitor without dielectric.

NOTE:

For sample, other than provided with the kit, measure the capacitance of the sample placed in between the SS disc with the help of any capacitance meter available. If measured capacitance value is not comparable to either of SC_1 or SC_2, connect the capacitor having value near to that measured value between the plugs provided at SC_3 and shift S_2 to SC_3 and repeat the step 4.

OBSERVATIONS:

1. Radius of brass plates (for PZT) = $\underline{12.5\times10^{-3}\,m}$
2. Radius of brass plates (for Glass, Plywood, Bakelite) = $\underline{3.75\times10^{-2}\,m}$
3. Thickness of PZT sample = $\underline{1.08\times10^{-3}\,m}$
4. Thickness of Glass sample = $\underline{4.66\times10^{-3}\,m}$
5. Thickness of Bakelite sample = $\underline{4.66\times10^{-3}\,m}$
6. Thickness of Plywood sample = $\underline{2.8\times10^{-3}\,m}$

OBSERVATION TABLE:

Sr. No	Dielectric Sample	Standard Capacitor SC	Voltage across		Capacitance with dielectric $C=(V_{SC}/V_{DC})*C_{SC}$ (F)	Capacitance without dielectric $C_O=\frac{r^2}{36d}$ (nF)	Dielectric constant $\varepsilon = C/CO$
			Standard Capacitor V_{sc} (volt)	Dielectric cell V_{DC} (volt)			
1	Glass	48 pf					
2	Bakelite	48 pf					
3	Plywood	48 pf					
4	PZT	15 nf					

CALCULATION:

RESULT: The dielectric constants measured from this experiment

For Glass =____________________.

For Bakelite =__________________.

For Plywood =__________________.

For PZT =____________________.

QUESTIONS: -

1] Define dielectric constant?

Ans: -____
____
____

2] Define capacitor?

Ans: -____
____
____

3] Write full form of PZT?

Ans: -____
____
____

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EXPERIMENT NO. 5 -6

BAND GAP OF SEMICONDUCTOR

OBJECTIVE: To determine material constant and energy band gap of a semiconductor.

APPARATUS: P-N junction set up, oven, diodes (IN 5402 and IN 5408), connecting leads, transistor (BC 109)

THEORY: The current I in the P-N junction is given by

$$I = I_0\left(e^{\frac{eV}{\eta KT}} - 1\right)$$

Where, I_0 = leakage current

e= charge of electron= $1.6\times10^{-19}\,coulomb$

V= junction voltage

η = material constant = 1 for Ge

= 2 for Si

K= Boltzmann constant= $1.38\times10^{-23}\,J/K$

T= temperature in Kelvin

For $e^{\frac{eV}{\eta KT}}$ >>1,

$$\therefore \ln I = \ln I_0 + \frac{eV}{\eta KT}$$

The above equation represents a straight line obtained when $\ln I$ is plotted on Y-axis & V is plotted on X-axis whose slope is $\frac{e}{\eta KT}$ which gives value of η.

The intercept of this graph on Y-axis gives the value of reverse saturation current.

Now, the reverse saturation current is also written as

$$I_0 = KT^m \exp\left[e\left(\frac{V - V_{G0}}{\eta KT}\right)\right]$$

For Si: m=1.5, η =2

For Ge: m=2, η =1

$$\therefore \ln I_0 = \ln K + m \ln T + e\left(\frac{V - V_{G0}}{\eta KT}\right)$$

At I=constant, differentiating w.r.t T,

$$0=0+\frac{m}{T} + \frac{d}{dT}\, e\left(\frac{V - V_{G0}}{\eta KT}\right)$$

$$0 = \frac{m}{T} + \left(\frac{e}{\eta KT}\right).\frac{dV}{dT} - e\frac{(V - V_{G0})}{\eta K}.\frac{1}{T^2}$$

$$V_{G0} = V - T.\frac{dV}{dT} - \frac{m\eta KT}{e}$$

The slope of the graph V vs T gives value of $\frac{dV}{dT}$ & hence V_{G0} can be calculated which gives the band gap at temperature T=300 K.

EXPERIMENTAL SET UP:

PROCEDURE:

1. Connect P-N junction set up to the AC mains.
2. Insert the oven knob to the oven socket provided on set up.
3. Connect the junction transistor lead to the terminals provided on set up as polarity indicated on it.
4. Switch on the set up
5. Vary the voltage & measure the current.
6. Plot the graph of lnI vs V & find out the slope $\frac{e}{\eta KT}$ from which η can be calculated.
7. The intercept of this graph on Y-axis gives the value of reverse saturation current.
8. Now insert the transistor in oven and set the forward current to a low value $I_f = 2mA$
9. Switch the display to TEMP mode & vary the oven temperature from ambient to about 360 K & measure the junction voltage.
10. Plot the graph of V vs T.
11. The slope of the graph V vs T gives value of $\frac{dV}{dT}$ & hence V_{G0} can be calculated which gives the band gap at temperature T=300 K

OBSERVATION TABLE:

Room Temperature, T = ____________ k

Sr. No.	Applied Voltage (V) volt	Forward current I (μA)	ln I

$I_f = 2mA$

Sr. No.	Voltage (V)	Temperature (K)

CALCULATION:

Slope = $\frac{e}{\eta KT}$ (for graph lnI vs V)

$\eta =$________________

NOW, $V_{G0} = V - T.\frac{dV}{dT} - \frac{m\eta KT}{e}$

=__________________

RESULT:

(1) Material constant η =________________

(2) Energy band gap =________________ eV.

QUESTIONS: -

1] Define band-gap?

Ans: -____
____
____

2] What is material constant and what does it suggest?

Ans: -____
____
____

3] Which of the two-semiconductor materials Si or Ge has larger conductivity at room temperature? Why?

Ans: -____
____
____

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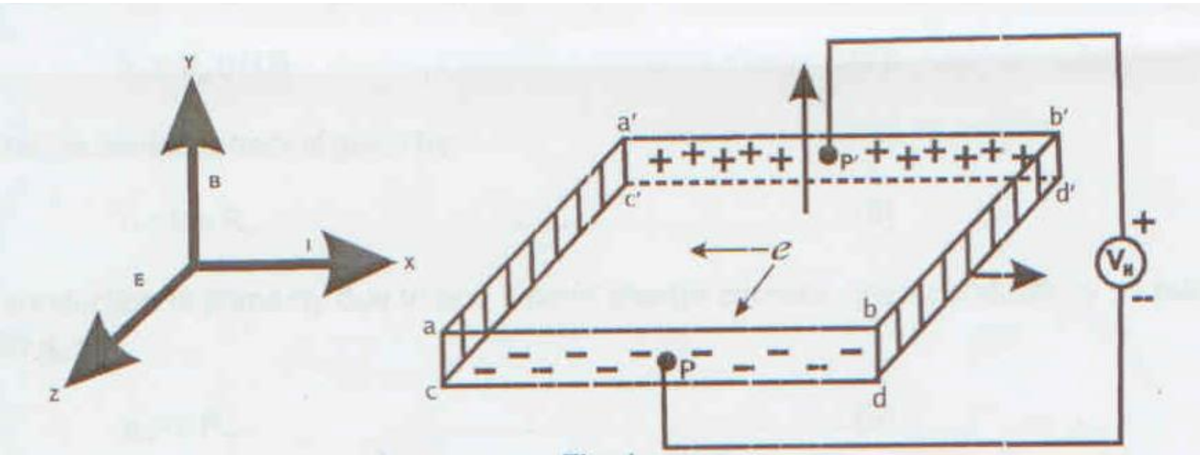
EXPERIMENT NO. 7

HALL EFFECT

OBJECTIVE: To determine the Hall coefficient and charge carrier density of a Semiconductor crystal

APPARATUS: Electromagnet, Electromagnet constant power supply, Hall probe, Gauss Meter, Semiconductor crystal mounted on PCB, multi meter.

THEORY: When a current carrying conductor is placed in a magnetic field perpendicular to the direction of current then an electro motive force is developed perpendicular to both the current and magnetic field applied. This effect is known as Hall Effect and the voltage developed is known as Hall voltage.



Suppose an electric current (Ix) flows in the x direction and the magnetic field (B_z) is applied normal to this electric field in the z direction. Each electron is then subjected to a force called Lorentz force perpendicular to the direction of flow of electron as well as perpendicular to the magnetic field. It causes the accumulation of electrons on one side of the crystal and is deficient on the other side. Thus an electric field is developed in Y direction, which is called Hall field (E_H).Under the equilibrium the Lorentz force on the electrons and hall force (the force on the electron due to hall field) balance each other.

$$\text{i.e. } q\,E_H = q\,v_x\,B_z$$

Where v_x is the velocity of electrons in x direction

$$E_H = v_x\,B_z$$

The magnitude of current density $Jx = n\ q\ v_x$, where n is the number of charge carriers per unit volume.

$$v_x = \frac{J_x}{nq} = J_x R_H$$

Here $R_H = \frac{1}{nq}$ is known as hall coefficient.

$E_H = J_x\,R_H\,B_z \quad but \;\; E_H = \frac{V_H}{t}, \quad and \quad J_x = \frac{I_x}{A} = \frac{I_x}{bt}$

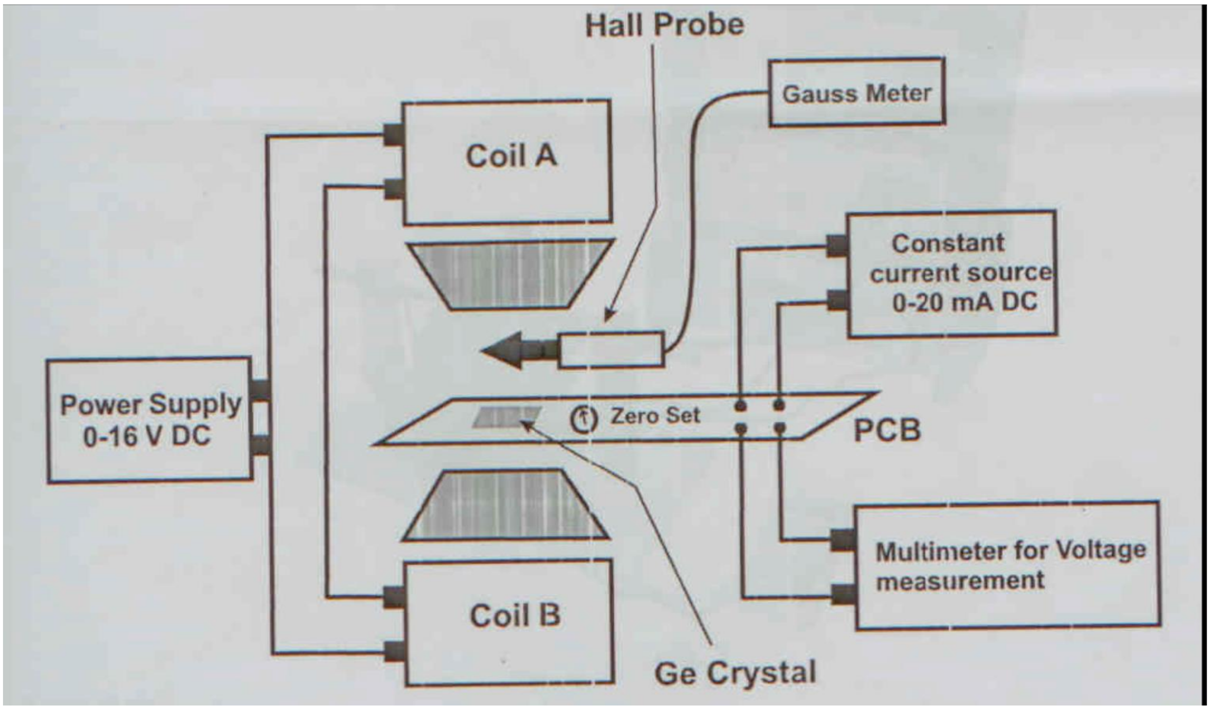
Substitute the value of E_H and Jx

$$R_H = \frac{V_H b}{I_x B_z}$$

Here t is the dimension of the crystal in y direction and 'b' is the dimension of the crystal in z direction. The number of charge carriers per unit volume i.e., charge carrier density is given by $n = \frac{1}{eR_H}$

If the conduction is primarily due to one type of charge carriers, then conductivity is related to mobility as $\mu_m = \sigma R_H$

EXPERIMENTAL SET UP:



PROCEDURE:

1. Mount PCB (with crystal) and hall probe on pillars and complete all the connections.
2. Switch on the Gauss meter and place hall probe away from the electromagnet. Adjust the reading of the Gauss meter as zero (do not switch on the electromagnet power supply at this moment).
3. Switch on the constant current source and set the current, say 5 mA. Keep the magnetic field at zero as recorded by Gauss meter (do not switch on the electromagnet power supply at this moment).
4. Set the voltage range of the multi meter at 0-200 mV. When a current of 5mA is passed through the crystal without application of magnetic field the hall voltage recorded by the multi meter should be zero (do not switch on the electromagnet power supply at this moment).

5. Bring the current reading of the constant current source to zero by adjusting the knob of the constant current source.

6. Now switch on the electromagnet and select the range of the Gauss meter as ×10 and measure the magnetic flux density at the center between the pole pieces. The tip of Hall probe and the crystal should be placed between the centers of the pole pieces. For carrying out the experiment the magnetic flux density should be maximum i.e. between 2000 to 3500 Gauss.
7. Vary the current through the constant current source in small increments. Note the value of current passing through the sample and the Hall voltage as recorded by the multi meter (do not change the current in the electromagnet).
8. Reverse the direction of magnetic field by interchanging the '+' and '-'connections of the coils and repeat the step 1 to 7.

9. PRECAUTIONS:

1 The Hall probe should be placed between the pole pieces such that maximum Hall voltage is generated.

2 Current through the Hall probe should be strictly within the limits.

3 Hall voltage developed should be measured very accurately.

OBSERVATIONS:

Thickness of the specimen, b= …………….mm

Magnetic flux density, B_z = ……………….. Gauss =………………. Tesla

OBSERVATION TABLE:

SR. NO	CURRENT I (mA)	VOLTAGE V_H (volt)	Hall coefficient $R_H = \frac{V_H b}{I_x B_z}$

CALCULATION:

1. Draw a graph between VH and Ix and Find the slope of the curve

$$\frac{\Delta V_H}{\Delta I_x}$$

Now $R_H = slope \times \frac{b}{B}$

=

2. Calculate the value of Hall coefficient using the formula

$$R_H = \left(\frac{\Delta V_H}{\Delta I_x}\right)\frac{b}{B_z}$$

3. Calculate the carrier charge density using the formula

$$n = \frac{1}{e R_H}$$

RESULT:

The value of Hall coefficient for the given semiconductor crystal is________________

The obtained value of carrier charge density is________________

QUESTIONS: -

1] Define hall-effect?

Ans: -____

____

____

2] What does the value of hall-coefficient suggest?

Ans: -____

____

____

3]What is the effect of temperature on hall-coefficient? What is mobility?

Ans: -____

____

____

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EXPERIMENT NO. 8

PLANCK'S CONSTANT

OBJECTIVE: To determine Planck's constant using LED.

APPARATUS: Planck's constant kit with inbuilt voltage source (0-2 V DC), current meter (0-2000 μ A), temperature controlled oven (ambient to 60 ^{0}C), LED (red & yellow).

THEORY: : The basic idea in this experiment is measurement of energy corresponding to potential barrier which electrons have to overcome to go from N-type region to P-type region of the diode when no external voltage V is applied to the diode. This can be related to the bandgap energy of the material from the relation,

$$E_g = eV_0 \quad \ldots\ldots (1)$$

In case of LED, when electrons from N-region combine with holes of P-region within junction area, electromagnetic radiation with wavelength λ is emitted in such a way that

$$Eg = \frac{hc}{\lambda} \quad \ldots\ldots (2)$$

From (1) & (2),

$$\frac{hc}{\lambda} = eV_0$$

$$\therefore h = \frac{eV_0\lambda}{c} \quad \ldots\ldots (3)$$

In present method, height of potential barrier (V_0) is obtained by directly measuring the dependence of diode current on the temperature, keeping the applied voltage fixed at a value lower than the barrier so that the disturbance to the barrier potential is minimum. The equation for diode current is

$$I = \exp\left[\frac{e(V - V_0)}{\eta KT}\right] \quad \text{……….……..…… (4)}$$

Where, V: applied voltage

V_0: barrier potential

η : Material constant

K: Boltzmann constant

T: temperature of diode

$$\therefore \ln I = \frac{eV}{\eta KT} - \frac{eV_0}{\eta KT} \quad \text{………………..…… (5)}$$

The above equation represents a straight line obtained when $\ln I$ is plotted on Y-axis & V is plotted on X-axis whose slope is $\frac{e}{\eta KT}$ which gives value of η.

From equation (5),

$$\ln I = \left[\frac{e(V - V_0)}{\eta K}\right]\frac{1}{T}$$

$$\therefore \frac{\ln I}{\frac{1}{T}}\left(\frac{\eta K}{e}\right) = V - V_0$$

$$\therefore V_0 = V - \left[\frac{\ln I}{\frac{1}{T}}\left(\frac{\eta K}{e}\right)\right] \quad \text{…………………... (6)}$$

Where, V is applied voltage below bandgap of LED (1.8 V for yellow/red)

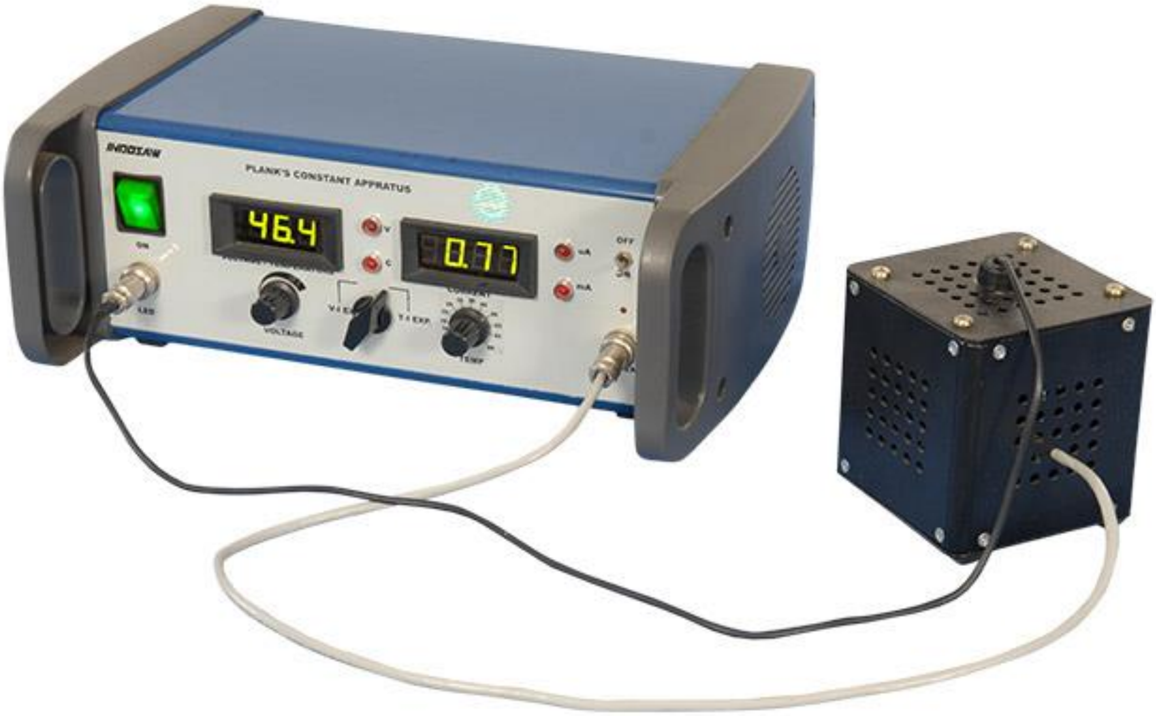
$\frac{\ln I}{\frac{1}{T}}$ can be calculated as a slope of the graph plotted as $\ln I$ vs $\frac{1}{T}$.

Now, from equation (3), Planck's constant can be calculated as

$$h = \frac{eV_0\lambda}{c} \quad \text{…………………….. (7)}$$

Here, λ is the wavelength of LED.

EXPERIMENTAL SET UP:



PROCEDURE:

(A) Determination of material constant (η):

1. Connect LED in socket on setup & switch on power.
2. Switch the two way switch to V-I position. In this position, first DPM would read voltage across LED & second DPM would read current passing through LED.
3. Increase the voltage gradually & record the readings of voltage & current.
   Applied voltage should not exceed 1.8 V.
4. Plot the graph of $\ln I$ vs V whose slope is $\dfrac{e}{\eta KT}$ which gives value of η.

(B) Determination of Planck's constant (h):

1. Keep the mode switch to V-I position and adjust the voltage across the LED (up to 1.8 V for both yellow and red LED and 1.95 V for green LED).
2. Change the mode of two-way switch to T-I position.
3. Insert LED in the oven & connect the other end of LED in the socket provided on setup. Before connecting the oven check that oven switch is in OFF position & SET temperature knob is at minimum position. Now first DPM would read ambient temperature.
4. Set the different temperatures with the help of SET temperature knob. Allow about 5 minutes on each setting for the temperature to stabilize and take the readings of temperature and current.
5. Plot the graph of $\ln I \text{ vs} \frac{1}{T}$ and find out the slope.

OBSERVATION TABLE:

(A) Determination of material constant (η):

Room Temperature, T = ____________ k

Sr. No.	Applied Voltage (V) volt	Forward current I (μA)	ln I

(B) Determination of Planck's constant (h):

Voltage, V = ________ Volt

Sr. No.	Temperature (^{0} C)	Temperature (^{0} K)	Current (mA)	$\frac{1}{T}\times10^{-3}$ (K^{-1})	ln I

CALCULATION:

(A) Determination of material constant (η):

$$\text{Slope} = \frac{e}{\eta KT} \quad \therefore \eta = \left(\frac{e}{KT}\right)\left(\frac{1}{slope}\right)$$

= ____________

(B) Determination of Planck's constant (h):

$$V_0 = V - \left[\left(slope\right)\left(\frac{\eta K}{e}\right)\right]$$

= __________ volt

Now, $h = \dfrac{eV_0\lambda}{c}$

= _______________ joule-sec.

RESULT: From this experiment, the value of Planck's constant is found to be

h= ___________ joule-sec.

QUESTIONS: -

1] What is planck's law?

Ans: -____
____
____

2] What is the relation between energy and wave-length?

Ans: -____
____
____

3]What is energy of quanta?

Ans: -____
____
____

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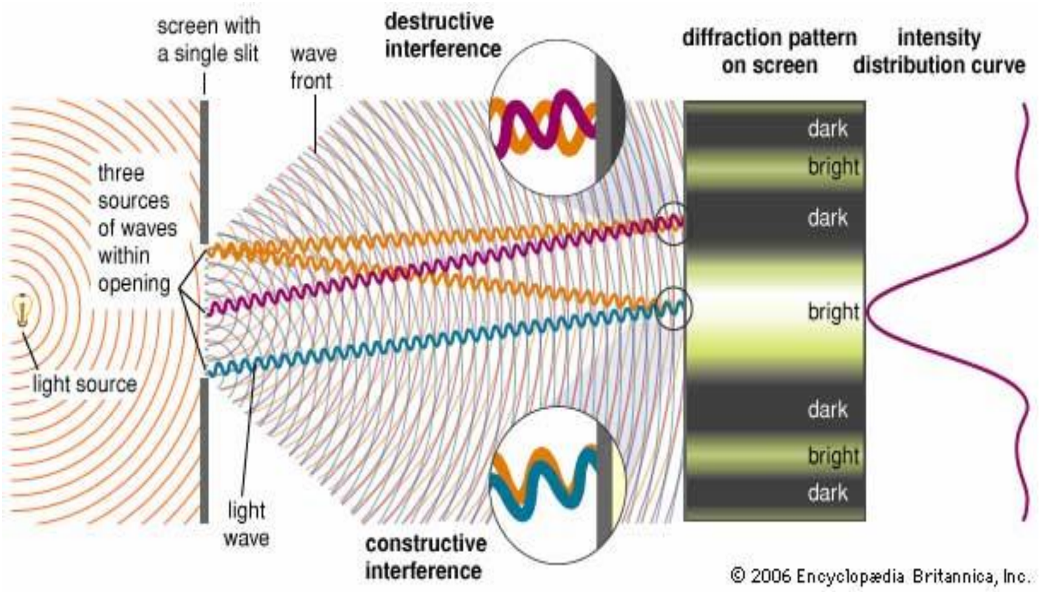
EXPERIMENT NO.9

WAVELENGTH OF LASER

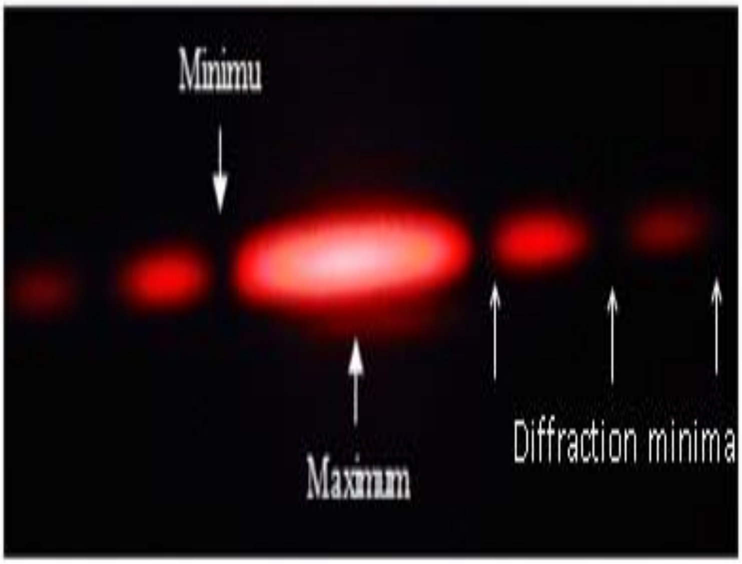
OBJECTIVE: To determine the wavelength of LASER using diffraction of light.

APPARATUS: Diode Laser Source, Screen, Scale, Holders and Bases, Diffraction Grating (100/ 300/600-Lines/meter)

THEORY: When waves pass through apertures or around obstacles, they spread out into regions which would be in shadow if they travelled in straight lines. This property is called diffraction and can be described in terms of Huygens Principle. Huygens proposed that every point on a wave front may be regarded as a source of secondary spherical wavelets. Where these waves cross, they constructively and destructively add (fig i). Diffraction is regarded as being due to the addition (superposition) of Huygens' secondary wavelets. Imagine that a slit consists of strips of equal width, parallel to the length of the slit. The total effect in a particular direction is then found by adding the wavelets emitted in that direction by all the strips.



When parallel waves of light are obstructed by a very small object (i.e. sharp edge, slit, wire, etc.), the waves spread around the edges of the obstruction and interfere, resulting in a pattern of dark and light fringes. When light diffracts off of the edge of an object, it creates a pattern of light referred to as a *diffraction pattern*. If a monochromatic light source, such as a laser, is used to observe diffraction, *a diffraction pattern is* created by a slit (as shown in fig iii).



Diffraction is the tendency of a wave emitted from a finite source or passing through a finite aperture to spread out as it propagates. Diffraction results from the interference of an infinite number of waves emitted by a continuous distribution of source points.

According to **Huygens's Principle** every point on a wave front of light can be considered to be a secondary source of spherical wavelets. These **wavelets** propagate outward with the characteristic speed of the wave. The wavelets emitted by all points on the wave front interfere with each other to produce the traveling wave. Huygens 'Principle also holds for electromagnetic waves. When studying the propagation of light, we can replace any wave front by a collection of sources distributed uniformly over the wave front, radiating in phase.

When light passes through a small opening, comparable in size to the wavelength λ of the light, in an otherwise opaque obstacle, the wave front on the other side of the opening resembles the wave front shown on the right.

The light spreads around the edges of the obstacle. This is the phenomenon of **diffraction**. Diffraction is a wave phenomenon and is also observed with water waves in a ripple tank.

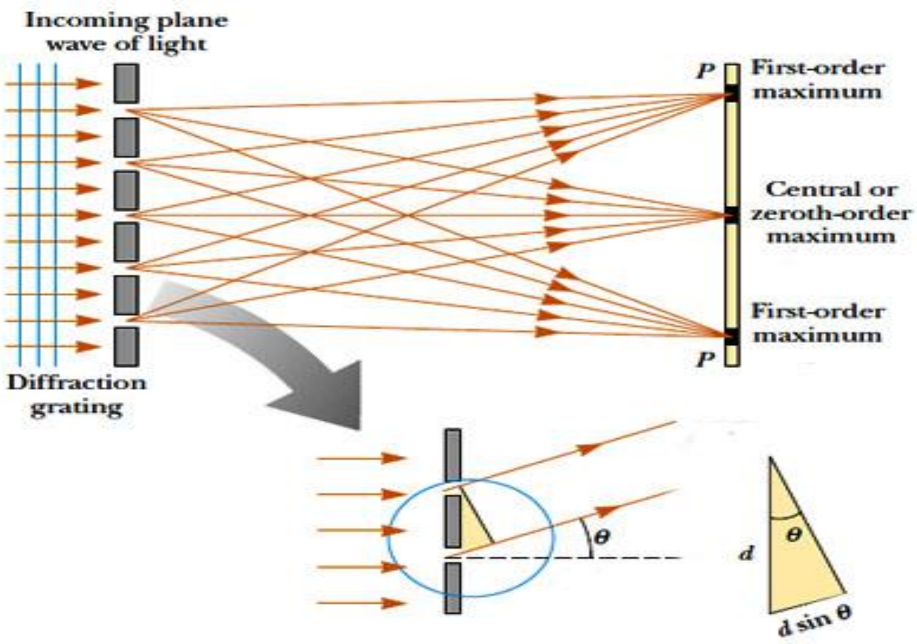
DIFFRACTION GRATING:

We have seen that diffraction patterns can be produced by a single slit or by two slits. When light encounters an entire array of identical, equally-spaced slits, called a diffraction grating, the bright fringes, which come from constructive interference of the light waves from different slits, are found at the same angles they are found if there are only two slits. But the pattern is much sharper. The figure on the right shows the interference pattern for various numbers of slits. The width of all slits is 50 micro meters and the spacing between all slits is 150 micro meters. The location of the maxima for two slits is also the location of the maxima for multiple slits. The single slit pattern acts as an envelope for the multiple slit patterns. Diffraction gratings contain a large number of parallel, closely spaced slits or grooves. They produce interference maxima at angles θ given by

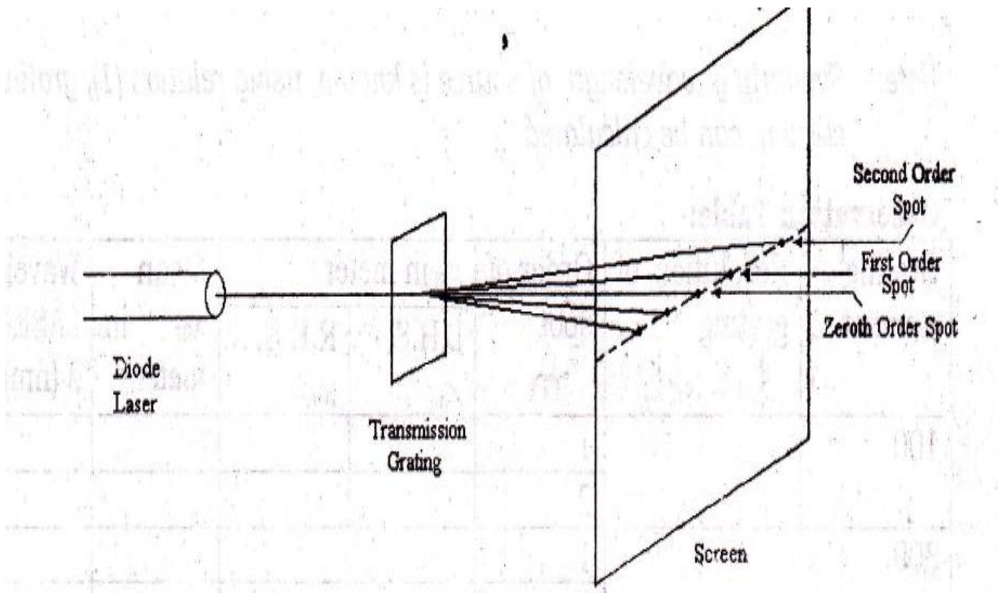
$$m\lambda = d\ sin\theta\ .$$

Because the spacing between the slits is generally very small, the angles θ are generally quite large. We cannot use the small angle approximation for relating wavelength and the position of the maxima on a screen for gratings, but have to use

$$\mathbf{Sin\ \theta = z/\ (L^2 + z^2)^{1/2}.}$$



EXPERIMENTAL SET-UP:



PROCEDURE:

- Place the LASER source on holder and mount on the heavy base.
- Hold the grating and screen in their respective holders and bases.
- Place the grating between LASER source and screen as shown is Fig.l.
- The LASER beam after passing through the grating will split into zero order, first order, and second order beam as shown in fig.2.
- Mark zero order, first order and second order spots on screen and measure the distance between first order spot & zeroth order spot & half of this distance. i.e

$$x_m = \left|\frac{Xmr+Xml}{2}\right|$$

$$\sin\theta_m = \frac{Xm}{\sqrt{Xm^2+f^2}}$$

Put $\sin\theta_m$ in formula $m\lambda = d\ sin\theta_m$

$$\lambda = \frac{d x_m}{m\sqrt{{x_m}^2 + f^2}}$$

Where, m = Order of spots,

λ = Wavelength of LASER beam (nm)

d = Resolution of a grating (= 1/grating element)

(i.e. $1 \times 10^{-3}/100$ or $1 \times 10^{-3}/300$ or $1 \times 10^{-3}/600$) meter/lines

x_m = Distance between zero order spot & first/second order spot (meter)

f = Distance between screen & grating element (meter)

OBSERVATION TABLE:

Grating element	Resolution of grating d (m)	Distance between sample and screen f (m)	Order of spot m	Distance between pattern and direct spot X_m (m)		Mean X_m(m)	Wavelength of laser beam λ(nm)
				L.H.S ($X_m l$)	R.H.S ($X_m r$)		
100			1				
			2				
300			1				
			2				
600			1				
			2				

CALCULATION:

RESULT:

Using Diffraction of light, the wavelength of given semiconductor laser is measured as_______________ A^0

QUESTIONS: -

1] Explain constructive and destructive interference?

Ans: -____

____

____

2] What is diffraction of light and what is the condition to occur?

Ans: -____

____

____

3] Define wavelength and mention the range for wavelength of seven colours?

Ans: -____

____

____

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EXPERIMENT 10

NUMERICAL APERTURE

OBJECTIVE: To Determine the Numerical Aperture of an Optical Fiber.

APPARATUS: The trainer consists of the following built in parts:

1. IC integrated DC power supply.
2. Fiber-optic Analogue Transmitter @ 660nm.
3. Fiber-optic Analogue Transmitter @ 850nm.
4. Fiber-Optic receiver.
5. One-meter PMMA Fiber patch cord.
6. Five-meter PMMA Fiber patch cord.
7. In-line SMA adaptor.
8. To potentiometer to vary forward current of LED in transmitter & current of phototransistor in receiver.
9. SPDT switch for selecting wavelengths 660nm and 850nm.
10. NA JIG with scale marked on it to measure length.
11. Mains On/OFF Switch, Fuse and jewel light.
12. The unit is operative on 230V±10% AT 50Hz A.C. Mains.
13. Adequate no of patch cords stackable 4mm spring loaded plug length ½ Meter.

THEORY: Optical Fiber:

Optical Fiber is a flexible, transparent fiber made of very pure glass (silica) not much bigger than a human hair that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication.

Optical fiber typically consists of a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those that only support a single mode are called single-mode fibers (SMF).

Principle of operation

An optical fiber is a cylindrical dielectric waveguide (non conducting waveguide) that transmits light along its axis, by the process of total internal reflection. The fiber consists of a core surrounded by a cladding layer, both of which are made of dielectric materials. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The boundary between the core and cladding may either be abrupt, in step-index fiber, or gradual, in graded-index fiber.

Numerical Aperture (**NA**):

The **numerical aperture** (**NA**) of an optical system is a dimensionless number that characterizes the range of angles over which the system can accept or emit light. Fiber with a larger NA requires less precision to splice and work with than fiber with a smaller NA. Single-mode fiber has a small NA.

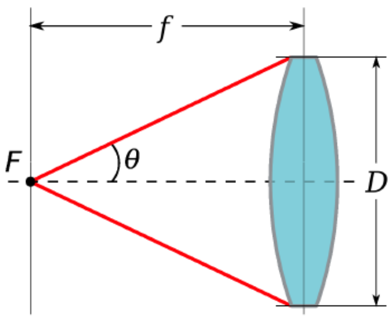


Fig: (1) Numerical Aperture of thin films

The Numerical Aperture of an optical system such as an objective lens is defined by

NA= $\mathbf{n_i} \times \boldsymbol{\sin\theta_{max}}$ n_i is 1 for air

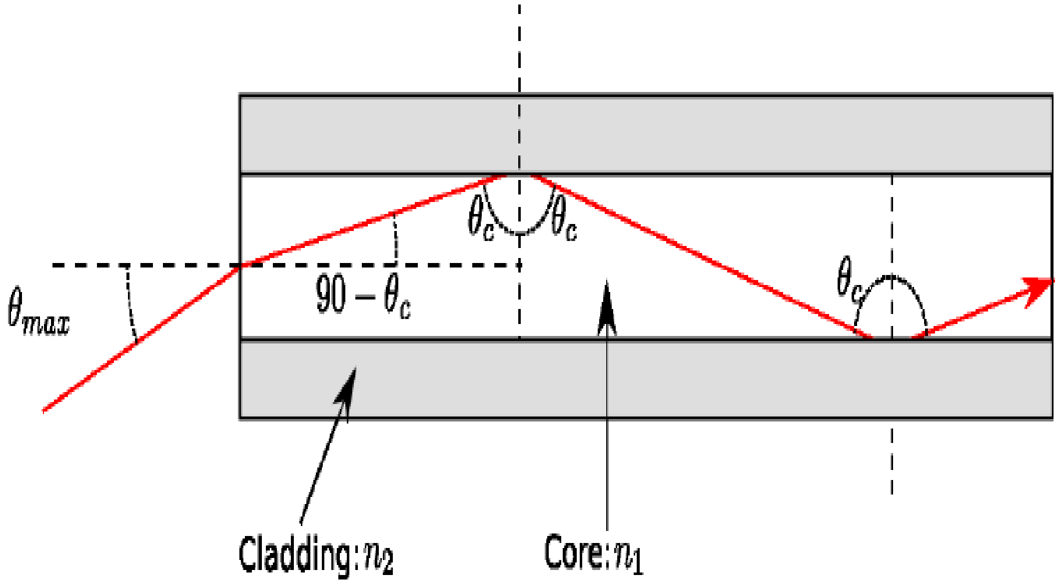
Hence **NA** = $\boldsymbol{\sin\theta_{max}}$

For a step-index fiber the Numerical aperture is given by

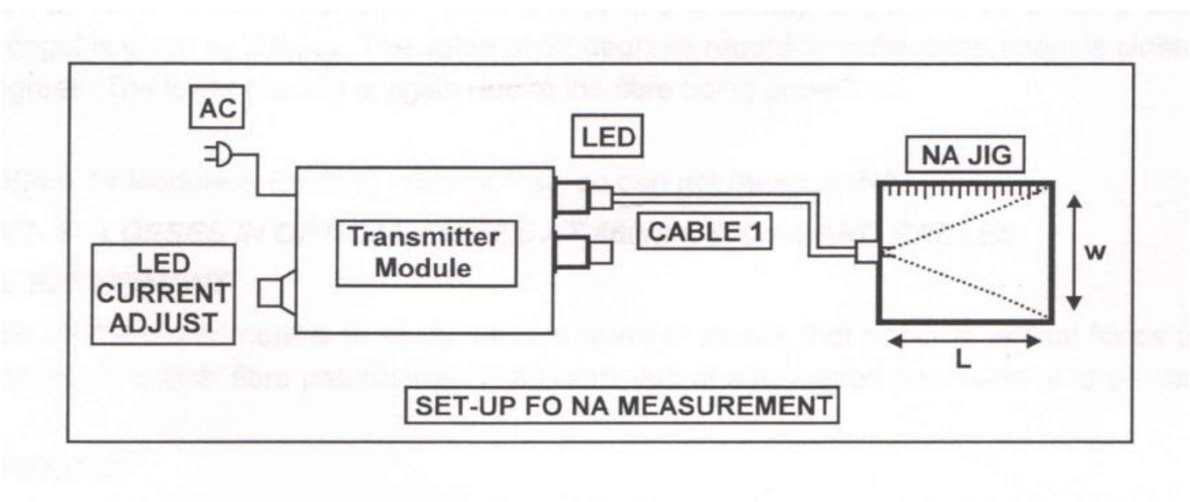
$$NA = \sqrt{\left({n_{core}}^2 - {n_{cladding}}^2\right)}$$

For very small differences in refractive indices the equation reduces to

$NA = n_{core}\sqrt{(2\Delta)}$,where Δ is the fractional difference in refractive indices.



EXPERIMENTAL SET UP:



PROCEDURE:

1. Connect one end of the cable 1 (1-meter FO cable) to LED port of the trainer and the other end to the NA JIG as shown in fig: 4.
2. Put the wavelength selector switch to 660 meter position.
3. Plug the AC mains to ON position; neon light will come ON indicating that instrument is ready for use. Light should appear at the end of the fiber on the NA JIG, Turn the LED CURRENT ADJUST knob clockwise to set to maximum Po. The light intensity should increase.
4. Hold the white screen with the 4 concentric circles (10, 15, 20 and 25mm diameter) vertically at a suitable distance to make the red spot from the emitting fiber with the 10mm circle (The circumference of the outermost) must coincide with the circle.
5. Record the distance "L" of screen from the fiber end and note the diameter (D) of the spot.
6. Compute NA from the formula. Tabulate the reading and repeat the experiment for 15, 20, 25mm diameters too.
7. In case of under filled, the intensity within the spot may not be evenly distributed. To ensure even distribution of light in the fiber, first remove twists on the fiber and then wind 5 turns of the fiber on to the mandrel as shown in fig (5). Use an adhesive tape to hold the winding in position. Now view the spot. The intensity will be more evenly distributed within the core.

OBSERVATION TABLE:

Sr. No.	Distance of spot from the screen L (mm)	Diameter of spot D(mm)	Acceptance angle $\phi = \tan^{-1}\left(\frac{D}{2L}\right)$ (degree)	$NA = \sin\phi$
1				
2				
3				
4				
5				

CALCULATION:

RESULT:

From this experiment,

The Numerical aperture of given optical fiber is measured as ___________________

And the acceptance angle of given optical fiber is measured as__________________

QUESTIONS: -

1] What is NA and acceptance angle?

Ans: -____
____
____

2] What is snell's law?

Ans: -____
____
____

3] Which type of optical fiber is used in this experiment?

Ans: -____
____
____

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EXPERIMENT 11

PARTICLE SIZE

OBJECTIVE: To determine the size of lycopodium powder particle using the phenomena of Diffraction of light

APPARATUS: Diode Laser Source, screen, scale, holder and Base, sample slide (Lycopodium powder for particle size determination)

THEORY:

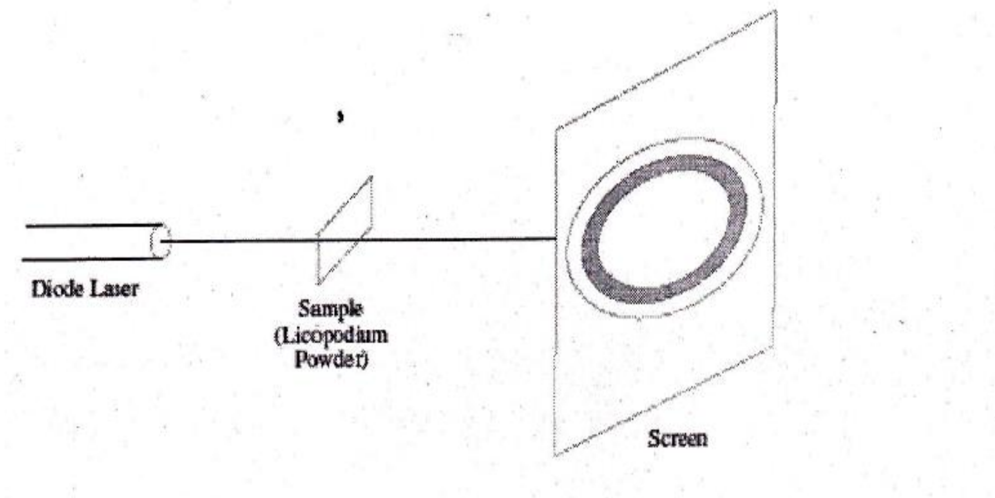
When waves pass through apertures or around obstacles, they spread out into regions which would be in shadow if they travelled in straight lines. This property is called diffraction and can be described in terms of Huygens Principle. Huygens proposed that every point on a wave front may be regarded as a source of secondary spherical wavelets. Where these waves cross, they constructively and destructively add. Diffraction is regarded as being due to the addition (superposition) of Huygens' secondary wavelets. Imagine that a slit consists of strips of equal width, parallel to the length of the slit. The total effect in a particular direction is then found by adding the wavelets emitted in that direction by all the strips.

In lycopodium slide containing the spherical powder particle, the diffraction takes place at all the angles round the spherical particles of powder and produces the annular rings.

The first disc is known as the array's disc whose diameter can be used to calculate the size of powder particle using the formula given by

$$D = \frac{1.22\lambda d}{\rho}$$

EXPERIMENTAL SET-UP:



PROCEDURE:

- Place the LASER source on holder and mount on the heavy base .Hold the sample slide (mounted on the holder and base) between LASER source and screen (as shown in figure) so as to obtain the good pattern on the screen.
- Measure the diameter of inner most circular disc in the pattern obtained on the screen.
- Calculate the particle size using the formula

$$D = \frac{1.22\lambda d}{\rho}$$

Where, $\lambda =$ Wavelength of LASER beam (630 nm)

d = distance between screen & sample slide (in meter)

$\rho =$ Diameter of the first circle (in meter)

OBSERVATION TABLE:

Sr. No.	Distance between Screen & Sample Slide (d in meter)	Diameter of First Circle ρ in meter	The Particle Size (D in meter)
1			
2			
3			
4			
5			

CALCULATIONS:

PRECAUTIONS:

- Mounting and coupling should be done carefully.
- Care should be taken so that the laser light will not directly fall into the eyes.
- As far as possible, experiment should be conducted in a dark room.

RESULT: The particle size of lycopodium powder using LASER source is measured as

___________ µm.

QUESTIONS: -

1] Which kind of laser is used in this experiment?

Ans: -____
____
____

2] What is Huygens Principle?

Ans: -____
____
____

3] What is the grating constant?

Ans: -____
____
____

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EXPERIMENT 12

POWER LOSS IN OPTICAL FIBER

OBJECTIVE: To study various types of losses that occur in Optical Fibers (PMMA) and measure the loss in dB of two optical fiber patch-cords.

APPARATUS: The trainer consists of the following built in parts:

1. IC integrated DC power supply.
2. Fiber-optic Analogue Transmitter @ 660nm.
3. Fiber-optic Analogue Transmitter @ 850nm.
4. Fiber-Optic receiver.
5. One-meter PMMA Fiber patch cord.
6. Five-meter PMMA Fiber patch cord.
7. In-line SMA adaptor.
8. To potentiometer to vary forward current of LED in transmitter & current of phototransistor in receiver.
9. SPDT switch for selecting wavelengths 660nm and 850nm.
10. NA JIG with scale marked on it to measure length.
11. Mandrel.
12. Adequate no of other electronic components.
13. Mains On/OFF Switch, Fuse and jewel light.
14. The unit is operative on 230V±10% AT 50Hz A.C. Mains.
15. Adequate no of patch cords stackable 4mm spring loaded plug length ½ Meter.
16. Digital Fiber-optic power OMEGA TYPE DFPM-021.
17. Digital Multi meter OMEGA TYPE DMM-201.

THEORY:

Loss or Attenuation (gradual loss in intensity of any kind of flux through a medium) in optical fibers occur at fiber-fiber joints or splices due to axial displacement angular displacement, separation (air-core), mismatch of cores diameters, mismatch of Numerical Apertures, improper cleaving and cleaning at the ends.

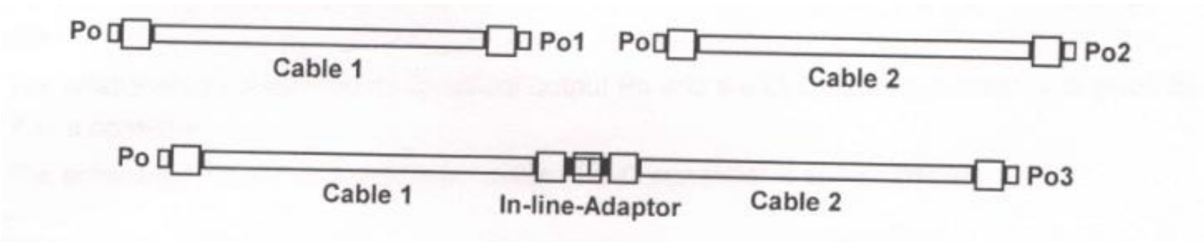
The optical power at a distance L, in an optical fiber is given by $P_L = P_0 10^{\left(-\alpha L/10\right)}$

Where

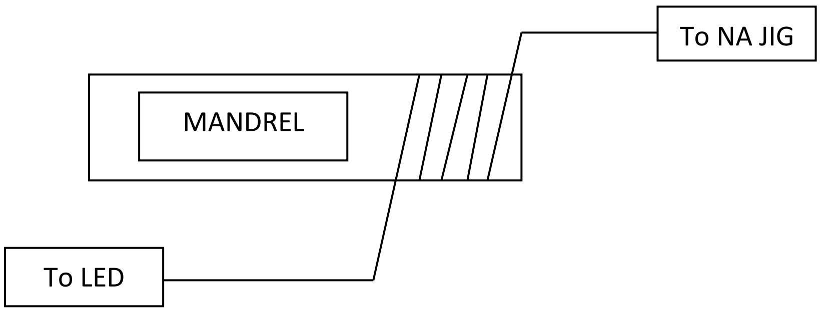
α is attenuation coefficient in decibels (db) per unit length

P_0 is the launched power & P_L is the power after covering distance L in the fibre.

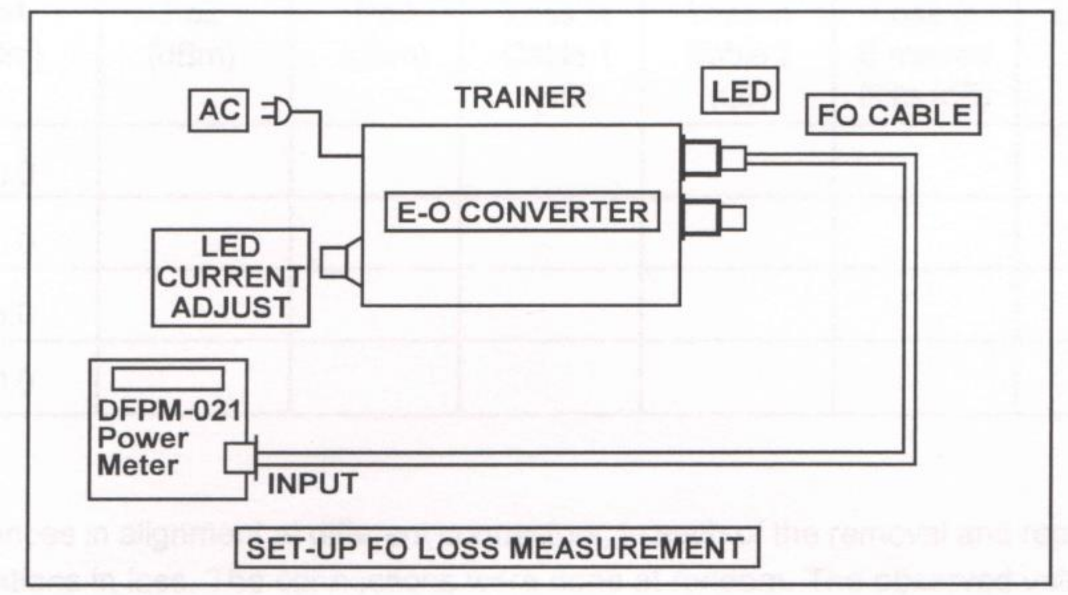
Propagation loss:



Bending loss:



EXPERIMENTAL SET UP:



PROCEDURE:

1. Connect the one end of 1 m cable to the LED port of the trainer and the other end to the power meter.
2. A digital multi meter is connected to measure the power in dBm unit directly, keeping the voltage range of 200 mV or 2000 mV.
3. Put the wavelength selector switch to particular wavelength (as 660nm) position.
4. Plug the AC mains. Neon light will glow indicating that instrument is ready for use.
5. Make sure that the optical fiber patch cord is connected securely, as shown after relieving all twists and strains on the fiber. Adjust the LED CURRENT ADJUST knob to set P_0 of the LED to a suitable value (around 15 or 20 dBm) and note this as $P_0 1$. (voltmeter reading of 150 mV corresponds to 15 dBm)
6. Now remove the other end of 1 m cable from power meter slots and connect it to another cable of 5 m length through in line adapter. And connect the other end of the 5 m cable to power meter and measure the volt meter reading. Divide the volt meter reading by 10 to get the power at the end of the combination of 1 m and 5 m cable as $P_0 2$.

7. P_01- P_02- (loss in adapter) gives power loss in 5 m cable. Generally the loss in in- line adapter is up to maximum 1 dBm.
8. Now connect one end of the 5 m cable to LED port and other end to power meter and measure P_01 (power at the end of 5 m cable)
9. Connect one end of 1 m cable with 5 m cable through adapter and other end to power meter to measure power at the end of combination as P_02.
10. P_01- P_02- (loss in adapter) gives power loss in 1 m cable.
11. To measure the bending loss, first measure the power (P_01) at the end of the fiber without any twist and turns.
12. Wind one turn of the fiber on the mandrel and note the new reading of the power as P_02. Now the loss due to bending and strain on the plastic fiber is P_01- P_02 dB. For more accurate readout set the power meter to the -20dB to -10dB range and take the measurement.
13. Wind second turn of the fiber on the mandrel and note the new reading of the power as P_03.
14. Find the difference P_02- P_03. This also gives loss per turn of the fiber.

OBSERVATION TABLE:

(For propagation loss)

Sr. No.	P_01 (dBm)	P_02 (dBm)	P_03 (dBm)	Loss in cable 1 (dB)	Loss in cable 2 (dB)	Loss in 6 m Fiber (dB)	Propagation loss (dB/m)
1							
2							
3							
4							

OBSERVATION TABLE:

(For bending loss)

Sr. No.	No. of turns	$P_0 1$ (dBm)	$P_0 2$ (dBm)	Loss in cable 1 (dB)	Loss in cable 2 (dB)	Loss in 6 m Fiber (dB)	Bending loss (dB/m)
1	0						
2	1						
3	2						

CALCULATION:

RESULT:

From this experiment,

Propagation loss in the fiber is measured as _________________ dB/km

Bending loss in the fiber is measured as_______________ dB/turn

QUESTIONS: -

1] Mention the types of loses occurring in optical fiber?

Ans: -____
____
____

2] Which type of optical fiber has least loss?

Ans: -____
____
____

3] What is TIR and mention it's conditions?

Ans: -____
____
____

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EXPERIMENT 13

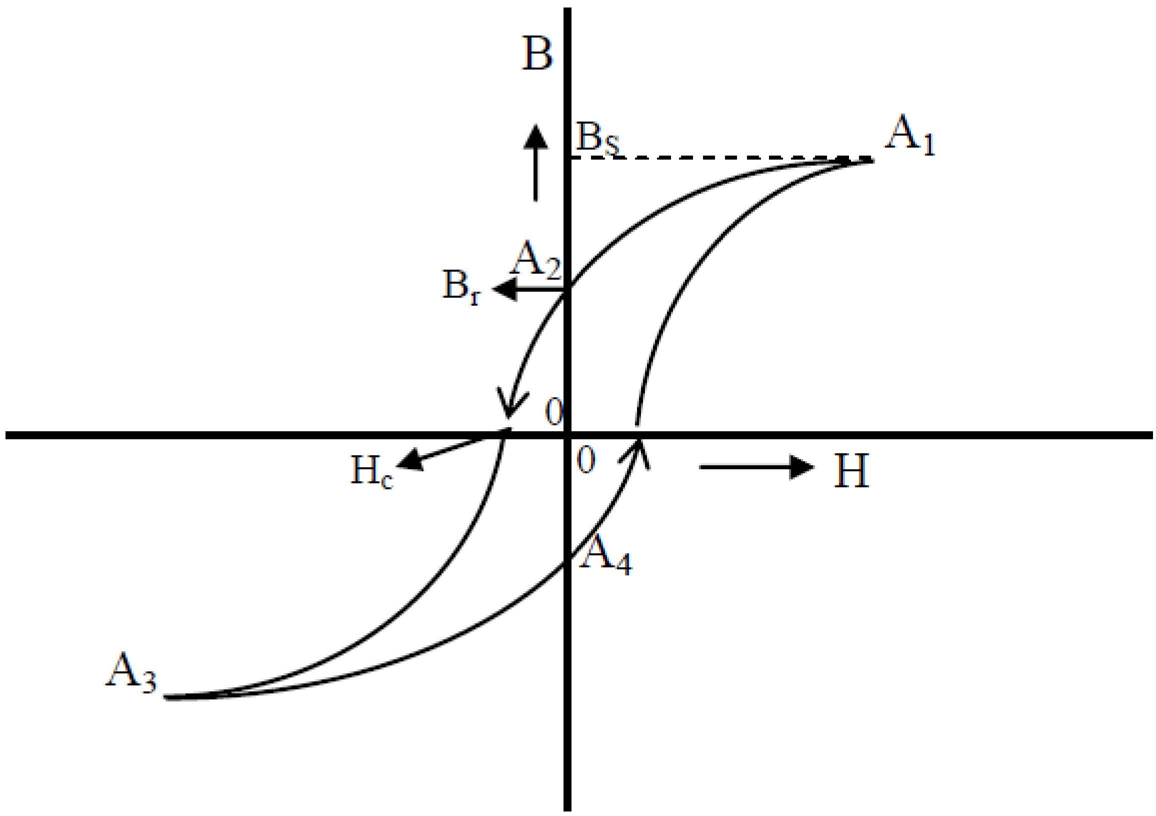
B-H CURVE

OBJECTIVE: To trace the B-H curve for an iron core and to study the effect of varying the voltage and frequency on hysteresis loop.

APPARATUS: Power supply, U and I core, coils with 300 turns, BNC connector cable, 50 cm lead, CRO.

THEORY:

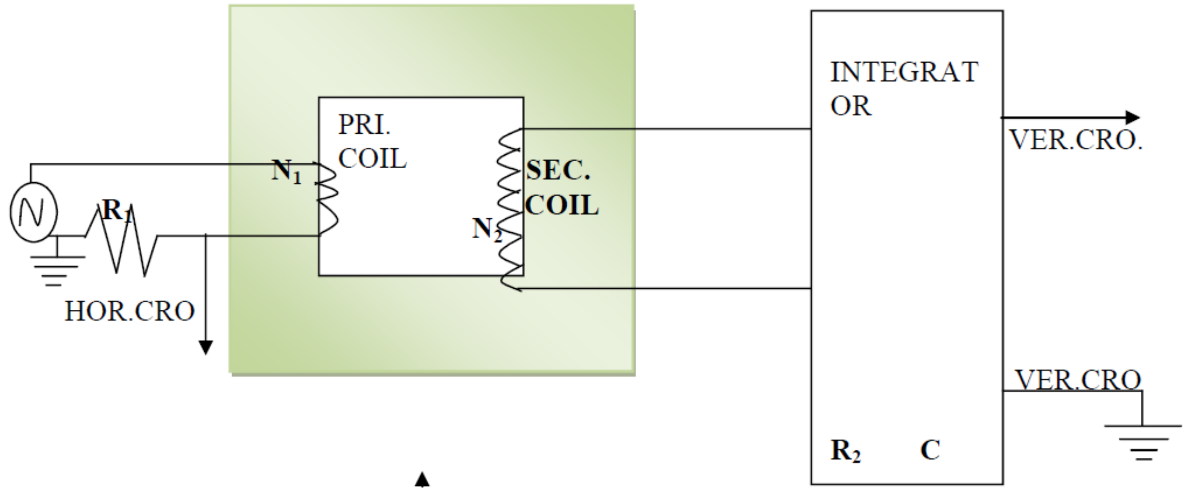
In a ferromagnetic material the magnetic induction field B is not a linear function of the magnetic field H. The magnetic induction field, for a given H, depends on the previous history of the specimen. The curve of B vs. H is shown in the following figure.



When the magnetic field H is very large in the positive or negative direction, the magnetic induction field B saturates at a value ±BS, called the saturation magnetic field. At any given value of the magnetic field H, there are two values for B, one when the magnetic field H is decreasing and another while the magnetic field H is increasing. Thus B depends on the history and the phenomenon is called hysteresis. If the magnetic field is reduced from a maximum value to zero, the magnetic induction field does not go to zero. It has a value ± Br depending on whether the magnetic field H is brought to zero from a positive value or from a negative value. The value of Br is called the residual magnetic induction field. To make the magnetic induction field B zero one has to apply a magnetic field ± Hc (+ when the magnetic field is increasing and – when it is decreasing). This field Hc is called the coercive field. The values of Br and Hc are characteristics of a ferromagnetic material. A material with a small Hc is called a soft ferromagnetic material while one with a large Hc is called a hard ferromagnetic material. If the ferromagnetic material is subjected to an AC magnetic field H, the area enclosed by the B-H curve gives the amount of heat generated per cycle per unit volume in the material. So hysteresis leads to wastage of electrical energy as heat.

Examples of ferromagnetic materials are Fe, Ni and Co at room temperature and ceramic materials which are oxides of iron or Ni and other elements like Zn. One can use materials with properties suited for a particular application. For example if one wants a ferromagnetic core material for winding a transformer, one should reduce the hysteresis loss i.e. one should have a soft magnetic material like soft iron with low coercive field. On the other hand if one would like to make a permanent magnet, the material must have a large residual magnetization and a large coercive field. Such a material is hard iron. If one wants to use a ferrite material for computer memories then it should have a square hysteresis loop (i.e. Br nearly equal to Bs) with a small coercive field. The state +Br will be called the state 1 and the state –Br will be called the state 0. A large variety of magnetic materials tailor-made for a number of applications are now commercially available.

CIRCUIT DIAGRAM:



A Magnetic field is generated in a U & I shape iron core by continuous (Sin or Triangular) wave to primary coil which generates the magnetic field strength H as

$H= (N_1/L).I_1$

Where L: Effective length of iron core, N1: Number of turn.

The corresponding magnetic induction B is obtained through integration of the voltage V induced in second coil as:

$B= (1/N_2.A). \int V.dt$

Where A: Cross-section of iron core, N_2: Number of turns.

In the present setup, the magnetization curve and Hysteresis curve as function of the magnetic field strength H is plotted.

EXPERIMENTAL SET UP:

PROCEDURE:

1. Connect the CRO to A.C mains and switch it on. Adjust the intensity and focusing controls so that fine and bright spot is observed on the screen when it is used in X-Y mode by setting it to the external input.
2. Supply the voltages from the power supply to the X-plates and Y-plates of CRO and switch on the supply connected to the primary of the U core.
3. Adjust the horizontal and vertical gain controls of CRO to get B-H curve of proper shape and size on the screen of CRO.
4. The closed curve represents the cyclic variations of B which is called magnetic hysteresis or B-H curve or hysteresis loop.
5. Trace the curve on tracing paper after making it symmetrical with respect to X-axis and Y-axis marked on the screen of CRO. Mark these two axis on trace paper along the B-H curve.
6. Trace the curves for different voltages keeping frequency constant and for various frequencies keeping the voltage constant.

OBSERVATION TABLE:

At frequency f = ______________ Hz

SR. NO.	Voltage	Area enclosed in B-H curve	B_{max}

At Voltage V = ______________ volt

SR. NO.	frequency	Area enclosed in B-H curve	B_{max}

CONCLUSION: ____
____
____

QUESTIONS: -

1] What is hysteresis loss?

Ans: -____
____
____

2] Difference between soft and hard magnetic materials.

Ans: -____
____
____

3] Types of magnetic materials and explain them with the help of its dipole arrangement?

Ans: -____
____
____

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