DEPARTMENT OF PHYSICS

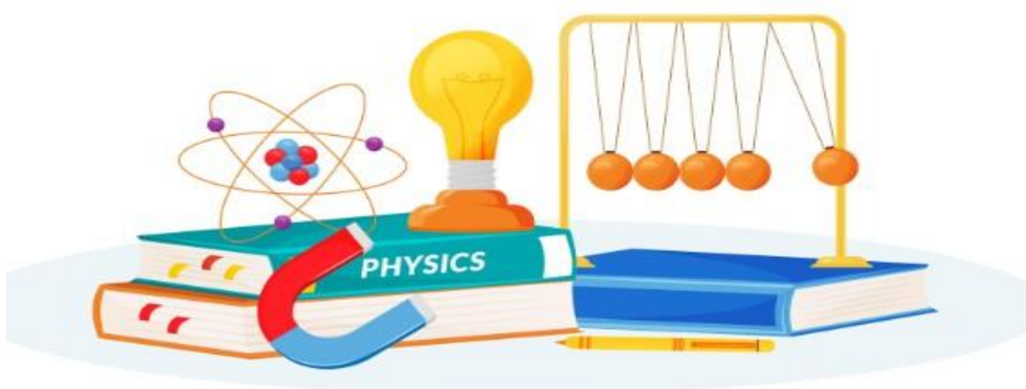
LAB MANUAL

ENGINEERING PHYSICS LAB (Integrated)

(24BEPHY103/203)

FOR

I/II SEMESTER BE/B.Tech (Common to all branch)



NAME OF THE STUDENT: …………………………………………………………

USN/ ROLL NO: ……………………………………………………………………

BRANCH: …………………………………SEM: ………………………………………

SECTION: …………………………………BATCH: …………………………………

Course Outcomes - CO (24BEPHY103/203):

Upon completion of this course, students will be able to **Practice** working in groups to conduct experiments in physics and **perform** precise and honest measurements

CONTENTS

DEPARTMENT OF PHYSICS

ENGINEERING PHYSICS LABORATORY

Do’S

- Keep your bags in the luggage rack.
- Bring observation book and record book regularly to the lab.
- Bring calculator & drawing materials regularly to the lab.
- Switch ON the power supply after the circuit connection is checked by the teacher.
- Disconnect (remove all the connecting wires) the circuit after the conduction of Expt.
- Handle the apparatus gently and carefully.
- Check lab manual, record, observation book, calculator etc, before leaving the lab.

Don’ts

- Dump your bag on the worktable.
- Use/carry mobile phones inside the lab.
- Give your observation book and records to others.
- Forget to check your belongings before leaving the lab.
- Spoil the apparatus as it is meant for your benefit only.
- Switch on electronic equipment before getting the approval by the teacher
- Play with LASER light, it’s Harmful.

1. DIFFRACTION GRATING

AIM: To determine the wavelength of LASER source using diffraction grating.

APPARATUS: Diffraction grating (500LPI), diode LASER source, image screen, meter scale.

FORMULA:

1. Wavelength of LASER source is given by

$$\lambda = \frac{d \sin\theta_m}{m} \qquad \text{(nm)}$$

2. Diffraction angle, $\theta_m = \tan^{-1}\left(\frac{X_m}{L}\right)$ in degree

Where, d = Grating constant in meter
θ = angle of diffraction in degree.
m = 1, 2, 3,…..n is called order of diffraction
X_m = distance of m^{th} order diffraction pattern from the centre 0^{th} order diffraction (m)
L = distance between screen and grating (usually taken as 100 cm)

(Note: to find grating constant, $d = \left(\frac{1}{N}\right) = \frac{1 inch}{500 lines} = \frac{2.54X10^{-2}}{500}$ = $5.08x10^{-5}$ m

PROCEDURE:

1. The laser is placed on experimental table and switched on. At about one meter away on the path of the laser a screen is placed, such that the laser beam exactly falls on the centre of the screen. The exact distance between screen and grating stand are noted, L = 1 m (100 cm).
2. The 500LPI (**L**ines **P**er **I**nch) grating is now placed on the grating stand close to the laser source and the diffraction pattern is observed which is shown in the figure. Equally spaced diffracted laser light spots are observed. The central direct ray is very bright in the picture; as the order increases the brightness decreases.
3. The center of the spots of the diffraction pattern are marked on the screen (graph sheet) using a pencil and after marking all the diffraction patterns on the screen, graph sheet is removed and the distances between consecutive order of diffraction is measured using a scale, and tabulated.
4. The distances between the two first orders diffraction spots are measured as $2x_1$ cm, next $2x_2$ cm. This is continued up to 6^{th} order, $2x_6$ cm.
5. The diffraction angles (θ_m) are calculated from 1^{st} to 6^{th} order and tabulated.
6. Wavelengths of laser source are calculated from 1^{st} to 6^{th} order and tabulated. The average value of wavelength is calculated.

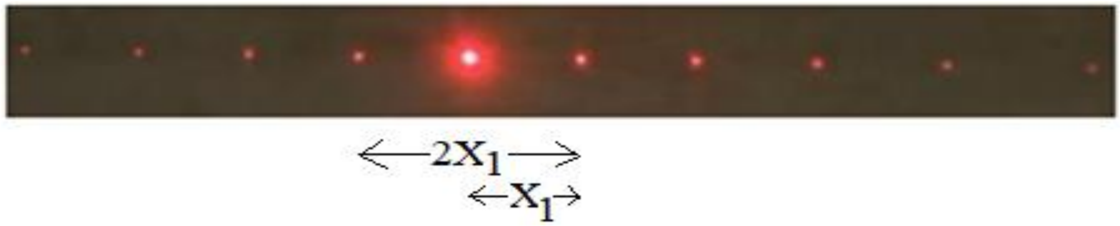
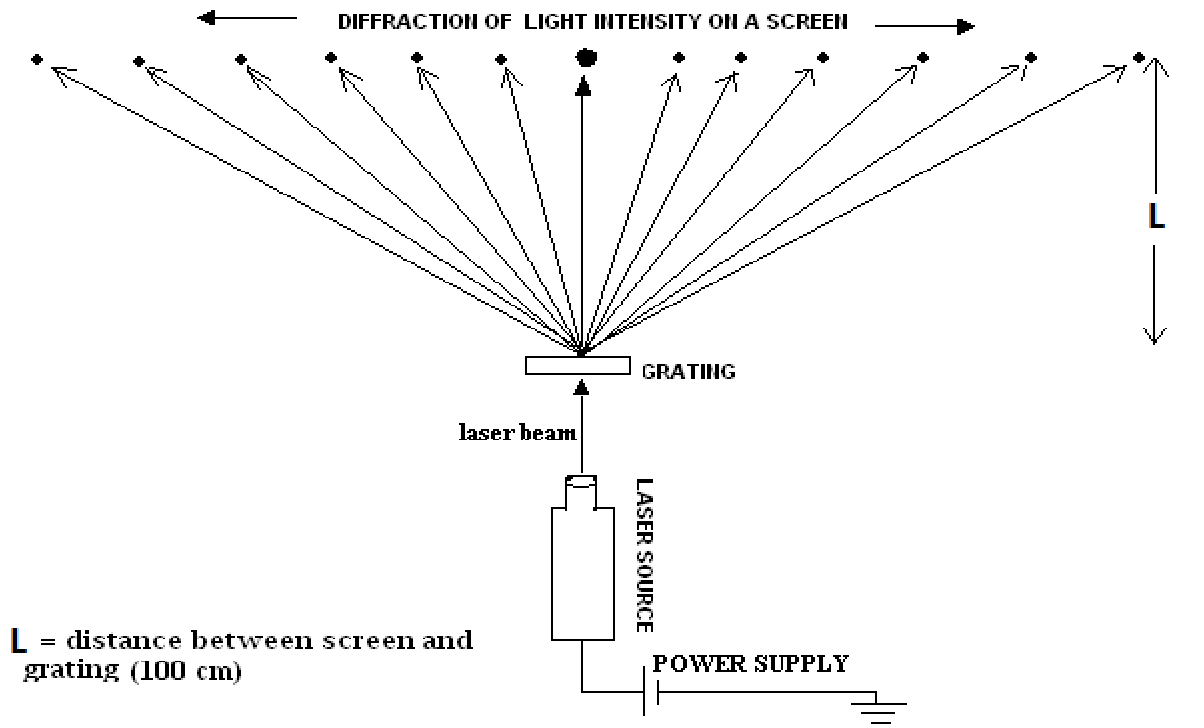


DIAGRAM:



TABULAR COLUMN:

Diffraction Order (m)	Distance $2x_m$ (cm)	Distance x_m (cm)	Diffraction angle (θ_m) $(^0)$	Wavelength λ (nm)
1				
2				
3				
4				
5				
6				

λ_{avg} = ………… nm

CALCULATION:

RESULT:

- The wavelength of the given diode laser source is (λ) = --------- nm

2. DIELECTRIC CONSTANT

AIM: To determine the dielectric constant of the given capacitor by the method of charging and discharging the capacitor.

APPARATUS: RC charging discharging experimental set up consisting of digital stop clock 0.1 sec resolution (0-100 sec), digital dc voltmeter 0-20V, set of resistors (100 KΩ) and set of capacitors (C_1) of known dimensions. DC regulated power supply (0-5V).

FORMULA:

Dielectric constant is given by

$$K = \frac{1.44T_{½}d}{10^6 \varepsilon_0 AR}$$

Where, $T_{½}$ = The time in sec at which the voltage across the capacitor during charging and discharging is the same.

d = Separation between the plates in m.

ε_0 = Permittivity of free space = 8.854×10^{-12} F/m.

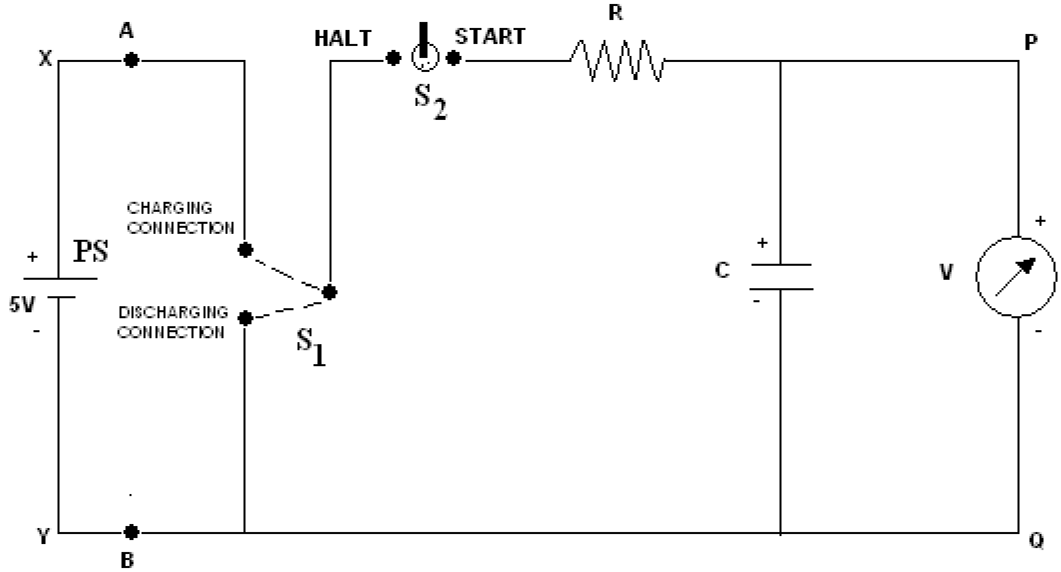
A = Area of the plates of the capacitor in m^2

R = Resistance in ohm.

PROCEDURE:

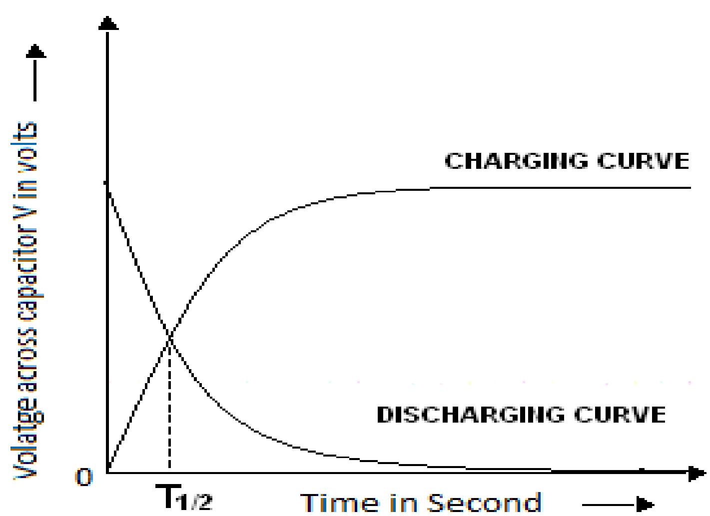
1. The circuit connections are to be made as shown in fig. Select R as 100KΩ and capacitor C_1.
2. Pressing reset button resets the digital stop clock. The display indicates 00.0.
3. The digital DC voltmeter and 5V power supply are connected to the circuit as shown in fig.
4. Switch S_1 (charge-discharge) is shifted to the charge position.
5. Switch S_2 (Halt- Start) is placed to the start position, watching the digital stop clock and the voltmeter.
6. Immediately the values of voltage readings are noted at an interval of 10 second each without pausing in between.
7. The experiment is carried out till it reaches steady state (constant voltage across capacitor). In each case the capacitor voltage is to be noted at an interval of 10 second.
8. When the capacitor is charged to maximum voltage, the charging is stopped and the charge-discharge switch is to move discharge position and clock is reset.
9. The voltage across the discharging capacitor is noted after 10, 20, 30,…. second. This is done until the capacitor is discharged fully.
10. Draw a graph by taking time on X-axis and voltage along the Y-axis as shown in the graph. The charging and discharging curve intersects at a point along the time axis, where the voltage across the capacitor during charging and discharging remains the same. The time $T_{½}$ at this point is to be noted.
11. Dielectric constant is determined using the formula.

CIRCUIT:



Where: PS: DC Power Supply (0-5V)
C: Capacitor
R: Resistor (100KΩ)
V: Voltmeter (0-5V)
S_1: Switch for charging and discharging
S_2: Switch for Halt and Start

NATURE OF GRAPH:



TABULAR COLUMN:

R = 100KΩ

Time in (second)	Voltage across capacitor C_1 (in volt)	
	During Charging	During Discharging
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		

Note:

For capacitor C_1:

Area, A = 235 mm^2 = 235x10^{-6} m^2
Separation between plates, d = 0.075 mm = 0.075x10^{-3} m
Resistor, R = 100x10^3 Ω

CALCULATION:

RESULT:

- The dielectric constant of the material in the capacitor is found to be K= ………

3. SERIES LCR CIRCUIT

AIM: To study frequency response of series LCR circuit and hence to determine its resonance frequency, band width, quality factor and self-inductance.

APPARATUS: Function generator (FG), inductance coil (L1), capacitors (0.047 μF), resistors (1 kΩ), Digital ac milli ammeter (0–20 mA) etc.

FORMULAE:

4. The self-inductance of a coil is given by

$$L = \frac{1}{4\pi^2 f_r^{\,2} C} \qquad \text{henry.}$$

5. Band width, BW= ($f_2 \sim f_1$) hertz

6. Quality factor, $Q = \dfrac{f_r}{f_2 - f_1}$

Where L= inductance of the coil in henry
f_r= resonant frequency in hertz
C= capacitance of the capacitor in farad
f_1= lower cut-off frequency in hertz
f_2= upper cut-off frequency in hertz

PROCEDURE:

1. The capacitor C, inductor L, resistor R, and a milli ammeter (mA) are connected in series with a function generator (FG) as shown in the circuit.

2. Set the suitable value of L, C, and R keeping all controls of the function generator at minimum, switch-on the function generator. Then set amplitude control at maximum and waveform button at sine wave.

3. Set the frequency (f) to 1 kHz and note down the milli ammeter (I) reading.

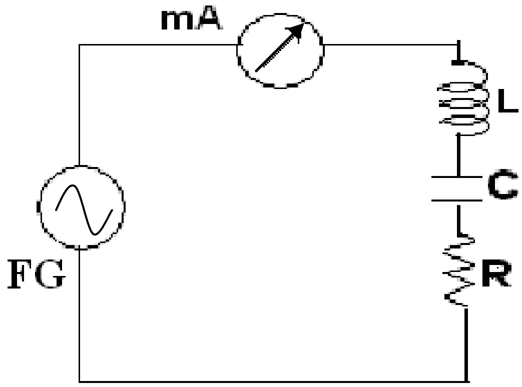
4. Increase the frequency in steps of 0.5 kHz and note down the corresponding current.

5. Plot a graph of current versus frequency.

6. The frequency corresponding to the peak (I_{max}) is the resonance frequency (f_r). The frequency corresponding to $\dfrac{I_{max}}{\sqrt{2}}$ be the cut-off frequencies f_1 and f_2.

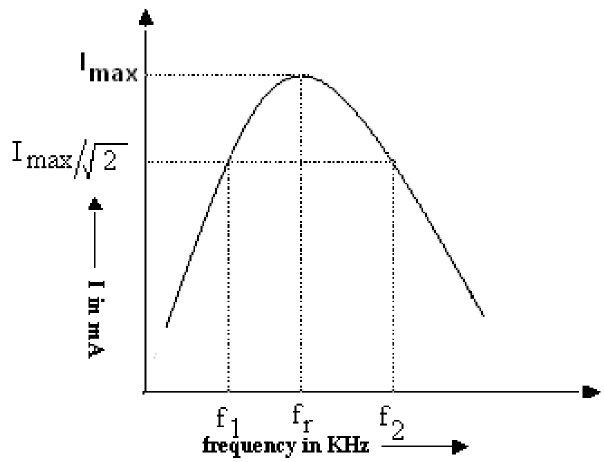
7. Finally calculate bandwidth, quality factor, and the self-inductance of a coil with the help of graph.

CIRCUIT:



where
FG: Function generator
mA: Milli Ammeter (0–20mA)
L: Inductor
C: Capacitor
R:Resistor

NATURE OF GRAPH:



TABULAR COLUMN:

Frequency (KHz)	Current (mA)
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	
6.0	

CALCULATION:

RESULT:

1. The resonant frequency, f_r = ……………… kHz.
2. Band width, BW = ……………. kHz.
3. Quality factor, Q =…………….
4. The self-inductance of the coil is found to be, L = …………..mH.

4. Hall coefficient of semiconductor

Aim: To determine the hall coefficient of the given sample using Hall effect.

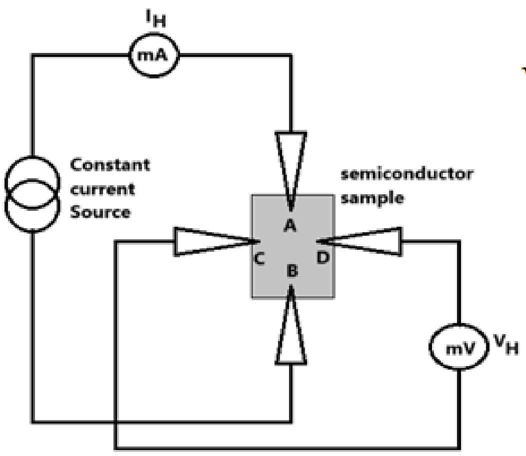
Apparatus: Hall probe with semiconductor, Electro magnet, current source and Gauss meter.

Formula: Hall coefficient $R_H = \frac{V_H t}{I_H B}$ m^3/Coulomb

Where,

V_H → Hall Voltage,
I_H → Hall Current,
B → Magnetic flux,
t →Thickness of the sample

Circuit diagram:



Where
A, B, C & D → Four probes
mA → milli ammeter (across probe A & B)
mV → milli voltmeter (Across probe C & D)

Procedure:

Part A: Calibration of the electromagnet

1. The constant current power supply is connected to the electromagnet and power is switched on.
2. The gauss meter probe is connected to the digital gauss meter. The gauss meter probe is positioned at the centre of the two pole pieces of the electromagnet and the electromagnet power supply is switched on.
3. The current in the constant current power supply is now set to 0.5A and the magnetic flux in the gauss meter is noted.
4. The experiment is repeated by increasing the current in steps of 0.1 A up to the maximum value of 1.5A.

Part B: Calculation of Hall voltage & Hall coefficient

1. The Hall probe or sensor with semiconductor sample is connected to the kit as shown in circuit diagram.
2. The current to the sample is set to 4mA or 3mA (constant) and the voltage developed across the slab without the magnetic field (when B=0) is noted which is V_{0H}.
3. The probe is placed in between the two pole pieces of the electromagnet and current to the electromagnet is switch on.
4. If the voltage increases the probe positions is correct or flip the probe to get correct position. With current passing through the sample, the voltage developed is noted by increasing the magnetic flux in steps 0.1K Gauss.
5. Hall voltage V_{HB} is calculated and V_{HB}/B values are calculated. By taking the mean of V_{HB}/B Hall coefficient is determined.

Tabular Column:

Probe current, I_H =__________mA
Probe voltage without B (magnetic field), V_{0H} =__________mV

Magnetic Current in A	Magnetic Flux B in K Gauss	Probe Voltage V_{BH} in mV	Hall Voltage $V_H = V_{BH}-V_{0H}$ (in mV)	V_H/B mV/kGauss
0.5				
0.6				
0.7				
0.8				
0.9				
1.0				
1.1				
1.2				
1.3				
1.4				
1.5				

Note : 1 KGauss = 10^{-1} T

Calculation:

Result: The Hall coefficient for the given sample is determined as: R_H = ____ m^3/Coulomb

5.BLACK BOX EXPERIMENT

AIM: Identification and determination of unknown passive elements (R –Resistance, L- Inductance, C- Capacitance) using Black box.

APPARATUS: Functional generator, Voltmeter and passive elements of Resistor, Inductor, Capacitor (Black box Kit).

FORMULAE:

1. Transfer Ratio (Voltage Gain)

$$A_v = \frac{V_0}{V_i}$$

Where V_r is the input voltage & V_0 is the output voltage.

2. Resistance $R_Z = \frac{R_L(1-A_v)}{A_v}$ in Ω

Where $R_L = 1K\Omega$

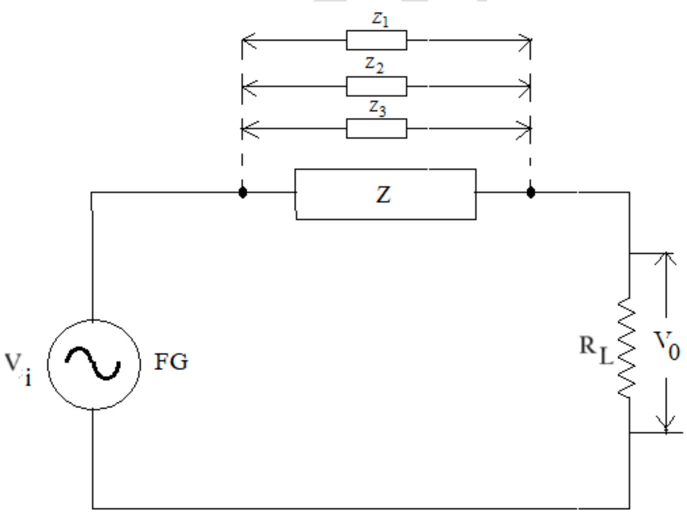
3. Inductance of an Inductor $L = \sqrt{\frac{Z^2 - R_L^2}{\omega^2}}$ in H

4. Capacitance value $C = \sqrt{\frac{1}{\omega^2(Z^2 - R_L^2)}}$ in F

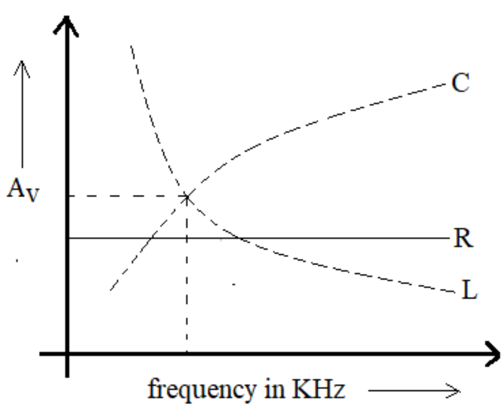
Total impedance $Z = \frac{R_L}{A_v}$ and $\omega = 2\pi f$

Z and ω are total impedance and angular frequency respectively. Where z and f values are corresponding values of the intercept of the two curves in the graph.

CIRCUIT:



NATURE OF GRAPH:



Where FG → Function Generator
Z → Unknown passive elements (Z_1,Z_2 & Z_3)
V_i →Input Voltage
V_0 →Output Voltage

TABULAR COLUMN:

The load resistance value R_L = 1000 Ω, Set Input ac voltage V_i : 1 V

f in KHz	Output voltage V_0 in volts			Transfer Ratio, $A_v = \frac{V_0}{V_i}$		
	Z_1	Z_2	Z_3	Z_1	Z_2	Z_3
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

PROCEDURE:

1. The circuit connections are made as shown in the figure.
2. Set the input voltage, V_i = 1 V and initial frequency, f = 1 KHz.
3. Connect Z_1 in the place of Z. The frequency is increased from 1 KHz to 10 KHz in steps of 1 KHz and the output voltage is noted down in each trial.
4. As frequency increases, the output voltage decreases. Hence Z_1 is an Inductor.
5. Connect Z_2 in the place of Z. The frequency is increased from 1 KHz to 10 KHz in steps of 1 KHz and the output voltage is noted down in each trial.
6. As frequency increases, the output voltage remains same. Hence Z_2 is a Resistor.
7. Connect Z_3 in the place of Z. The frequency is increased from 1 KHz to 10 KHz in steps of 1 KHz and the output voltage is noted down in each trial.
8. As frequency increases, the output voltage also increases. Hence Z_3 is a Capacitor.
9. The Transfer ratio (A_V) is calculated across the elements Z_1, Z_2 & Z_3 using the formula.
10. Plot the graph of A_V versus applied frequency for all the three elements.
11. Identify the value of A_V for the element Z_2, and calculate the unknown resistance (R_Z) using the formula.
12. Identify the value of A_V and f from the curves drawn for Z_1 and Z_3 in the graph. Using total Impedance (Z), the unknown values of L and C are calculated using the formula.

CALCULATION:

RESULT:

1. Z_1 is identified as______________ and its value is ______________
2. Z_2 is identified as ______________ and its value is ______________
3. Z_3 is identified as ______________ and its value is ______________

6. Optical fibre

AIM: To determine the acceptance angle and numerical aperture of the given optical Fiber.

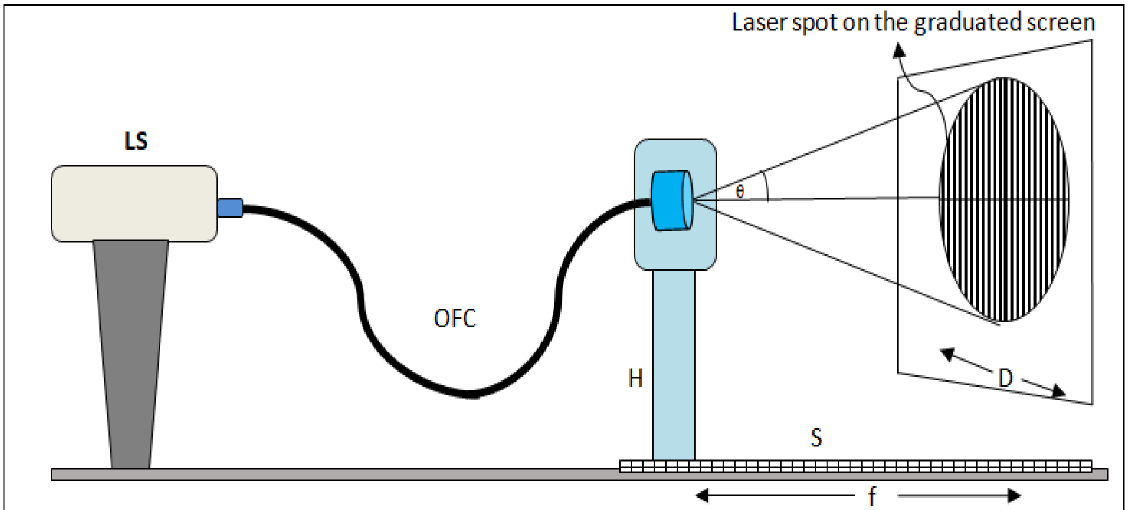
APPARATUS: Laser source, optical fibre cable, screen and scale

FORMULAE:

1. Acceptance angle, $\theta_A = \tan^{-1}\left(\frac{D}{2f}\right)$
2. Numerical aperture, NA= $\sin(\theta_A)$

Where, f → Distance between the optical fibre end and screen.
D → Diameter of the Laser spot on the screen.

FIGURE:



Where,
LS = Laser Source
OFC = Optical fiber cable
H = OFC holder/ Chuck
S = Scale
f = Distance between holder/ chuck and screen.
D = Diameter of the spot.

PROCEDURE:

1. The optical cable is coupled to the laser and the laser light coming through other end of the cable is verified.
2. The other end of the cable is coupled to the chuck fixed on the transverse motion bench. The chuck carrying the OFC is brought close to the graduated screen and the laser spot is seen on the graduated screen.

3. By adjusting the fine motion screw of the microscopic bench the spot size is reduced to 8 mm.
4. The distance between the fixed screen and chuck carrying OFC is noted on the graduated scale fixed along the X-axis and tabulated.
5. The trial is repeated by increasing the size of the spot to 10 mm, 12 mm, 14 mm and the corresponding ‘f’ is noted. This is done until the spot is sufficiently bright and clear.

TABULAR COLUMN:

Sl. No	D (in mm)	f (in cm)	f (in mm)	$\theta_A = \tan^{-1}\left(\frac{D}{2f}\right)$ in Deg	NA = Sin(θ_A)
1	8				
2	10				
3	12				
4	14				
5	16				
6	18				

Mean θ_A = _____ Mean NA = _____

CALCULATION:

RESULT:

The angle of Acceptance is determined as θ_A = _______ degree and Numerical aperture of the fibre optics cable was found to be NA= _____

7.PLANCK'S CONSTANT

AIM: To determine the Planck`s constant by using LED.

APPARATUS: Planck`s Constant Kit, different colour LEDs and connecting wires.

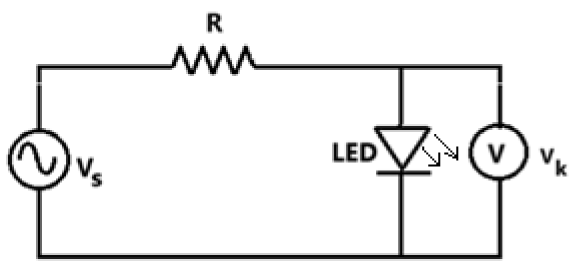
FORMULA:

Planck`s constant $h = \frac{eV_K\lambda}{c}$ Js

Where

e → charge of electron,
λ → wavelength of the LED
V_K → knee voltage
c → velocity of light.

CIRCUIT DIAGRAM:



Where,
V_S → Power supply
R → Resistor
LED → Light Emitting Diode
V → Voltmeter

PROCEDURE:

1. The circuit is connected as shown in the circuit diagram.
2. The input to the LED is an AC signal, and the rectified output across the LED is a unidirectional pulsating signal. A peak-reading meter is used to measure the voltage across the LED.
3. Using a digital peak-reading voltmeter, the voltage across the LED is recorded, and the readings are tabulated. The peak-reading voltmeter provides the knee voltage V_K.
4. The procedure is repeated by replacing the LED, and the corresponding knee voltage is noted for each trial.
5. The product of the wavelength and the knee voltage is calculated, and its average value is determined.
6. Using the average value of λV_K, Planck's constant is calculated using the formula provided.

TABULAR COLUMN:

Colour	**Wavelength λ (in nm)**	**Knee Voltage V_k (in V)**	**λV_k (in V-nm)**
Yellow	576		
Green	548		
Blue	350		
Red	620		
IR LED	780		

$(\lambda V_k)_{Avg}$ = ...

CALCULATION:

RESULT:

Using an LED, Planck's constant is determined as h = ___________ JS

.

8.PHOTODIODE CHARACTERISTICS

AIM: To study the characteristics of photodiode in response to power of LED source.

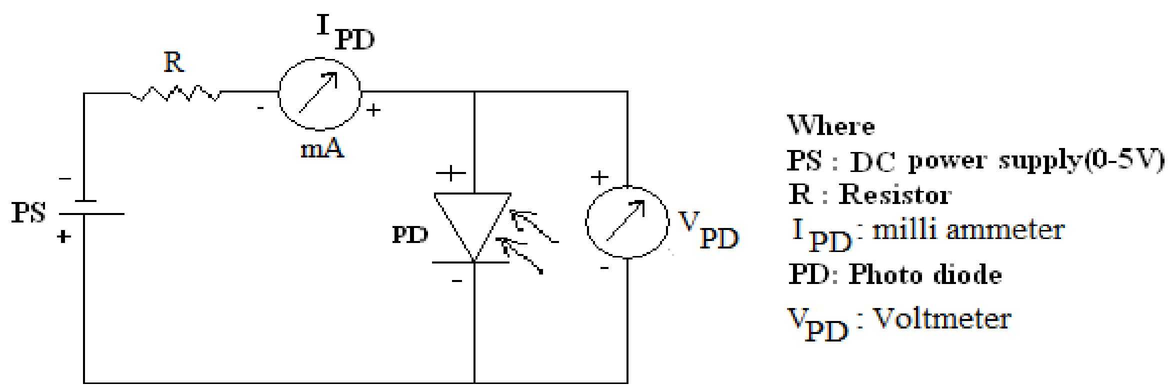
APPARATUS: Photodiode kit, LED, photodiode and connecting wires.

FORMULA:

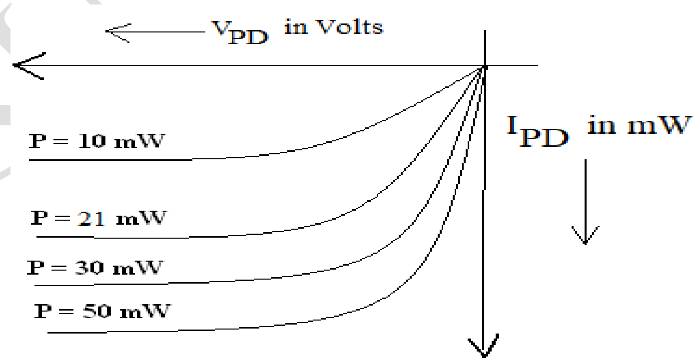
Responsivity, $R_\lambda = \frac{I_{PD}}{P}$ A/W

Where I_{PD} is photo diode current and
P is the light input power

CIRCUIT DIAGRAM:



MODEL GRAPH:



PROCEDURE:

1. The circuit is connected as shown in the circuit diagram.
2. The white light LED and PD are placed face-to-face 10cm apart (This is the industry standard for any LED measurements). The light arrangement is switched on and the LED power is set to 10mW.
3. After ensuring that the LED is glowing, the cover is placed so that any external light will not affect the observation.

4. PD is connected reverse bias to the power supply with ammeter and voltmeter.
5. The voltage across PD is set to -0.1V by varying power supply. The PD current I_{PD} is noted.
6. The trial is repeated by increasing V_{PD} in suitable steps up to a maximum of -3.5V. The corresponding I_{PD} values are noted and tabulated.
7. The experiment is repeated by setting the LED power to 21 mW, 30 mW, 50 mW and in each case variation in V_{PD} and corresponding I_{PD} are noted.
8. For V_{PD} = -1V the corresponding values of I_{PD} are taken for different powers and responsivity is calculated using the formula provided.
9. A graph is plotted with V_{PD} along the X-axis and I_{PD} along the Y-axis, showing the characteristics of the given photodiode.

TABULAR COLUMN: I-V Characteristics of Photo Diode

V_{PD} (in V)	**I_{PD} (in mA)**			
	P_{LED} = 10mW	**P_{LED} = 21mW**	**P_{LED} = 30mW**	**P_{LED} = 50mW**
-0.1				
-0.2				
-0.4				
-0.6				
-0.8				
-1.0				
-2.0				
-3.0				
-4.0				
-5.0				

For V_{PD} = -1 V

Power in mW	**I_{PD} in mA**	**Responsively, R_λ =(I_{PD}/P) A/W**
10		
21		
30		
50		

Mean R_λ = ________A/W

RESULT:

I-V characteristic curve of PD shown in the graph and the responsivity is measured as R_λ =________A/W

9.RESISTIVITY BY FOUR PROBE METHOD.

AIM: To determine the variation of resistivity of the given sample with temperature by using Four probe method.

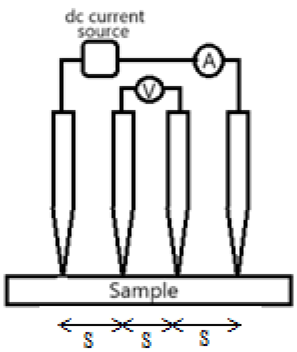
APPARATUS : Four probe kit with semiconductor sample, furnace and digital thermometer.

FORMULA: Resistivity $\rho = \frac{\rho_o}{f(W/S)}\ \Omega - \text{cm}$

Where $\rho_o = \left(\frac{V}{I}\right) 2\pi S\ \ \Omega - \text{cm}$

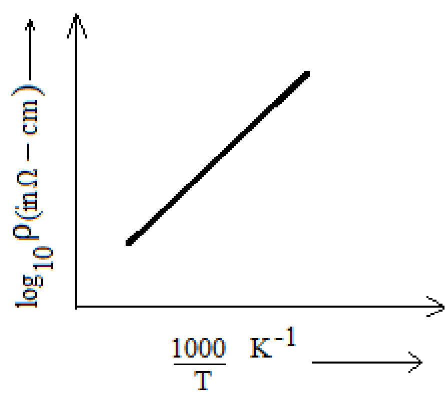
W is the thickness of the crystal in mm,
S is the distance between the probes in mm (convert to cm),
V is the voltage across the inner probes,
I is the current through the crystal,
f (W / S) is the correction factor and its value is 5.54.

DIAGRAM:



Where,
A: milli Ammeter
V: milli votmeter
S : Distance between two successive probes

NATURE OF GRAPH:



PROCEDURE:

1. This method is employed with the sample consists of a thin semiconductor material deposited on a substrate.
2. The experimental setup consists of four probes arranged linearly in a straight line, each spaced 2 mm apart.
3. A constant current is passed through the two outer probes, and the potential drop across the middle two probes is measured.
4. An oven equipped with a heater is used to heat the sample, and a digital thermometer monitors the temperature to study the behaviour of the sample at various temperatures.
5. The current I is fixed (e.g., 2 mA). The heater is then turned on, and the voltage is measured at 5°C intervals up to a range of 70^{o} C. The results are tabulated.

6. Using the formula provided, the resistivity (ρ) is calculated for various temperatures.
7. A graph of temperature 1000/T versus log (ρ) is plotted and found to be a straight line. The resistivity decreases exponentially with an increase in temperature.

Tabular Column:

Current, I = ________ mA

S = 0.2 cm

T (in °C)	V (in mV)	ρ_o (in Ωcm)	ρ (in Ωcm)	T (in K)	1000/T (in K^{-1})	$\log_{10}\rho$
30						
35						
40						
45						
50						
55						
60						
65						
70						

Calculation:

RESULT:

The temperature dependence of the resistivity of semiconductor sample is studied and the dependence of resistivity is exponential with temperature.

10.FERMI ENERGY

AIM: To determine the Fermi energy of the material (copper) of the wire.

APPARATUS: Beaker, copper wire, thermometer and External circuit containing mA and mV with power supply.

FORMULA: The Fermi energy of the material is given by

$$E_F = 1.437\, X 10^{-15} \sqrt{\frac{A\rho S}{L}} \quad \text{(J)}$$

Where, $A = \pi r^2 = 1.639 \times 10^{-7}$ m^2 (area of cross section of the copper wire)

r = radius of copper wire in meter (m)

ρ = density of copper wire = 8.96×10^3 kg/ m^3

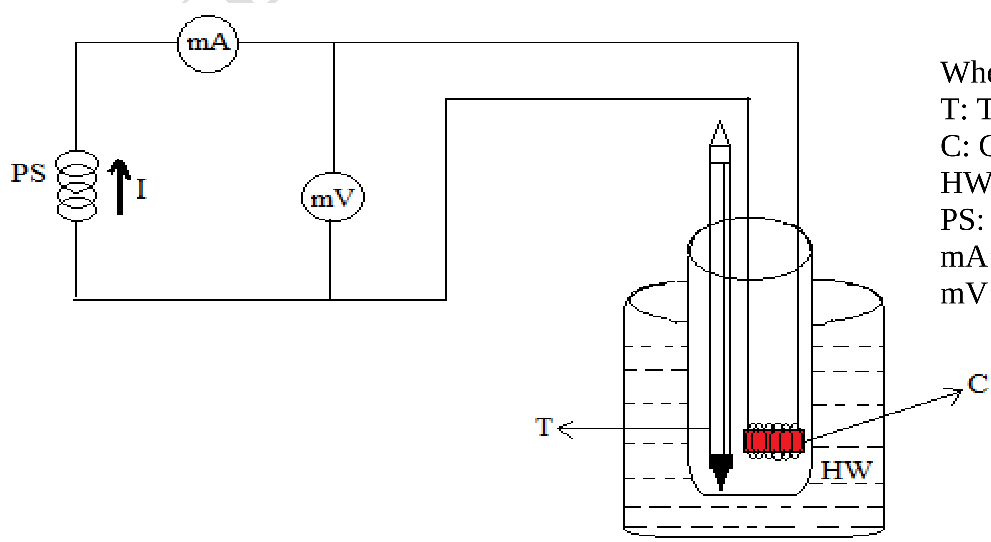
S = slope

L= length of copper wire in meter (3.6 m)

PROCEDURE:

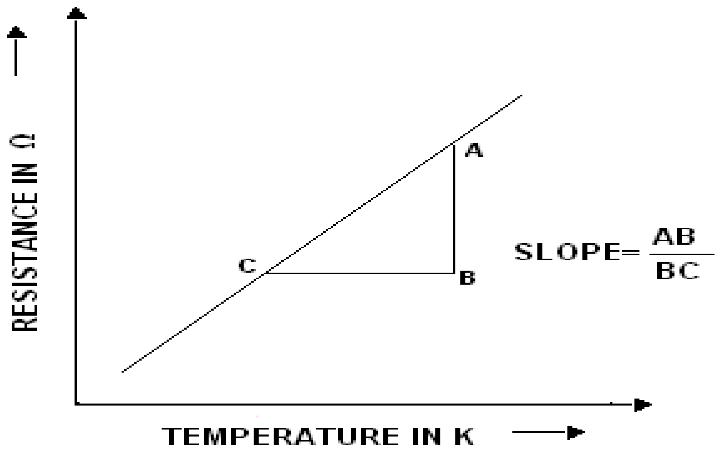
1. The copper wire of suitable dimension is wounded on the insulating material is taken, the coil is kept inside a suitable test tube and in turn test tube is immersed in pre heated water in a beaker.
2. The two ends of the coil wire are connected to an external circuit with milli ammeter and milli voltmeter.
3. A thermometer is immersed in the test tube, which is kept in the water container.
4. The current reading in mA and voltage reading in mV is taken at a temperature say 70^0 C and corresponding resistance is calculated using Ohm's law.
5. The experiment is repeated for every decrease of 5^0 C of temperature and corresponding resistance is calculated using current and voltage readings.
6. A graph of resistance versus temperature is plotted and the slope of the straight line is determined.
7. Finally, the Fermi energy of the material (copper) of the wire is calculated using the formula.

FIGURE:



Where,
T: Thermometer.
C: Copper coil.
HW: Hot Water
PS: Power supply
mA: Milli Ammeter
mV: Milli Voltmeter

NATURE OF GRAPH:



TABULAR COLUMN:

1 eV = 1.6×10^{-19} J

Trial no	Temperature t (^{0}C)	Temperature T (K)	I in mA	V in mV	Resistance $R = \frac{V}{I}$ (Ω)
1	70	343			
2	65	338			
3	60	333			
4	55	328			
5	50	323			

CALCULATION:

RESULT:

The Fermi energy of the material (copper) of the wire is found to be, E_F = ………eV.

VIVA-VOCE
1. Diffraction Grating

1. Expand the term LASER?
Laser stands for Light Amplification by Stimulated Emission of Radiation.

2. What is diffraction?
Diffraction is the process of bending of light and hence its encroachment into geometrical shadow region when it passes through small obstacle whose size is comparable with the wavelength of light.

3. What are the types of diffraction?
There are two types of diffraction namely Fresnel and Fraunhoffer diffraction.

4. What is diffraction grating?
Grating is an optically flat glass plate on which many equidistant rulings are drawn with the help of tip of the diamond.

5. How many types of grating are there?
Two (Transmission grating and reflection grating)

6. What is grating constant?
It is the distance between two consecutive lines in the grating.

7. Which property of light is used to explain diffraction?
Wave property of light.

8. What is the effect on the diffraction pattern if we increase the number of lines per unit length?
The dots become wider.

9. What is the condition to be satisfied to get observable diffraction?
The size of the aperture should be comparable with the wavelength of light.

10. Do we get the same pattern if Mercury vapour lamp is used?
Since mercury vapour lamp is composite light, a spectrum is obtained instead of diffraction pattern.

11. What is the result if we increase the distance between screen and grating?
The distance between the dots becomes more, though the diffraction angle remains same.

12. What is the effect on diffraction pattern if we use a blue laser?
Since wavelength of blue is less, the orders of the spots increases and hence distance between the dots decreases.

13. What type of laser is used in the experiment?

Semiconductor laser diode is used and its wavelength is around 625 nm.

14. Give some properties of laser.

Laser is monochromatic, intense, parallel, unidirectional and coherent source of light.

15. What is monochromatic light?

Light of single wavelength is called as monochromatic. (Single color).

16. What is stimulated emission?

The process in which an atom in the excited state is induced to go to a lower energy state by the influence of a suitable external photon and is made to emit an additional photon which is identical to the stimulating photon is known as stimulated emission.

17. What is a coherent source of light? Give an example.

Two sources of light are said to be coherent if they have a constant phase relation between them. Laser is one example for coherent source.

18. Mention the different types of laser.

Solid state laser (Ruby laser), Semiconductor laser, He-Ne gas laser etc.

2. Dielectric Constant

1. What is a capacitor?

Capacitor is a device used to store charges and hence electrical energy.

2. On what factors capacitance of parallel plate capacitor depends?

Capacitance of parallel plate capacitor depends on

- **(i)** Area of each plate
- **(ii)** Separation between the plates (thickness of dielectric medium)
- **(iii)** Medium of higher dielectric placed between the plates

3. What is a dielectric medium? Give example.

Dielectric medium is an insulator which does not allow the charges to flow through them.
Ex: air, paper, wood, plastic etc

4. Why insulator does not conduct electricity?

Insulator does not conduct electricity because; free electrons are bound to the respective atoms and forbidden energy gap is high (6 eV).

5. Define dielectric constant?

Dielectric constant is defined as the ratio of absolute permittivity of the given medium to the absolute permittivity of the free space/air/vacuum.

6. What is the SI Unit of dielectric constant?

It has no unit. (Dimensionless quantity)

7. Define 1 Farad.

Capacitance of a capacitor is said to be 1 Farad if a capacitor stores 1 Coulomb of charge at a potential of 1 Volt.

8. How does capacitor stores charges?
It stores the charges exponentially.
9. What is $T_{½}$ in the formula?
It is the time at which voltage across the capacitor is same in charging and discharging process.

10. What is charging and discharging process?
Adding charges to a capacitor is called charging process and removing charges from a capacitor is called discharging process

11. When the capacitor is said to be fully charged?
Capacitor is said to be fully charged if the voltage across the capacitor is equal to voltage across the battery.

12. How dielectrics are different from insulators?
Dielectrics are the insulators which can act as a conductor at a particular electric field while insulators never act as a conductor at any electric field.

13. What is dielectric strength?
It is the maximum value of the applied electric field up to which the dielectric retains its insulating property.

14. What is dielectric breakdown?
It is the particular value of the applied electric field above which the dielectric loses its insulating property and acts as a conductor.

15. What does dielectric medium consists of?
Dielectric medium is an insulator which consists of both polar and non-polar molecules.

3. Series LCR Circuit

1. What is resonance?
When the natural frequency of the system matches with the applied frequency, the system is set to be under resonance.

2. What is the condition for the resonance in LCR circuit (Electrical resonance)?
At resonance, the capacitive reactance is equal to the inductance reactance, ie,
$\mathbf{X_c = X_L}$ **or** $\mathbf{1/\,2\pi f_r C = 2\pi f_r L \quad \Rightarrow \quad LC = 1/\,4\pi^2 f_r^2 \quad \Rightarrow L = 1/4\pi^2 f_r^2 C}$

3. How do we identify the resonance in the LC circuit?
When LC is in series with power supply, the current attains the maximum at resonance frequency, whereas LC is in parallel the current will be minimum at resonance frequency.

4. Why the series resonance circuit is called an accepter circuit and the parallel circuit is called rejecter circuit?

In LCR series, the circuit accepts one frequency component out of the range of ac input signals and attains maximum current at that frequency known as resonance frequency, and hence the LCR series circuit is called an acceptor circuit.
Similarly, in parallel resonance circuit rejects the signal of the same frequency as its own resonance frequency. LCR parallel circuit is called rejecter circuit.

5. What is self-inductance of an inductor?

The emf induced in an inductor **e = -L dI/ dt.**
Where, L is coefficient of self-inductance and is often referred as self-inductance, **dI/ dt** is the rate of change of current. The coefficient of self-inductance is numerically equal to emf induced in it when the rate of change of current **dI/ dt** = 1 amp/second.

6. What is the function of inductor?
An inductor is a coil which opposes the change of alternate current.

7. Define 1 henry.
An inductor is said to be 1 henry if 1 volt of emf is induced in the coil when current through it changes at one amp/second.

8. What is power factor?
Power factor is defined as the ratio of the resistance(R) to the impedance (Z).

9. Define inductive reactance X_L and capacitive reactance Xc?
Inductive reactance of a coil is its effective opposition offered by the inductor to the flow of current. It is given by $X_L = \omega L = 2\pi fL$
Capacitive reactance of a coil is its effective opposition offered by the capacitor to the flow of ac current. It is given by $X_C = 1/\omega C = 1/ 2\pi fC$.

10. What are the applications of LCR circuit?
LCR circuits are used in oscillating circuits and in radio and communication engineering, noise filters, AC main filters etc.

12. At resonance frequency what is the magnitude of impedance?
Impedance will be the minimum.

13. What is the effect of resistance on resonant frequency?
Resonant frequency is independent of the resistance.

14. What is the effect of resistance on Q-factor?
Q-factor is inversely proportional to resistance. i.e., resistance increases the bandwidth and decreases the sharpness of the curve.

15. What is quality factor?
Quality factor defines sharpness of resonance curve. The sharpness and resonance gives a measure of the rate of fall of current amplitude from its maximum frequency value on either side of it.

16. What is the difference between reactance and a resistance?

Reactance is the opposition to flow of ac and the resistance is the opposition to flow of dc.

17. Why series LCR is high pass filter and parallel LCR is called low pass filter?
The bandwidth in series LCR is very high and it allows large range of frequencies and in parallel LCR, the bandwidth is very low and it allows only small range of frequencies.

18. Why current is max in series and min in parallel?
Due to minimum impedence current is max in series and due to maximum impedance current is minimum in parallel.

19. Can a series resonant circuit be used as an amplifier?
A series resonant circuit cannot be used as an amplifier because the circuit being passive made of L,R & C cannot supply extra power to a load resistance.

4. Hall coefficient of semiconductor

1. What is Hall Effect?
When a current carrying conductor is placed in a magnetic field mutually perpendicular to the direction of current a potential difference is developed at right angle to both the magnetic and electric field. This phenomenon is called Hall Effect.

1. What is the Hall voltage?
The voltage produced during the Hall Effect is called Hall voltage.

2. Define Hall co-efficient?
It is numerically equal to Hall electric field (E) induced in the specimen by unit current density (j) when it is placed perpendicular to an unit magnetic field (B).

3. What is SI unit of Hall co-efficient?
SI unit of Hall co-efficient is m^3/Coulomb.

4. Can you determine the type of semiconductor and concentration of charge carriers with the help of the Hall Coefficient?
In N-type semiconductors the Hall coefficient is negative

5. What Hall Coefficient signifies in the Hall Effect experiment?
The sign of the hall coefficient signifies the nature of the semiconductor material.

6. Which material has been used in the experiment to explain the Hall Effect?
Semiconductor

8. **What are the applications of Hall Effect?**

- **i.** Determination of types of superconductor.
- **ii.** Calculation of carrier concentration.
- **iii.** Determination of mobility.
- **iv.** Determination of magnetic flux density.
- **v.** Proximity sensor, Hall sensor, and hall probe.

5.Black Box Experiment

1.What is Black box?
Black box is a device or system or object which can be viewed in terms of its inputs and outputs without any knowledge of its internal working.

2.Why it is called as black box?
It is called as Black box because without any knowledge of the component, we can identify the component and also their values can be determined using analysis of input and output characteristics.

3.What does black box consists of?
In the Experiment, Black box consists of passive components like L, C & R.

4.How does the voltage vary in case of ac circuit containing Inductor?
In case of Inductor, the output voltage decreases with the increase in frequency.

5.How does the voltage vary in case of ac circuit containing Resistor?
In case of Resistor, output voltage remains constant with the increase in frequency.

6.How does the voltage vary in case of ac circuit containing Capacitor?
In case of Capacitor, the output voltage increases with the increase in frequency.

7. What is Impedance?
The effective opposition offered by the LCR circuit for the flow of AC is called impedance.

8.How Resistance and Reactance are different?
Resistance is the opposition for DC and it is independent of frequency. Whereas Reactance is the opposition for AC and it is dependent on frequency.

9.What is Transfer ratio?
It is also called as voltage gain (A_v). It is defined as the ratio of Output voltage to the input voltage.

10.What are the uses of Black box?
It is used in identification of unknown electronic element like resistor, capacitor and inductor etc. Black box are used in **aviation** as **flight recorder** to know the discovery of crash (The flight data recorder logs information about controls and sensors, and the cockpit voice recorder preserves the most recent sounds in the cockpit, including conversation of the pilots. If an accident happens, investigators can use the recordings to assist in the investigation.), **Train event recorder**, black box program in **computing**, **software engineering**, **black box testing** etc.

6.Angle of acceptance & NA of an optical fibre

1. What is a optical fiber?
It is a device used to send or transport the light signal in any desired path.

2. On which material optical fiber is made up of?
It is made up of dielectric materials like glass or quartz.

3. On what principle does optical fiber works?
It works on the principle Total Internal Reflection (TIR).

4. What are the conditions of TIR?
Light should travel from denser medium to rarer medium. Angle of incidence should be greater than critical angle.

5. What is the importance of TIR?
There is no absorption of light energy from the reflecting surface, and entire energy retained even after many reflections.

6. What are the different parts of optical fibers?
The inner part is known as core having higher refractive index and the outer part is known as cladding having lower refractive index.

7. Which light source is used in optical fiber experiment?
Laser light source.

8. Mention the different types of optical fibers.
i. Single mode optical fiber
ii. Step index multi-mode fiber.
iii. Graded index multimode fiber

9. Define angle of acceptance.
It is the maximum angle of incidence on the core for which Total Internal Reflection takes place inside the core.

10. What is Numerical aperture?
It is the Sine of the angle of acceptance or it is ability of a fiber to accept the light.

7.Determination of Planck's constant

1.What is LED?
Light Emitting Diode

2.How does LED emit the light?
During the forward bias of PN junction, the barrier potential effect is reduced and majority carriers crossthe junction. Then the free electrons from n region crosses the barrier causes an electron-hole pair recombination. Each recombination radiates energy in the form of light.

3.Why does LED emit the light in forward bias only?
During the reverse bias of PN junction there is no recombination of majority carriers and causes no radiation of light.

4.What is knee voltage?
The minimum voltage required to emit the light radiation by the LED in forward bias is called the knee voltage or cut-in voltage.

5.**Why does knee voltage different for different color LED?**

Knee voltage is Depends on amount of impurity added.

6.**How does Knee voltage vary with wavelength?**
A wavelength of the emitted light is inversely proportional to the turn – on voltage.

7.For which colour LED, the Knee voltage is maximum and minimum?
Knee voltage is maximum for blue colour LED and minimum for IR LED.

8.Explain the principle of the experiment.
Energy of the emitted radiation is proportional to the frequency of the radiation emitted.

8.Photodiode characteristics

1. What is photo diode?
Photo diode is a semiconductor diode made of photo sensitive material whose conductivity changes with the intensity of light in reverse bias.

2. In which bias photo diode works?
Photo diode works in reverse bias

3. What is the principle of photo diode?
The conductivity of pn- junction (photo diode) increases with the intensity of light in reverse bias

4. Explain working of photo diode.
A photo diode operates in the reverse bias mode. When the light is incident on the junction surface, electron-hole pairs are created. This is because; valence electrons are liberated after absorbing radiant energy. Due to increase in the number of electron-hole pair, reverse electrical current increases. ie increase in electron-hole pair is directly proportional to the number of photons striking the junction surface. Therefore as the intensity of light increases, saturation current also increases.

5. What is dark current of photodiode?
When there is no incident light, the reverse current is almost negligible and is called dark current. When incident light increased reverse current also increases.

6. Why photo diode is called as photo detector?
Photodiode is called as photo detector because it can be used to switch ON the current in a very short time of the order of nanosecond.

7. What happens to the reverse saturation current if the temperature of pn junction increases?
The reverse saturation current also increases.

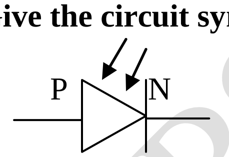
8. Why sides of the photo diode are painted black except at window?
Light is allowed to fall only on one surface across the junction through window. If the light falls other than this window (junction) it will be absorbed by the black surface.

9. How photodiode is different from ordinary diode?
In photo diode the conductivity of pn- junction increases with the intensity of light in reverse bias where as in ordinary diode this will not happens.

10. How photodiode works in forward bias?
Photo diode works just like an ordinary diode (ie conducts maximum current in forward bias).

11. How Does a Photodiode Work?
The photodiode works due to the effect of the energy of photons of light when they fall on the diode. The photon energizes the ionized atoms and thus free electrons are produced. These electrons deplete the neutral layer between two materials and subsequently current starts to flow across the junction.
12. Mention few applications/uses of photo diode?
Photo diodes are used in photo detectors (both visible and invisible), to measure intensity of light, logic circuits, switching circuits, demodulation, optical communication systems, etc.

13. Give the circuit symbol of photo diode.



The arrow mark indicates Radiation/ Light

9.Resistivity measurement using four probe method.

1.What is the Principal behind the four probe?
The current is forced through the outer probes and the voltage drop across the inner probe is measured.

2.Why is Four-Probe method preferred over other conventional methods for measuring resistivity?
The Four-Probe method preferred because it eliminates the effect of contact and spreading resistances that are present in the two probe method.

3.**Why is a constant current source is is needed in four probe method?**
The voltage across inner probe is an indication of resistance or resistivity only if current is constant.

4.**What is Electrical resistivity?**
Electrical resistivity is the property of the material which opposes the flow of current. It is defined as the resistance offered by the material of unit length and having unit area of cross section.

5.**What is SI unit of Electrical resistivity?**
The SI unit of Resistivity is Ωm (Ohm-meter)

6.**For which material Resistivity is calculated in the experiment?**
Semiconductor.

7.**How the resistivity varies with temperature in a semiconductor?**
In semiconductor resistivity is inversely proportional to the temperature. As temperature increases, Resistivity decreases.

8.What is the distance between two successive probes?
The distance between two successive probes is 2 mm

9.What are the applications of four probes?
Four probes is used in Remote sensing areas, Resistance thermometers, Induction hardening process, Accurate geometry factor estimation, Characterization of fuel cells bipolar plates.

10.Fermi Energy

1. What is Fermi energy?
It is the maximum energy that electrons in a metal can possess at absolute zero kelvin.

2. What is Fermi temperature?
It is the temperature at which the average thermal energy of the free electron in a solid becomes equal to the Fermi energy at 0K.

3. What is Fermi velocity?
The velocity of the electrons which occupy the Fermi level is called Fermi velocity.
4. What is meant by insulator?
Solid materials which do not conduct electric current under normal conditions are known as insulators.

5. What is meant by conductors?
Materials which conduct electric current when a potential difference is applied across them are known as conductors.

6. What are fermions? Give example
Particles with odd half integral spins (1/2, 3/2, 5/2…) are fermions. Fermions obey the Pauli's exclusion principle. Ex: electrons

7. What is Pauli's exclusion principle?

The Pauli Exclusion Principle states that, in an atom, no two electrons can have the **same** four electronic quantum numbers. We are aware that in one orbital a maximum of two electrons can be found and the two electrons must have opposing spins. That means one would spin up (+1/2) and the other would spin down (-1/2).

8. Define ohms law.

Current flowing through the conductor is directly proportional to the potential difference V across the ends of conductor **V =IR or** I= $\frac{V}{R}$ **or R =** $\frac{V}{I}$

R is the resistance of the conductor, depend on its dimensions, composition and temperature but it is independent of V.

9. Define valence band?

The electrons present in the outer most orbits are called valance electrons.

10. Explain the phenomenon of negative temperature co-efficient of resistance for semi conducting materials.

For semiconductors, the resistivity is inversely proportional to the temperature (**$\rho \ \alpha 1/T$**) (i.e.) it has negative temperature co-efficient of resistance.

11. What is a free electron?

Free electron is the electron which moves freely (or) randomly in all directions in the absence of external field. These electrons collide with each other and also with the lattice elastically and hence there is no loss in energy.

12. Discuss the variation of resistivity of a conductor with respect to temperature.

The resistivity of a conductor remains constant at lower temperature. The resistivity is proportional to 5th power of absolute temperature. The resistivity is directly proportional to T.

13. Explain the variation of Fermi energy with respect to the temperature

In Intrinsic semiconductors at 0 kelvin the Fermi energy lies exactly at the midway between the CB and VB

In extrinsic semiconductor at 0 kelvin, for 'n' type it lies near the conduction band and for p type it lies near the valance band.

14. What is the magnitude of 1eV.

1 eV = $1.609X10^{-19}$ J.

15. Define 1eV.

It is the energy gained by the electrons when a potential difference of 1V is applied.

END