DEPARTMENT OF PHYSICS
RV COLLEGE OF ENGINEERING®
(AUTONOMOUS INSTITUTION AFFILIATED TO VTU, BELAGAVI)

ENGINEERING PHYSICS
PRACTICAL FILE

COURSE CODE: PHY211AI / PHY221CI

2023-24

For the First / Second Semester B.E

Name of the student	
Section, Batch	
Program	
Roll No. / USN	
Faculty In-charge	1.
	2.

DEPARTMENT OF PHYSICS

VISION

TO ENABLE ENGINEERING GRADUATES TO UNDERSTAND, LEVERAGE AND APPRECIATE THE ROLE OF PHYSICS FOR THE DEVELOPMENT OF SUSTAINABLE AND INCLUSIVE TECHNOLOGY.

MISSION

1. EDUCATES THE STUDENTS WITH A PROGRAM CHARACTERIZED BY ART OF TEACHING WITH EXPERIMENTING SKILLS, PROJECT WORK/SEMINAR, SELF STUDY, EFFECTIVE COUNSELING AND AN ACTIVE INVOLVEMENT OF STUDENTS IN THEIR EXPERIENTIAL LEARNING.
2. IMBIBE INQUISITIVENESS IN STUDENTS TO USE PHYSICS FOR ENGINEERING INNOVATION.
3. EMPOWER THE FACULTY AND STUDENTS TO INVOLVE IN RESEARCH AND TO DEVELOP THE DEPARTMENT AS A KEY FACILITATOR FOR R&D TO ALL ENGINEERING PROGRAMS.

RV COLLEGE OF ENGINEERING®

(An Autonomous Institution, Affiliated to V.T.U, Belagavi)
Mysuru Road, Bengaluru – 560059

DEPARTMENT OF PHYSICS

CERTIFICATE

This is to certify that Mr./Ms……………….....................................….... has satisfactorily completed the course of experiments in **Physics practical (PHY211AI / PHY221CI)** prescribed by the department of Physics for the I / II semester of BE graduate programme during the year 2023 - 2024.

Signature of Head of the Department
Date

Signature of the
faculty in-charge

50
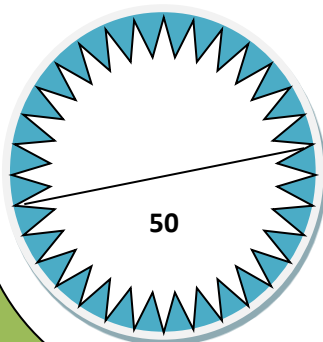
Name of the Candidate……………………………

Roll / U.S.N No………………………………………

PHYSICS FACULTY

Sl. No.	Name	Designation	Initials
01	Dr. Sudha Kamath M K	Associate Prof. & Head	SKMK
02	Dr. Bhuvaneswara Babu T	Professor	TBB
03	Dr. Avadhani D N	Associate Professor	DNA
04	Dr. Shireesha G	Associate Professor	GHS
05	Dr. Shubha S	Assistant Professor	SHBS
06	Dr. Tribikram Gupta	Assistant Professor	TG
07	Dr. Rajesh B M	Assistant Professor	BMR
08	Dr. Ramya P	Assistant Professor	RAP
09	Dr. Karthik Shastry	Assistant Professor	KAS
10	Dr. Niranjana K M	Assistant Professor	NKM
11	Dr. Dileep M S	Assistant Professor	DMS

STAFF

Sl. No.	Name	Designation	Initials
01	Eshwarachari C	Assistant Instructor	EC
02	Satheesha KS	Attender	SKS
03	Shobha B	Peon	SB

MARKS SHEET

Name :   Sec/Batch :   USN/Roll No :

SI.NO	SET NO.	LIST OF EXPERIMENTS	DATE (EXPT CONDUCTED)	DATE (EXPT SUBMITTED)	MARKS OBTAINED
1.	I	Transistor Characteristics			
2.		Zener diode Characteristics			
3.	II	Series LCR Circuit			
4.		Wavelength of LED			
5.	III	Laser Diffraction			
6.		Dielectrics Constant			
7.	IV	Black box			
8.		Numerical Aperture and Attenuation in Optical Fiber			
9.	V	Fermi energy of copper			
10.		Band Gap of a Thermistor			
Regular experiments Average (5,6,7,8,9,10)					/30
Experiential Learning Average (1,2,3,4)					/10
Internal Marks					/10
Total Marks					/50
Signature of the faculty					

SCHEME OF EVALUATION

Particulars	Marks
Data sheet + Experimental Set up	10
Conduction of Experiment	10
Calculation & Viva-Voce	10
Lab Internal	10
Experiential Learning	10
Total Marks	50

GENERAL INSTRUCTIONS TO STUDENTS

1. Scan the QR code in each experiment to watch the video tutorial and read the procedure, come well prepare to the class.

2. Lab sub-batches will be allotted at the beginning of the semester.

3. Students will have to perform two experiments in one lab.

4. Every student has to perform the one/two experiments whichever is allotted to him /her, no change of experiments will be entertained.

5. While attending every laboratory session the student must bring the data sheets with all the relevant details written pertaining to the experiments.

6. **The data sheet must contain entries like *aim of the experiment, apparatus required, circuit diagram or the diagram of the experimental setup, tabular columns,* the necessary formulae of the experiments as given in the in the practical file except the principle and procedure.**

7. Separate data sheets should be prepared for each experiment. *The procedure and principle of the experiment must be read by the student before coming to the laboratory and it should not be written on the data sheets.*

8. Students are required to obtain the signature (entry signature) of the faculty on the data sheet before proceeding to the experiment.

9. All calculations pertaining to the two experiments should be completed in the laboratory. *The results must be shown to the batch in charge faculty and must obtain the exit signature from batch teacher before he or she leaves the laboratory.*

10. Entries of observations should be made in data sheets with pen only.

11. Substitutions and calculations should be shown explicitly in the data sheet and the practical file.

12. Submission of practical file along with necessary data sheets (to be pasted to the particular experiment once readings are transferred to practical file) in every lab session for evaluation.

13. In the event the student is unable to complete the calculations in the regular lab session, with the permission of the lab in-charge, the student should complete calculations, transfer the readings to practical file and submit the file for evaluation in the next lab session. (***In case of any difficulty in calculation, the student can consult the batch teacher within two working days after the lab).***

14. Mobile phones are not allowed to the lab. The student should wear lab coat and also bring his/her own calculator, pen, pencil, eraser, etc.

15. The experiments are to be performed by the students in the given cyclic order. This will be made clear to the student in the instructions class. If for some reason a student is absent for a practical lab session/unable to perform experiments then the student must move on to the next set in the subsequent lab session. The experiment that he or she has missed will have to be performed by him or her in the repetition lab.

16. *Please remember that practical file is evaluated during regular lab session. Therefore it is imperative that each student takes care to see that the experiments are well conducted, recorded and submitted for valuation regularly.*

17. There will be a continuous internal evaluation (CIE) in the laboratory. An internal test will be conducted at the end of the semester. The total internal assessment marks are for a maximum of 50.

Note: Stamp of rubrics for evaluation on the first page of data sheet is mandatory for each Experiment.

RUBRICS FOR EVALUATION

Particulars	Maximum Marks*	Excellent	Very Good	Good	Satisfactory
Data sheet + Experimental Set up	10	10	08	07	04
Conduction of Experiment	10	10	08	07	04
Substitution, Calculation & Accuracy	10	10	08	07	04
Experiential Learning	10	10	08	07	04

Tentative

All students are strictly required to adhere to the Do's and Don'ts in the laboratory:

✓ Do's	✗ Don'ts
✓ Come prepared to the lab. ✓ Wear lab coat in the lab. ✓ Maintain discipline in the lab. ✓ Handle the apparatus with care. ✓ Confine to your table while doing the experiment. ✓ Return the apparatus after completing the experiment. ✓ Switch off the power supply after completing the experiment ✓ Switch off the electrical circuit breaker if there is burning of insulation. ✓ Utilize the First Aid box in emergency situation. ✓ Keep the lab clean and neat.	✗ Come late to the lab and leave the lab early. ✗ Carry mobile phones to the lab ✗ Touch un-insulated electrical wires. ✗ Use switch if broken. ✗ Overload the electrical meters. ✗ Talk with other students in the lab. ✗ Make the circuit connection when the power supply is on.

Multi meter

A multi meter is an instrument with many meters like ammeters, voltmeters (both AC and DC), ohmmeters etc., of various ranges built into it. By conveniently switching the rotatable knob of the multi meter, we can choose the electrical meter required for a particular measurement.

Note;

1. On the display if there is a numeral 1 at the extreme left the measured quantity is more than the maximum of the meter, move/rotate the selector knob to the higher range .

2. If the display shows BAT the battery is low in power, ask for a different multi meter.
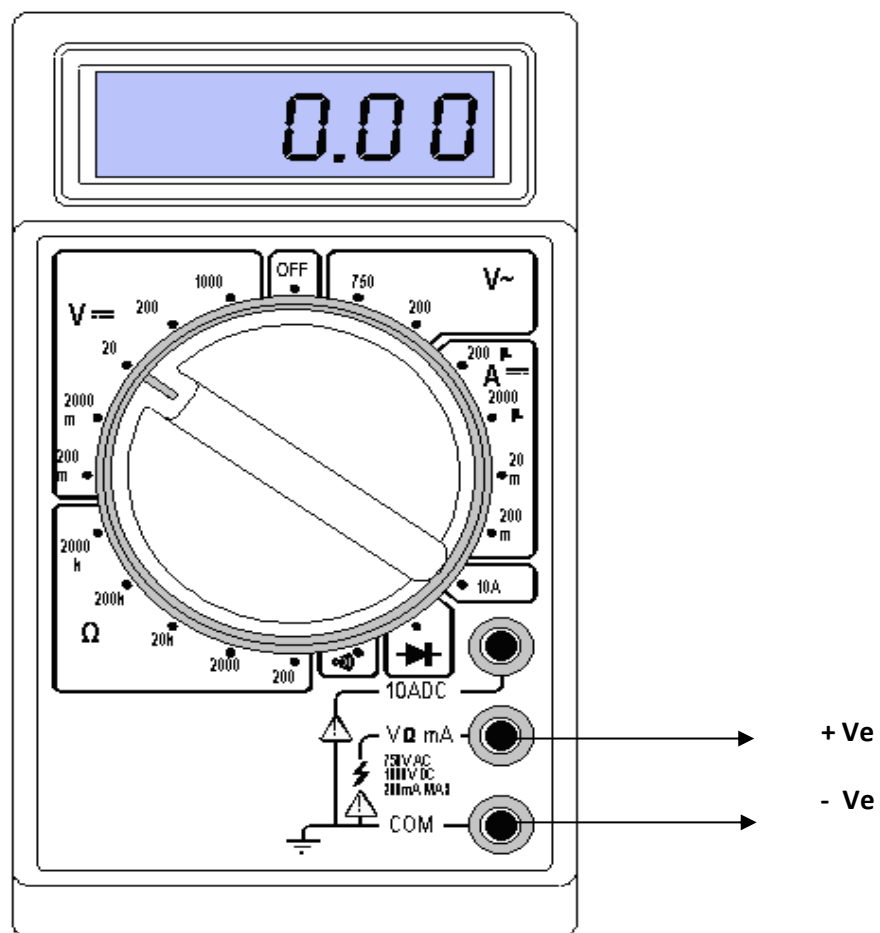
expEYES -17 (expEriments for Young Engineers & Scientists)

INTRODUCTION:

Science is the study of the physical world by systematic observations and experiments. However, almost everywhere science is mostly taught from the text books without giving importance to experiments, partly due to lack of equipment. As a result, most of the students fail to correlate their classroom experience to problems encountered in daily life. To some extent this can be corrected by learning science based on exploration and experimenting. The advent of personal computers and their easy availability has opened up a new path for making laboratory equipment. Addition of some hardware to an ordinary computer can convert it into a science laboratory.

The simple and open architecture of expEYES (see the figure given below) allows the users to develop new experiments, without getting into the details of electronics or computer programming.

1. About the device:

ExpEYES-17 is interfaced and powered by the USB port of the computer, and it is programmable in Python. expEYES can run on any computer having a Python Interpreter and required modules. The USB interface is handled by device driver program that presents the USB port as a Serial port to the Python programs. It can function as a low frequency oscilloscope, function generator, programmable voltage source, frequency counter and data logger etc.
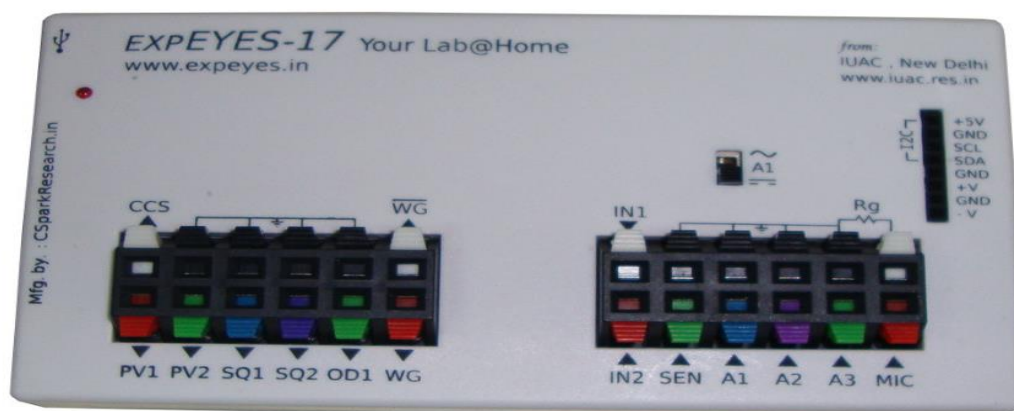

Figure: ExpEyes-17

External connections:

The functions of the external connections briefly explained below. All the black coloured terminals are at ground potential, all other voltages are measured with respect to it.

Outputs:

Constant Current Source (CCS):

The constant current source can be switched ON and OFF under software control. The nominal value is 1.1 mA but may vary from unit to unit, due to component tolerances.

Programmable Voltage (PV1):

Can be set, from software, to any value in the -5V to +5V range. The resolution is 12 bits, implies a minimum voltage step of around 2.5 mill volts.

Programmable Voltage (PV2):

Can be set, from software, to any value in the -3.3V to +3.3V range. The resolution is 12 bits.

Square Wave SQ1:
Output swings from 0 to 5 volts and frequency can be varied 4Hz to 100 kHz. The duty cycle of the output is programmable. Setting frequency to 0Hz will make the output HIGH and setting it to −1 will make it LOW, in both cases the wave generation is disabled. SQR1 output has a 100Ω series resistor inside so that it can drive LEDs directly.

Square Wave SQ2:
Output swings from 0 to 5 volts and frequency can be varied 4Hz to 100 kHz. All intermediate values of frequency are not possible. The duty cycle of the output is programmable. SQR2 is not available when WG is active.

Digital Output (OD1):
The voltage at OD1 can be set to 0 or 5 volts, using software.

Sine/Triangular Wave WG:
Frequency can be varied from 5Hz to 5 kHz. The peak value of the amplitude can be set to 3 volts, 1.0 volt or 80 mV. Shape of the output waveform is programmable. Using the GUI sine or triangular can be selected. WG bar is inverted WG.

Inputs:

Capacitance meter IN1:
Capacitance connected between IN1 and Ground can be measured. It works better for lower capacitance values, up to 10 nano Farads, results may not be very accurate beyond that.

Frequency Counter IN2:
It is capable of measuring frequency up to several MHz.

Resistive Sensor Input (SEN):
This is mainly meant for sensors like Light Dependent Resistor, Thermistor, Photo-transistor etc. SEN is internally connected to 3.3 volts through a 5.1kΩ resistor.

±16V Analog Inputs, A1 & A2:
It can measure the voltage within the range of ±16 volts. The input voltage range can be selected from 0.5V to 16V full scale. Voltage at these terminals can be displayed as a function of time, giving the functionality of a low frequency oscilloscope. The maximum sampling rate is 1 Msps /channel. Both have an input impedance of 1M Ω.

±3.3V Analog Input A3:
It can measure voltage within the ±3.3 volts range. The input can be amplified by connecting a resistor from Rg to Ground, $gain = 1 + \frac{1}{10000}$. This enables displaying very small amplitude signals. The input impedance of A3 is 10M Ω.

±6V /10mA Power supply:
The VR+ and VR- are regulated power outputs. They can supply very little current, but good enough to power an Op-Amp.
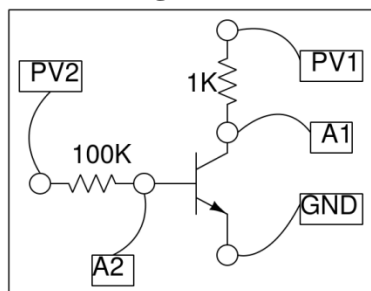
How to Use expEYES-17:
Connect the device through a USB port and start the expEYES-17 program from the menu. The default window shows **Transistor experiment screen**. Graphical User Interface for various experiments can be selected from the pull down menu. The user should browse the RVCE tab on the screen then select the Physics 1st year experiments.
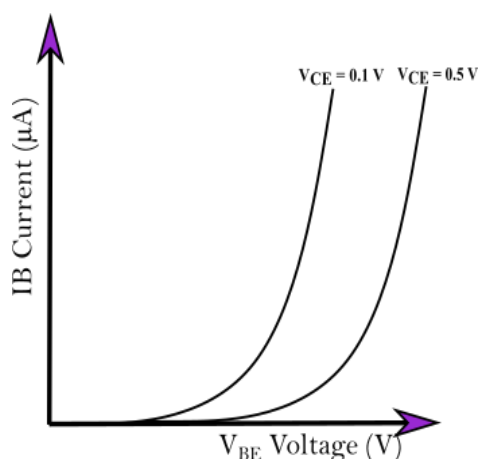
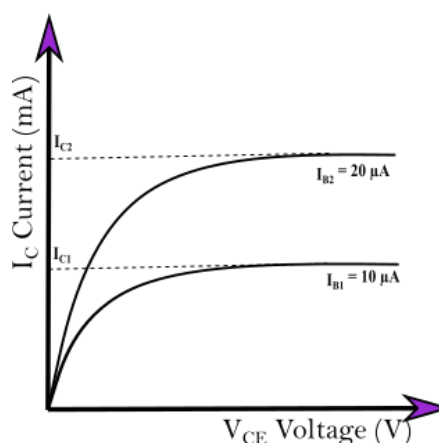**TRANSISTOR CHARACTERISTICS (expEYES-17)**

OBSERVATIONS

Circuit diagram

Graph plotting with GNUPLOT

Go to respective folder in which the file is saved.

Right click at the empty area and select **'open in terminal'**

Run the following commands

```
gnuplot
set timestamp
set title 'Transistor Characteristics-Raj'
set xlabel 'Voltage in Volts'
set ylabel 'Current in  A'
plot 'transistor-input.txt' w lp
plot 'transistor-output.txt' w lp
```

Model Graph

Input characteristics

Output characteristics

Tabular Column

Input characteristics				Output characteristics			
$V_{BE}(V)$	$I_B(\mu A)$	$V_{BE}(V)$	$I_B(\mu A)$	$V_{CE}(V)$	$I_C(mA)$	$V_{CE}(V)$	$I_C(mA)$

Calculations:

To calculate transistor parameters α and β from output characteristics

$$\beta = \left[\frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}} \right]_{V_{CE}} = \qquad\qquad \text{Using the value of } \beta, \quad \alpha = \frac{\beta}{\beta + 1} =$$

Result: Current gain (β) in Common Emitter configuration is_____
        Current gain (α) in Common Base configuration is _____

TRANSISTOR CHARACTERISTICS

Experiment No: Date:

Aim: To plot the V-I characteristics of the transistor and calculate the parameters α and β.

Apparatus: Transistor SL100, 1K and 100 K Ω resistors, Bread board, Connecting wires, expeyes kit.

Theory: A transistor has three terminals namely emitter, base and collector. It can be operated in three configurations *i.e.* common base, common emitter and common collector. Common emitter is the most commonly used as it has high current gain.

Procedure:

Instructions for Input Characteristics:
- Make the connections of NPN transistor provided with the kit as shown in the diagram.
- Enter the V_{CE} value as 0.1 volt
- Run the experiment by clicking the Start button.
- Enter the V_{CE} value as 0.5 volt and click on Start button
- save the data values by using the "Save Data" button

Instructions for Output Characteristics:
- The output characteristic curve of an NPN transistor at different base currents is plotted.
- The base current is set by the voltage at PV2.
- Enter the PV2 as 1 volt and press **START** to get a plot for a particular I_{B1}.
- Enter the PV2 as 2 volt and press **START** to get a plot for a particular I_{B2}.
- Save the data value by using the "Save Data" button.

Procedure to plot the graph using a graph sheet.
Note down the sample data points from input & output characteristics and tabulate it.

Transistor Pin Configuration
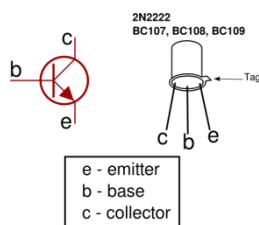
RESULT: The input and output characteristics have been plotted and

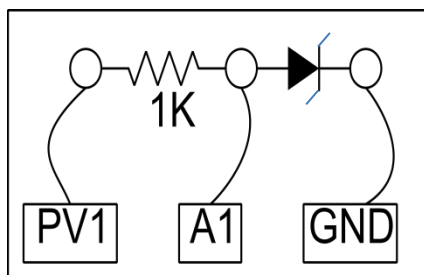   The α & β values are _____ & _____.
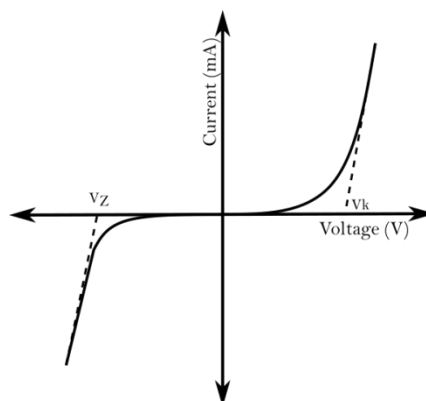
ZENER DIODE CHARACTERISTICS

(expEYES-17)

OBSERVATIONS:

Circuit Diagram: **Model Graph:**

Forward bias fit: **Reverse bias fit:**

x-intercept =   x-intercept =

y-intercept =   y-intercept =

Slope =   Slope =

Calculations:

The forward resistance is calculated by

$$R_f = \frac{\Delta V_f}{\Delta I_f} = \frac{1}{Slope} =$$

Where ΔV_f is change in forward voltage, ΔI_f is change in forward current in Ampere.

Graph plotting with GNUPLOT

Go to respective folder in which the file is saved.

Right click at the empty area and select **'open in terminal'**

Run the following commands

```
set timestamp
set zeroaxis
set title 'Zener Diode Characteristics-Rajesh'
set xlabel 'Voltage in Volts'
set ylabel 'Current in mA'
plot 'zener.txt' w lp
```

Results:

The Knee voltage: _____V

The breakdown voltage: _____V

The forward bias resistance: _____Ω

Paste the data sheets here

ZENER DIODE CHARACTERISTICS

Experiment No: Date:

Aim: To study forward and reverse bias characteristics of a zener diode and hence to determine forward bias resistance, knee voltage and zener breakdown voltage.

Apparatus: expEYSE-17 hardware, zener diode, resistor and wires.

Principle: A heavily doped semiconductor diode which is designed to operate in reverse direction is known as the Zener diode. The symbolic representation of Zener diode is shown in the figure below.
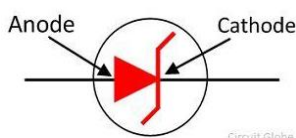
A zener diode is constructed for operation in the reverse breakdown region. The relation between I-V is almost linear in this case $V_Z = V_{Z0+}$, where r_z is the dynamic resistance of the zener at the operating point. V_{Z0} is the voltage at which the straight-line approximation of the I-V characteristic intersects the horizontal axis. After reaching a certain voltage, called the breakdown voltage, the current increases widely even for a small change in voltage. However, there is no appreciable change in voltage. So, when we plot the graph, we should get a curve very near to x-axis and almost parallel to it for quite some reverse. After the zener potential V_Z there will be a sudden change and the graph will become exponential.

Procedure:

- Identify the side with the black notch in the zener diode is the n side and brown region is the p side. Connect p side to PV1 through 1kΩ resistor and n side to ground. Make the connections similar to the circuit diagram.
- Click on the **START** button to plot the current versus voltage I/V characteristics for forward biased and reverse bias mode.
- Adjust the width of RO (region of interest in pink color shade) in the linear portion of the 1st quadrant and click on the **FIT with I= V/R**.
- Note down the slope, x & y intercept values.
- Similarly, do it at the 3rd quadrant to know the breakdown voltage.
- Then click on the **Save data** and save the file in .txt form (example: zener.txt) and plot current versus voltage using GNUPLOT.
- The reciprocal of the slope at forward bias region gives the forward resistance.

Results:
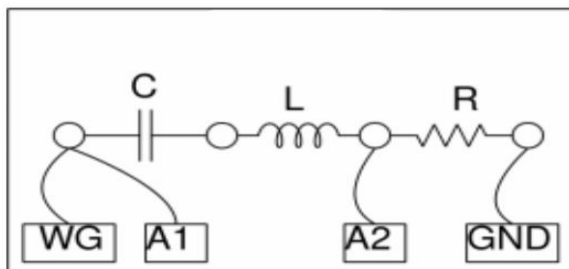The Knee voltage: _____V
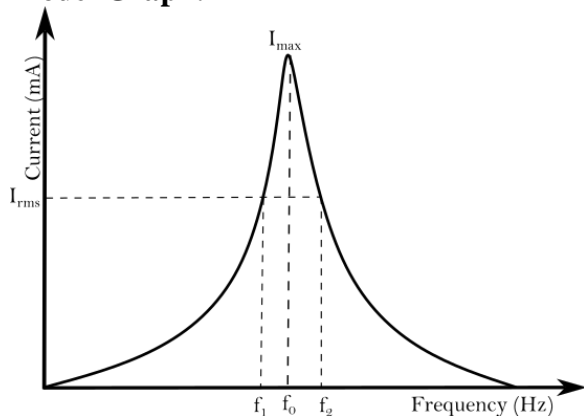The breakdown voltage: _____V
The forward bias resistance: _____Ω

Department of Physics, RVCE   3

SERIES L-C-R CIRCUIT

OBSERVATIONS**:**

Circuit:

Model Graph:

Graph plotting with GNUPLOT
Go to respective folder in which the file is saved.
Right click at the empty area, select **'open in terminal'** and Run the following commands:

```
set timestamp
set title 'Series LCR circuit-Raj'
set xlabel 'Frequency in Hz'
set ylabel 'Current in mA'
plot 'lcr.txt' w lp
```

Marking points on the graph

- Take the cursor to the tip of the curve
- Press the scroll button on the mouse
- Note down the resonant frequency and I_{max}
- Find out I_{RMS}
- Press the scroll button on the mouse at I_{RMS}
- (Both at left and right side of the curve)
- Note down f_1 and f_2
- Export the file as PDF

Formulae

I_{max}	=		mA
$I_{rms} = I_{max}/\sqrt{2}$	=		mA
Resonant Frequency f_0	=		Hz
Lower Cut off frequency f_1 =			Hz
Upper Cut off frequency f_2 =			Hz
Band width $\Delta f = f_2 - f_1$	=		Hz
Quality Factor $Q = f_0/\Delta f$	=		
Capacitance C	=		nF

$$L = \frac{1}{4\pi^2 f_0^2 C} = \qquad = \qquad H$$

Calculations:

Result:

1.	Resonant frequency of the circuit f_0	Hz
2.	Self-inductance of the given coil L	H
3.	Quality factor from graph Q	
4.	Band width $\Delta f = f_2 - f_1$	Hz

Department of Physics, RVCE

SERIES L-C-R CIRCUIT

Experiment No: Date:

Aim: To study the frequency response of LCR circuit and determination of a) Self-inductance of the given coil, b) Quality factor (Q- value) and c) Band-width

Apparatus: expEYES-17 kit, Resistance box, Capacitor, Inductor

Principle: In a series LCR circuit, as the frequency increases inductive reactance X_L of the circuit increases and capacitive reactance X_c decreases. At resonant frequency f_0. The inductive reactance and capacitive reactance are equal hence the total impedance of the circuit is minimum and there by the current is maximum. Therefore, at resonance $X_l = X_C$,
$2\pi f_0 L = 1/2\pi f_0 C \rightarrow L = 1/4\pi^2 f_0^2 C$

Where f_0 is the resonant frequency, L is the inductance of the coil and C is the value of capacitance.
The property of a reactive circuit to store energy is expressed in terms of quality factor or 'Q' factor. It is a figure of merit that enables us to compare different coils. It is defined as follows $Q = \omega_0$ x energy stored / average power dissipated. $[Q = f_0/f_2 - f_1]$
The band width Δf is the difference in frequencies corresponding to current $I_{max}/\sqrt{2}$

Procedure:
1. Make the connections as per the circuit diagram.
2. Select the frequency range in the right side of GUI window.
3. Enter the value of resistance in the box (keys unplugged in the resistance box).
4. Enter the frequency interval steps in the GUI window.
5. Click on START button to plot the current versus frequency.
6. Save the data by clicking on the Sava Data button.
7. A graph of frequency versus current is plotted using GNUPLOT software, this graph is called frequency response of the L C R circuit.
8. The frequency corresponding to maximum current I_{max} is called resonant frequency and is denoted by f_0. Corresponding to a current $I = I_{max}/\sqrt{2}$ from the current axis, a horizontal line is drawn such that it cuts the graph at points A and B. From the points A and B vertical lines are drawn to cut the frequency axis at f_1 and f_2 respectively. These frequencies are lower cut off and upper cut off frequencies (or half power frequencies). The frequencies f_0, f_1 and f_2 are noted. Self-inductance of the given coil, Quality factor and Band width Δf are calculated using the relevant formulae.
9. Note down the data points from the txt file.
10. Plot the graph on the graph sheet using the data points and find out f_1, f_0 and f_2.

WAVELENGTH OF LED (expEYES-17)

OBSERVATIONS:
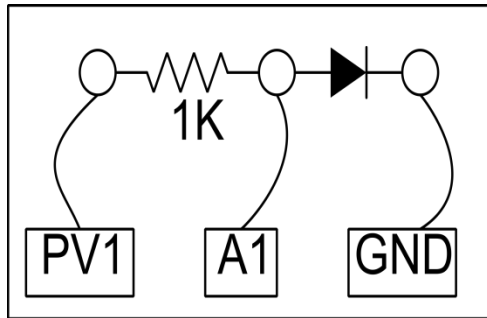
Circuit Diagram: **Model Graph:**
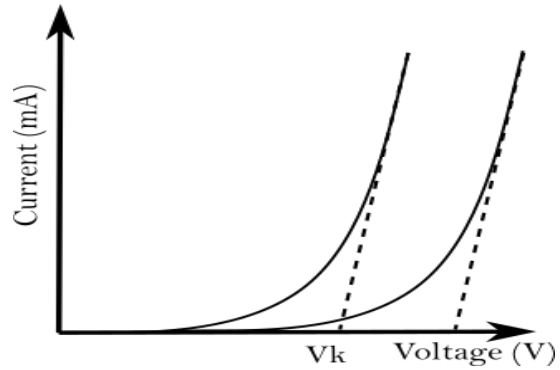
Formula: Energy of the photons emitted by LED = $E = \dfrac{hc}{\lambda} = eV_K$

The wavelength of LED is $\lambda = \dfrac{hc}{eV_K}\, nm$

Color of LED	Knee Voltage (V_K)	Wavelength(λ) in nm

Graph plotting with GNUPLOT

Go to respective folder in which the file is saved.

Right click at the empty area and select **'open in terminal'**

Run the following commands

```
gnuplot
set timestamp
set title 'Wavelength of LED-Rajesh'
set xlabel 'Voltage in Volts'
set ylabel 'Current in mA'
plot 'led.txt' w lp
```

Calculations:

Result: Wavelength of given LED's are determined.

WAVELENGTH OF LIGHT EMITTING DIODES

Experiment No: Date:

Aim: To study the I-V Characteristics of a diode and determine the wavelengths of the given LED's.

Apparatus: expEYES-17 hardware, LED's, 1 K Ω Resistor and connecting wires.

Principle: Light emitting diode is special type of semiconductor diode. It consists of heavily doped P type and N type direct band gap semiconductors. The LED absorbs electrical energy and converts it into light energy. When the PN junction is forward biased, the electrons from the N region migrate into P region and combine with holes in the P region. This recombination of electrons and holes results in the emission of photons.

Procedure:

1. Make the connections as shown in the circuit diagram.

2. Click on START button to plot the current versus voltage I/V characteristics curve.

3. Click on the FIT button and note down the knee voltage for the corresponding color of the LED.

4. Repeat the experiment with three more LEDs and save data in the folder at Desktop.

5. Plot current versus voltage I/V graph of LEDs using GNUPLOT.

6. Calculate the wavelength of the LED using the given formula.

   The wavelength of LED is $\lambda = \dfrac{hc}{eV_K} nm$

Where, h is Planck's constant = 6.63 x 10^{-34} Js; C is Speed of Light = 3 x 10^{8} ms^{-1}, e is charge on electron = 1.602 x 10^{-19} C; V_K is the Knee voltage of the LED.

LASER DIFFRACTION

OBSERVATIONS:

Diagram:
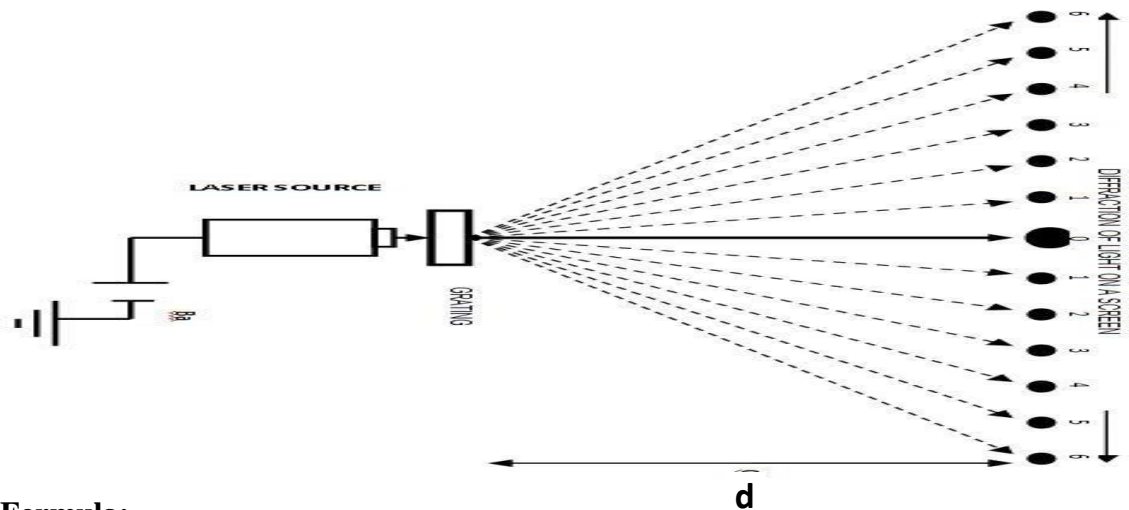
Formula:

Wavelength of Laser source $\lambda = \dfrac{C \sin\theta_n}{n}$ ……. m

Where C is the grating constant, n is the order of the maximum, θ is the angle of diffraction

Grating Constant: $C = \dfrac{1\,\text{inch}}{\text{No. of lines (N) per inch}} = \dfrac{2.54 \times 10^{-2} m}{500} = 5.08 \times 10^{-5} m$

Distance between the grating and the screen, d = _____ cm

Table:

Diffraction order (n)	Distance $2X_n$(cm)	Distance X_n(cm)	Diffraction angle (θ_n) $\theta_n = \tan^{-1}\left(\dfrac{X_n}{d}\right)$	Wavelength λ (nm) $\lambda = \dfrac{C \sin\theta_n}{n}$
1.				
2.				
3.				
4.				
5.				
6.				

Calculations:

Result: The wavelength of laser light is found to be…………………………….nm

Department of Physics, RVCE

LASER DIFFRACTION

Experiment No: Date:

Aim: To determine the wavelength of a given laser beam

Apparatus: Laser source, Grating, Optical bench with accessories and metre scale etc.,

Principle: Diffraction is the bending of a wave round the corners of an obstacle and its effects are well observed if the wavelength is comparable with the size of the obstacle. In the given grating equidistant, parallel lines are drawn on an optically flat glass plate with a diamond tip. Each line acts as an obstacle and the distance between the corresponding points on the successive lines is comparable with the wavelength of the laser.

Formula:

Wavelength of laser light, $\lambda = \dfrac{C \sin\theta_n}{n}$ ……. m

Where C is the grating constant and it is the distance between corresponding points of two successive lines on the grating, n is the order of the maximum, θ_n is the angle of diffraction of the nth maximum,

Procedure:
- Mount the laser on an upright and fix the upright at one end of the optical bench. Mount a screen on another upright and fix it at the other end of the optical bench.
- Mark four quadrants on a graph with 'O' as the origin and fix the graph sheet on the screen using pins. Adjust the position of the graph sheet, so that the centre of the laser spot coincides with the origin O.
- Mount the grating on the grating stand such that the length of the grating is on the grating stand and move the stand closer to the laser source. Adjust the grating plane such that the diffraction pattern is along the horizontal on the screen with the central maximum at the origin. Note down the distance 'd' between grating and the screen.
- Mark the centres of the central maximum and secondary maxima on the graph sheet using pencil and remove the graph sheet from the stand. Measure the distance between the first order maxima on either side of the central maximum as $2X_1$, for the 2nd order maxima measure the distance as $2X_2$, continue this for all the pairs of maxima on the screen.
- By using the grating constant C and the angle of diffraction θ_n, calculate the wavelength of laser light for all the orders. Finally find the average value of wavelength.

Result: The wavelength of laser light is found to be…………………………….nm

BLACK BOX

OBSERVATIONS:
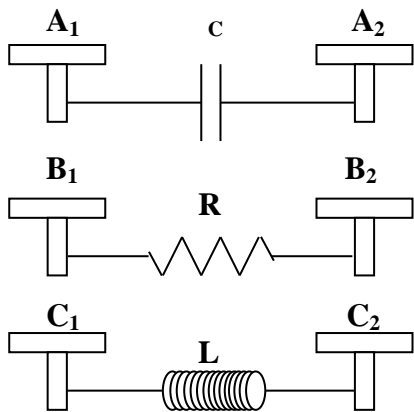
Example
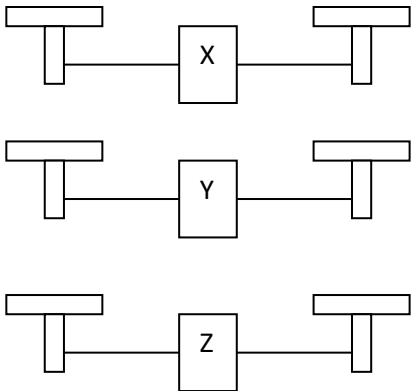
X could be a resistor, capacitor or an inductor. The same holds for Y and Z.

Circuit Diagram
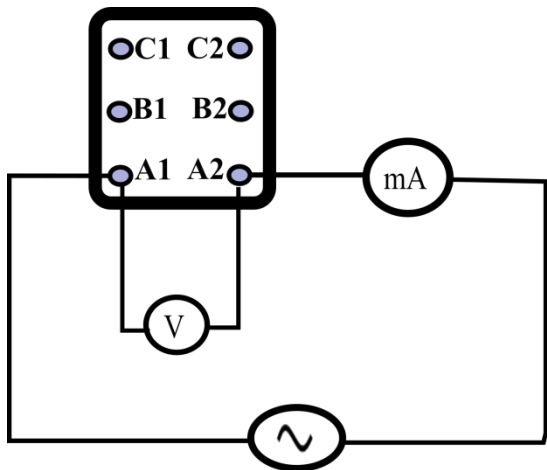
Calculations:

Tabular column
TERMINALS A_1 AND A_2

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)	Component value

Terminals A1 and A2 correspond to _____.
The average value of the component is _____

BLACK BOX

Experiment No: Date:

Aim: Identification of the unknown passive electrical components (L,C and R) enclosed in a black box and determination of their values.

Apparatus: Black box, audio frequency oscillator, ac milli-ammeter (0-20 mA) and ac voltmeter (digital multimeter in ac voltage mode).

Description: Black box is a closed box, which consists of an inductor, a capacitor and a resistor. One passive component is connected across each pair of terminals. At a time one pair of terminals is connected in the circuit and the voltage and current for various frequencies are determined.

Procedure: In the circuit a pair of terminals with a passive component across them is connected in series with an audio oscillator and a milli-ammeter. A voltmeter is connected parallel to the terminals.

For the experiment, the type of signal selected should be sinusoidal. A suitable ac potential is applied across the experimental component (say across A_1 and A_2) using the voltage selector provided in the audio oscillator (or level knob). The frequency range is selected by pressing the corresponding range knob. By switching on the audio oscillator, variable frequency dial of the oscillator is adjusted to the minimum frequency of selected range. By varying the frequency of the applied signal in regular steps the readings of the milli-ammeter and voltmeter are noted for a set of frequencies. The experiment is repeated for terminals B_1 and B_2 and then for the terminals C_1 and C_2.
From the variation of the current and the voltage with the applied frequency the components are identified and their values are calculated as follows

a)   Identification and determination of resistance

With the change in the frequency if the current and the voltage are not varying then the component across the terminals is a resistor. When a pure resistor is in an ac circuit then the resistance of the resistor and the current in the circuit are independent of the frequency of the applied voltage.

The value of the resistance is calculated using the formula $R = \dfrac{V}{I}\ \Omega$

b)   Identification and determination of capacitance

During the experiment if the current, I, in the milli-ammeter increases and the voltage, V, in the voltmeter decreases with increase in the frequency of the applied voltage, it can be concluded that the component across the terminals is a capacitor.

TERMINALS B₁ AND B₂   **Calculations:**

Frequency (Hz)	Voltage, V (Volts)	Current I (mA)	Component value

Terminals B1 and B2 correspond to _____.
The average value of the component is _____

TERMINALS C₁ AND C₂

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)	Component value

Terminals C1 and C2 correspond to _____.
The average value of the component is _____

Formulae

- For resistance: $R = \dfrac{V}{I}$ (Ω)   where

  V is the potential difference across,
  I is the current through the component.

- For inductance: $L = \dfrac{V}{2\pi f I}$ (H)   L is the inductance

  C is the capacitance
  R is the resistance

- For capacitance: $C = \dfrac{I}{2\pi f V}$ (μF)   f is the frequency of applied signal

In the case of a capacitor, reactance, X_C, of a capacitor depends upon the frequency f of the applied voltage. The current flowing through it changes with the change in the frequency of the applied voltage. Since capacitive reactance is inversely proportional to the frequency, with the increase in frequency of the applied voltage the reactance decreases, and vice-versa. That is $X_C = 1/2\pi fC$ where C is the capacitance of the capacitor.

The value of the capacitance of the capacitor is calculated using the formula

$$C = \frac{1}{2\pi fX_c} = \frac{I}{2\pi fV}\ \mu F,\ \text{ where f is the frequency of the applied voltage.}$$

C. Identification and determination of inductance of the inductor.

During the experiment, with the increase in frequency, if the current I through the inductor decreases and the voltage V across it increases, the component across the terminals is an inductor

In the case of an inductor the inductive reactance X_L depends upon the frequency f of the applied voltage. The current flowing through it changes with the change in the frequency of the applied voltage. Since inductive reactance is directly proportional to the frequency, it increases with the increase in frequency of the applied voltage and vice-versa. That is $X_L = 2\pi fL$ where L is the inductance of the inductor.

The value of the inductance of the inductor is determined by using the formula
$$L = \frac{1}{2\pi fX_l} = \frac{V}{2\pi fI}$$

Results:

1. The component _____ of value _____is connected across terminals A_1 and A_2.

2. The component _____ of value _____is connected across terminals B_1 and B_2

3. The component _____ of value _____is connected across terminals C_1 and C_2

NUMERICAL APERTURE AND ATTENUATION COEFFICIENT OF

AN OPTICAL FIBER

OBSERVATIONS:

Diagram: Experimental Setup:
Part A: Numerical aperture measurement
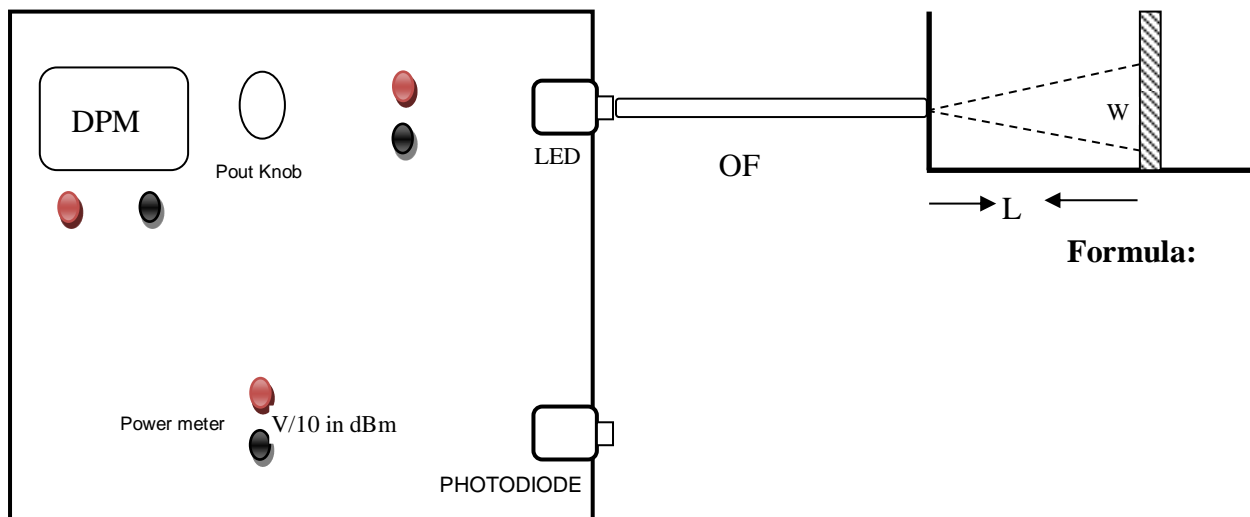
Numerical Aperture, $N.A. = \sin\theta_0 = \frac{W}{\sqrt{(4L^2 + W^2)}}$,

Where, W→ diameter of the beam spot, L→ distance from the Optical Fiber to the screen

Part B: Measurement of attenuation co efficient

Department of Physics, RVCE

NUMERICAL APERTURE AND ATTENUATION COEFFICIENT OF AN OPTICAL FIBER

Experiment No: Date:

Aim: Part A: To determine the Numerical aperture of the given Optical Fibre

   Part B: To measure the attenuation coefficient of the given Optical Fibre

Apparatus: Optical Fibre Kit, Optical fibre cables, In-line adapter, Numerical Aperture Jig.
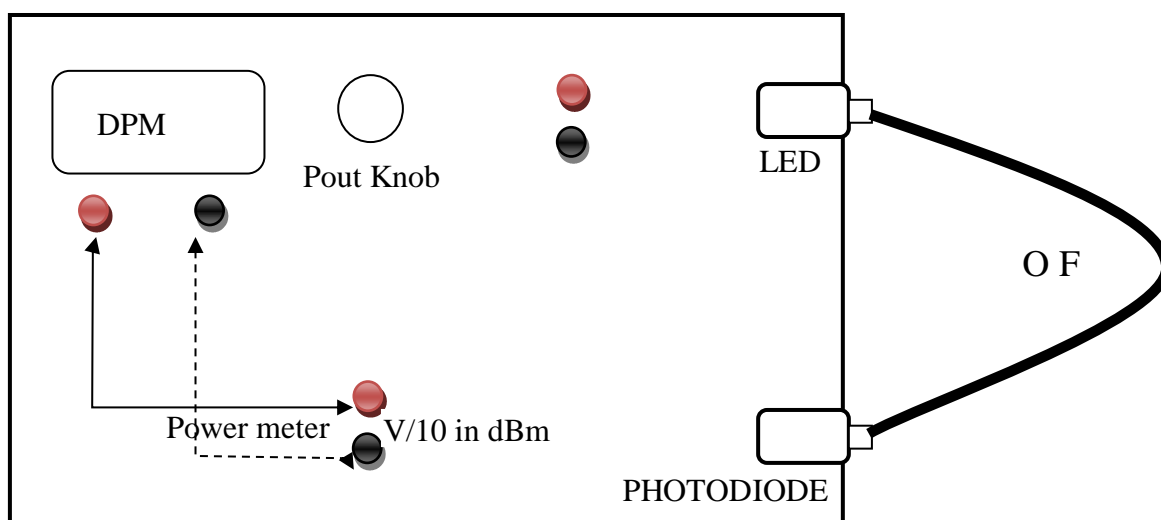
Part A: To determine the Numerical aperture of Optical Fibre

Principle:

Optical fibres are wave guides that transmit light from one point to another. The principle behind the propagation of light in the optical fibre is Total Internal Reflection (TIR) at the core-cladding interface.

Acceptance angle (θ_0) is the maximum angle from the axis of the optical fibre at which the light ray may enter the fibre so that it will propagate by Total Internal Reflections in the core. The input and output cones of light beams are symmetric, hence the semi vertical cone angle of the emergent beam is equal to the acceptance angle.

Numerical Aperture (NA): It is the light gathering ability of the optical fibre. Sine of acceptance angle gives the numerical aperture.

$$\mathbf{Sin\theta_0 = \frac{n_1}{n_0} \sqrt{1 - \frac{n_2^2}{n_1^2}} = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}}$$

Where, n_1 and n_2 are the refractive indices of the core and cladding of the optical fibre respectively, n_0 is the refractive indices of the surrounding medium ($n_0 = 1$)

Formula: $NA = \sin\theta_0 = \dfrac{W}{\sqrt{(4L^2 + W^2)}}$,

Where, $W \rightarrow$ diameter of the beam spot, $L \rightarrow$ distance from the Optical Fibre to the screen

Procedure:

- Connect one end of the optical fibre cable (1-metre or 5 metre) to LED and the other end to the numerical aperture jig as shown in the figure.
- Plug the kit to the AC mains and switch on the circuit board. Light should appear at the end of the fibre on the numerical aperture jig.
- Turn the P_{out} knob clockwise to set to maximum P_{out} for the maximum intensity of the laser spot.
- Hold the white screen in front of the optical fibre such that the light coming out of the fibre falls on the screen and the centre of the spot coincides with the centre of the scale on the screen.
- Avoid bends in the optical fibre.

Table A:

Sl. No	L (mm)	W$_1$ (mm)	W$_2$ (mm)	W= (W$_1$+ W$_2$)/2 (mm)	Numerical aperture(NA)	Acceptance angle, $\theta = \sin^{-1}$(NA) in degree
1.						
2.						
3.						
4.						

Table B:

Length (m)	(A) Attenuation in dB	Length (m)	(B) Attenuation in dB	(B-A) Attenuation for 4m length in dB
1		5		

Attenuation coefficient: Attenuation per unit length (**α)**

$$\alpha = \frac{\text{Attenuation loss}}{Length} = \text{\_\_\_\_\_} = \text{_____} dB/m = \text{\_\_\_} dB/km$$

CALCULATIONS:

Result:

1.	The numerical aperture of the given optical fibre is	_____
2.	The acceptance angle θ is	_____°
3.	The attenuation coefficient of the fibre α	_____ dB/m

- Note down the diameter of the laser beam spot W_1 on the horizontal axis W_2 on the vertical axis of the scale and find the average width W of the laser spot (width of the laser spot = W= order of the outermost illuminated ring x 4mm).
- Repeat the experiment for different distances (L) and enter the readings in the table-A.
- Compute the numerical aperture and acceptance angle using the given formulae.

Part B: Measurement of attenuation coefficient of the given Optical Fiber

Principle: Attenuation coefficient is defined as the loss in the energy per unit length of the fibre. The major factors contributing to the attenuation in optical fibre are i) Absorption loss, ii) Scattering loss, iii) Bending loss, iv) Intermodal dispersion loss and v) Coupling loss. These losses are a consequence of material, composition, structural design of the fibre and can be minimized by taking proper care in selection of materials, design and the operating wavelengths.

Attenuation in fibre is measured in terms of attenuation coefficient, (α). It is denoted by symbol α. mathematically attenuation coefficient of the fibre is given by,

$$\alpha = -\frac{10 \times \log(P_{out} / P_{in})}{L} \text{ dB/km}$$

Where Pout and Pin are the output power and input power of the signal respectively, and L is the length of the fibre.

Procedure:

- Connect one end of optical fibre cable (1 meter) to the LED and the other end to the photo diode.
- Connect the Digital Panel Meter (DPM) to the power meter as shown in the figure B
- Plug in AC mains, fix the output power (P_o) knob to some known value in the DPM. This is attenuation in the fibre of one metre length.
- Repeat the above procedure for a different cable length as given in table (say 5m) and note the attenuation of the fibre in the DPM.
- The difference in the DPM readings gives the transmission loss for a known length of the fibre (say 5m -1m =4m).
- Calculate the attenuation coefficient α (transmission loss / length)

Result:

1.	The numerical aperture of the given optical fibre is	_____
2.	The acceptance angle θ is	_____ °
3.	The attenuation coefficient of the fibre α	_____ dB/m

DIELECTRIC CONSTANT

OBSERVATIONS

Circuit diagram:

R = <u>47</u> KΩ   **Battery voltage=_____Volt**

<div style="transform: rotate(-90deg)">Paste the data sheets here</div>

Time in seconds (s)	Voltage during charging (V)	Voltage during discharging (V)		Time in seconds (s)	Voltage during charging (V)	Voltage during discharging (V)
0						
30						
60						
90						
120						
.						
.						
.						
.						

DIELECTRIC CONSTANT

Experiment No: Date:

Aim: To determine the capacity of a parallel plate capacitor and hence to calculate the dielectric constant of the dielectric medium in it.

Apparatus: Battery of ten volts, electrolytic capacitor, digital multi meter, two way key and stop clock.

Principle: When a capacitor and a resistor are in series with a dc source, the capacitor gets charged and at any instant the voltage of the capacitor is $V = V_0(1 - e^{-t/RC})$ where V_0 is the maximum voltage. Where RC = τ is called the time constant of the circuit, it is the time taken for the voltage to reach 63% of V_0. Similarly while discharging the voltage across the capacitor is given by $V = V_0(e^{-t/RC})$. The time constant is the time taken for voltage to decrease to 37% of the maximum value ie V_0

FORMULA:
The capacitance and dielectric constant of the given capacitor are calculated by using the formulae given below:

$$1.\ C = \tau/R \quad (F)$$

$$2.\ \varepsilon_r = \frac{Cd}{\varepsilon_o A}$$

where τ : time constant.

ε_r : relative permittivity or the dielectric constant of the dielectric.

ε_o : Absolute permittivity of free space = 8.854×10^{-12} F/m.

C : capacitance of the capacitor (F).
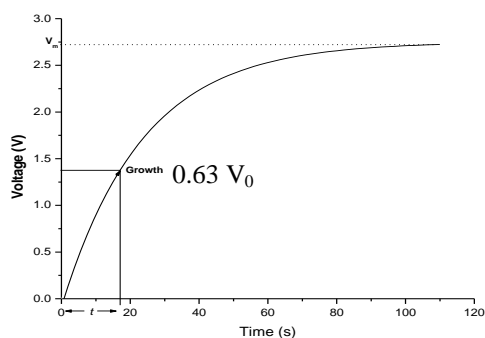R: resistance (Ω)
A: area of each plate (m^2).
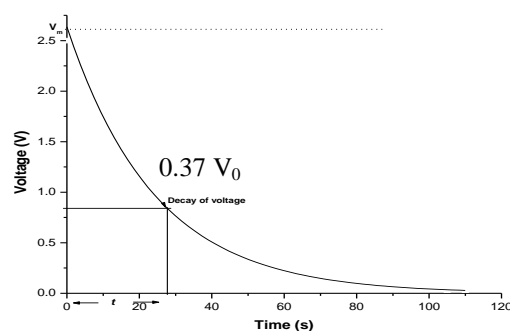d: thickness of the dielectric (m).

Data:

C = 3300 µF	C = 4700 µF
R = 47 kΩ	R = 47 kΩ
L = 47 cm	L = 55 cm
B = 1.5 cm	B = 2.5 cm
d = 80 µm	d = 80 µm

(I) Charging Curve   (II) Discharging Curve:

Charging time constant $\tau_1 =$ _____ s   Discharging time constant $\tau_2 =$ _____ s

Average time constant $\tau = \dfrac{\tau_1 + \tau_2}{2} =$ _____ s

Capacitance of the capacitor $\quad C = \dfrac{\tau}{R} \quad =$ _____F

Where R is the resistance and C is the capacitance of the capacitor in the circuit.

Dielectric constant is determined by using the formula, $\varepsilon_r = \dfrac{Cd}{\varepsilon_o A}$

where τ : time constant, ε_r : dielectric constant of the dielectric.

    ε_o : Absolute permittivity of free space = 8.854×10^{-12} F/m.

    C: capacitance of the capacitor (F).

Calculation:

Thickness of dielectric medium, d (m)	
Area of each plate A (m^2)	

Result:

1. Capacity of parallel plate capacitor C = _____F
2. Dielectric constant of the given dielectric material ε_r = _____

Procedure:

(I) Charging:

The circuit connections are made as shown in the figure. To start with, the key K is closed along **a b**, the voltage across the capacitor increases slowly. For every thirty seconds, the reading of the voltmeter across the capacitor is recorded in tabular column till it reaches maximum (say 2 V). A graph of voltage versus time is drawn as shown in the figure. It is clear from the graph that the voltage increases exponentially with time and attains maximum value V_m after a finite time. The time taken by the voltage to become 63.2% of its maximum value V_m is noted. It is called time constant ($\tau = R \times C$) of the circuit

(II) Discharging

When the voltage across the capacitor is maximum, the two way key K is opened along **a and b** and closed immediately along **a and c.** Then voltage decreases with time, for every thirty seconds the voltage across the capacitor as indicated by the voltmeter is recorded in the tabular column. A graph of voltage versus time is plotted as shown in the figure. The time taken for the voltage to become 36.8% of its maximum value is noted from the graph. This is again time constant (τ).

Note:

Don't connect a wire between *b* and *c*

Multiply the result by 10^{-6}. This correction is needed because the dielectric in the given electrolytic capacitor is not a homogenous medium and it is a paper with alumina deposition by electrolysis
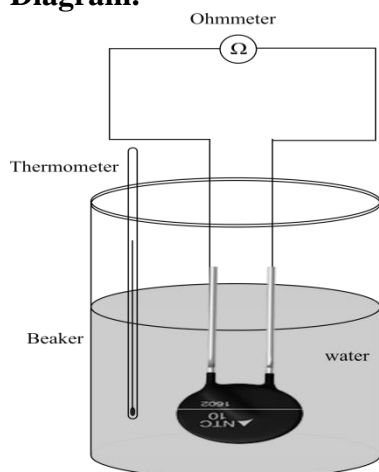
RESULT:
1. Capacity of parallel plate capacitor C = _____F

2. Dielectric constant of the given dielectric material ε_r = _____
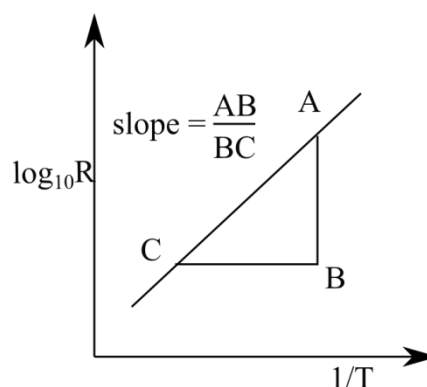
BAND GAP OF A THERMISTOR

OBSERVATIONS:

Diagram:

Model Graph:

Formula: $E_g = \dfrac{4.606 \times k \times m}{1.6 \times 10^{-19}}$ eV

Where

E_g = Energy gap of a given thermistor in eV

k = Boltzmann constant = 1.381 x 10^{-23} J/K

m = Slope of the graph

Table:

Sl. No	Temp t °C	Temp T(K)	R (Ω)	log R	1/T (×10⁻³ K⁻¹)
Room Temp					
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

CALCULATIONS:

Result: The energy gap (band gap) of the given thermistor is _____ eV.

Paste the data sheets here

BAND GAP OF A THERMISTOR

Experiment No: Date:

Aim: To determine the energy gap (E_g) of a Thermistor.

Apparatus: Glass beaker, Thermistor, Multi meter, Thermometer.

Principle: A thermistor is a thermally sensitive resistor. Thermistors are made of semiconducting materials such as oxides of Nickel, Cobalt, Manganese and Zinc. They are available in the form of beads, rods and discs.

The variation of resistance of thermistor is given by $R = a e^{\frac{b}{T}}$ where 'a' and 'b' are constants for a given thermistor, b is a measure of the band gap. The resistance of thermistor decreases exponentially with rise in temperature. At absolute zero all the electrons in the thermistor are in valence band and conduction band is empty. As the temperature increases electrons jump to conduction band and the conductivity increases and hence resistance decreases. By measuring the resistance of thermistor at different temperatures the energy gap is determined.

Formula: $E_g = \dfrac{4.606 \times k \times m}{1.6 \times 10^{-19}} eV$

Where, E_g = Energy gap of a given thermistor in eV, k = Boltzmann constant = 1.381 x 10^{-23} J/K .

m = Slope of the graph of log R vs 1/T.

Procedure:
- Make the circuit connection as shown in the figure.
- Keep the multi meter in resistance mode (200 Ω range).
- Insert the thermometer in a beaker containing tap water, thermistor and note down the resistance at room temperature.
- Immerse the thermistor in hot water at about 90°C.
- Note down the resistance of the thermistor for every decrement of 1°C in the beginning and a decrement of 2^0 up to 60°C.
- Plot the graph of log R versus 1/T and calculate the slope 'm'.
- Calculate the energy gap of a given thermistor using relevant formula.

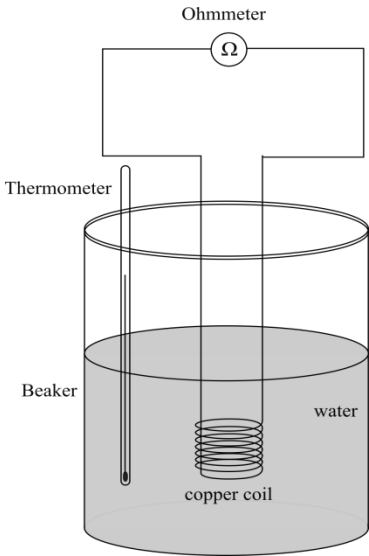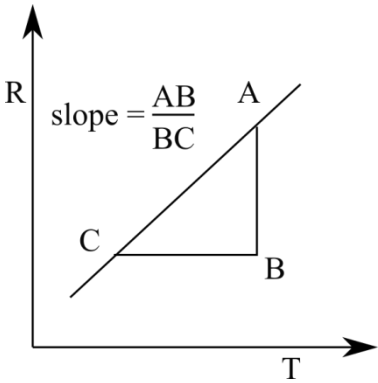**Result:** The energy gap (band gap) of the given thermistor is _____eV.

FERMI ENERGY OF COPPER

OBSERVATIONS:

Diagram: **Model Graph:**

Formula:

$$E_F = 1.36 \times 10^{-15} \sqrt{\frac{\rho \, A \, m}{l}} \quad \text{(in J)}$$

$$E_F = \frac{1.36 \times 10^{-15} \sqrt{\frac{\rho \, A \, m}{l}}}{1.6 \times 10^{-19}} = \text{............} eV$$

$$\text{Slope} = m = \frac{n \sum xy - (\sum x)(\sum y)}{n \sum x^2 - (\sum x)^2}$$

$$\text{y-intercept} = c = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n \sum x^2 - (\sum x)^2}$$

Tabular Column: **Calculations:**

Sl. No	Temp (^{0}C) (x)	R (Ω) (y)	x^2	xy
Room Temp				
1.				
2.				
3.				
4.				
5.				
6.				
Sums	$\Sigma x =$	$\Sigma y =$	$\Sigma x^2 =$	$\Sigma xy =$

m =

c =

x	y = mx + c
30	
80	

$E_F =$

Result: The Fermi energy of copper is $E_F =$ _____ J, _____ eV

Paste the data sheets here

FERMI ENERGY OF COPPER

Experiment No: Date:

Aim: To determine the Fermi energy of copper

Apparatus: Multi meter, Beaker, Thermometer and copper wire.

Theory: In a conductor, the electrons fill the available energy states starting from the lowest energy level. Therefore at 0K, all the levels with an energy E less than a certain value $E_{F(0)}$ will be filled with electrons, whereas the levels with E greater than E_{F0} will remain vacant. The energy E_{F0} is known as Fermi energy at absolute zero and corresponding energy level is known as Fermi level. For temperature greater than zero Kelvin, Fermi energy is the average energy of the electrons participating in electrical conductivity. By measuring the resistance of the copper wire at different temperatures Fermi energy is calculated by the following formula.

$$E_F = 1.36 \times 10^{-15} \sqrt{\frac{\rho \, A \, m}{l}} \ \text{J}$$

Where, E_F is the Fermi energy

T is the reference temperature (K),
A is area of cross section of the given copper wire (m^2)
l is the length of the copper wire (m)
Charge of the electron, e = 1.602 x 10^{-19} C.
ρ is the density of copper = 8960 Kg/m^3
m is the slope of the straight line obtained by plotting resistance of the metal against absolute temperature of the metal.

Procedure:

- Connect the copper coil to the digital multi meter.
- Set the multi meter to 200 Ω mode.
- Immerse the copper coil in a beaker containing cold water, note down the resistance in multi meter and enter the readings in the tabular column.
- Immerse the copper coil in a beaker containing hot water at about 90°C.
- Note down the resistance in multi meter for every decrement of 5°C to about 50°C and enter the readings in the tabular column.
- Plot a graph of resistance along y-axis and temperature along x-axis and calculate the value of slope m of the resulting graph (m = AB/BC)
- Calculate the Fermi energy of the material by using the relevant formula.

Result: The Fermi energy of copper is E_F = _____ J, _____eV.

TRANSISTOR CHARACTERISTICS

1. What is a transistor?
A transistor is a three terminal semiconducting device. It consists of two PN junctions jointed back to back.

2. What are the types of transistors?
The types of transistors are npn and pnp

3. What are the terminals of a transistor? How do you identify them?
The terminals of a transistor are Emitter, Base and Collector. A transistor will have a notch (projection). The lead very close to the notch is the emitter and the farther one is collector. The lead in between these two is the base.

4. How are the junctions biased in a transistor?
The emitter base junction is forward biased and the collector base junction is reverse biased.

5. What is the level of doping in emitter, base and collector?
Emitter is heavily doped, base is lightly doped and collector is moderately doped.

6. What are different configurations in connecting a transistor?
The different configurations in connecting a transistor are common emitter, common base and common collector.

7. Which is the most commonly used configuration? Why?
Common emitter configuration is most commonly used configuration because the current gain β in this configuration is high.

8. Define α and β?
α is the current gain in common in common base configuration. It is the ratio of collector current to emitter current. Its value ranges from 0.95 to 0.99.
β is the current gain in common emitter configuration. It is the ratio of collector current to base current. Its value ranges from 40 to 200.

9. What are the applications of transistor?
A transistor is used as an amplifier and as a switch.

10. What is an amplifier?
An amplifier increases the strength or magnitude of the weak input signal.

1. Why is transistor called as a current controlled device?
A transistor is called a current controlled device because the output current is controlled by the input current.

2. The input characteristics of transistor is similar to which semiconducting device?
The characteristics is similar to the forward biased diode because the emitter base junction behaves as forward biased diode.

ZENER DIODE

1. What is a semiconductor?
A semiconductor is a material in which there is a small energy gap called forbidden energy gap between conduction band and valence band. It is of the order of one volt.

2. What is a diode?
When a p type semiconductor is joined together with an n type semiconductor a pn junction is formed. A pn junction is also known as a diode.

3. What is a zener diode?
A heavily doped pn junction is a zener diode.

4. What is biasing? Explain the types of biasing.
Biasing is a method of applying voltage to a diode.
The types of biasing is Forward bias and Reverse bias. When p type of the diode is connected to positive terminal of the battery and n type to negative of diode then it is forward bias and when p type is connected to negative to the battery and n type to positive of diode it is reverse bias.

1. What is breakdown?
If the reverse bias voltage is increased a point is reached when the junction breaks down and stars conducting heavily. This critical value of voltage is called breakdown voltage. Once breakdown occurs, there is an abrupt rise in reverse current.

2. What are the types of breakdown? Explain.
The types of breakdown are Zener breakdown and Avalanche breakdown.
When reverse bias is increased, the electric field at the junction also increases. High electric field causes covalent bonds to break. Thus a large number of carriers are generated. This causes a large current to flow. This mechanism of breakdown is called zener breakdown.
In case of Avalanche breakdown, the increased electric field causes increase in the velocities of minority carriers. These high-energy carriers break covalent bonds thereby generating more carriers. Again, these generated carriers are accelerated by the electric field. They break more covalent bonds during their travel. A chain reaction is thus established, creating a large number of carriers. This gives rise to a high reverse current. This mechanism of breakdown is called avalanche breakdown.

7. What are $V\gamma$ and V_z ?
$V\gamma$ is the knee or cut in voltage or threshold voltage. It is the minimum voltage at which the diode goes into its conducting state. The value for Si is 0.7v and for Ge is 0.3v.
V_z is the Zener breakdown voltage. There is an abrupt rise in current at this point.

8. What are the applications of Zener diode?
It is used as voltage regulator and as a standard voltage for calibration of meters.

9. What do you mean by regulation?
The output is maintained a constant irrespective of the changes in the input.

10. Explain the working of zener diode.

The depletion layer in zener diode is very thin due to heavily doped junction materials. Low voltage produces very strong electric field across the junction causing zener breakdown. At this constant voltage in reverse bias, its resistance falls to a very low value and conducts heavily. The voltage remains constant irrespective of the current. The external series resistance and maximum power dissipation capability of the device limit the current.

WAVELENGTH OF LED's

1. What is LED?
Light Emitting Diode is a heavily doped p n junction, where voltage yields a flow of current.

2. What is quantum?
According to Quantum theory, it is a bundle of energy given by $E = h\upsilon = hc/\lambda$
Where E is the energy of the quantum, h is the Planck's constant and υ is the frequency of the light emitted.

3. Discuss the mechanism How light is produced from LED?
A photo P-N junction can convert absorbed light energy into an electrical energy. The same process is reversed here (i.e. the P-N junction emits light when electrical energy is applied to it). This phenomenon is generally called electroluminescence, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward-biased P-N junction, as the electrons cross from the N-region and recombine with the holes existing in the P-region light is emitted. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some portion of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light

4. What is semiconductor diode laser?
Semiconductor diode laser is a specially fabricated p-n junction. It emits laser light when it is forward biased and the applied current must be above the threshold value.

SERIES RESONANCE (LCR)

1. What is an Inductor?
   A non resistive coil of wire in which there will be an opposing emf when there is varying current is passing through it. It is a passive component used to store energy in the form of magnetic field.

2. What is Resistance?
   The resistance of a conductor is the opposition offered by the conductor to the flow of electric current through it. The opposition is due to the collision of electrons with ion cores of the conductor. It is independent of frequency.

3. What is Impedance?
   Impedance measure the effective opposition to the flow of current due to the reactance and resistance. It is frequency dependent.

4. What is Inductive reactance?
   The opposition offered by the inductor to the flow of AC is called inductive reactance (X_L). $X_L = \omega L = 2\pi f L$.

5. What is capacitive reactance?
   The opposition offered by the capacitor to the flow of AC is called capacitive reactance (X_C). $X_C == 1/\omega C = 1/C2\pi f$

6. What do you mean by resonance in LCR series circuit?
   The condition at which the current is maximum due to the matching of inductive and capacitive reactance's.

7. What is Quality factor? Explain the variation of quality factor with change in resistance of the circuit.
   It is defined as the ratio of resonant frequency to the bandwidth of the circuit. Quality factor measures the sharpness of resonance $Q = 1/R$ (sqrt(L/C)

8. The smaller the value of resistance, the greater is the current at resonance and the resonance curve is sharper. As the resistance is increased, the sharpness of resonance decreases and the circuit becomes less selective.

9. What is Bandwidth?
   It is the difference between upper and lower cut off frequencies. Bandwidth is the applicable range of frequencies.

10. What are the applications of LCR resonant circuits?
    They are used as tuning circuits in radio and television receivers.

LASER DIFFRACTION

1. What is meant by diffraction?
Bending of waves round the edges of an obstacle is called diffraction.

2. What is the condition for diffraction?
Size of the obstacle should be comparable with that of the wave length of the light source. Since grating constant and wave length are of the same order (10-6metre), diffraction takes place within the grating.

3. Distinguish between diffraction and dispersion?
Diffraction: Bending of light round the edges of an obstacle is called diffraction. In this case lower the wave length lesser will be the deviation.
Dispersion: When white light passes through a prism it splits into its constituent colors. This phenomenon is called dispersion. In this case lower the wave length higher will be the deviation.

4. Distinguish between polychromatic & monochromatic source.
Polychromatic source a source having different wave lengths. Ex. Mercury vapour lamp.
Monochromatic source is a source having single wave length. Ex Sodium vapour lamp.

5. What does LASER stands for?

The term LASER stands for Light Amplification by Stimulated Emission of Radiation.

6. What are the characteristics of laser radiation?
Laser radiations have high intensity, high coherence, high monochromaticity and high directionality with less divergence.

7. What is population inversion?
When the number of atoms are more in higher energy state than in the lower energy state, this condition is known as population inversion, it is essential for stimulated emission.

8. What is pumping in a laser?
It is the process in which atoms are excited to higher energy states by continuously supplying energy.

9. What is meant by the term coherence?
The state of vibration, same phase or constant phase difference is known as coherence.

10. What is an active medium?
A solid, liquid, or gaseous medium in which population inversion can be achieved is called an active medium.

11. What is the action of an optical resonator?
It gives the directionality to the laser beam and amplifies the laser beam.

BLACK BOX

1. What is meant by black box in this experiments?
A box containing passive elements inside and having the terminals out side the box is referred to as black box.

2. What re passive elements ?
The circuit element which cannot deliver any electrical power and does not performs the operations like amplification, rectification etc., are called passive elements.
Ex: Resistor, inductor, capacitor

3. What are active components?
The circuit elements which can deliver electrical power to the system and can perform the operations like amplification, rectification etc. are called active elements.
Ex. Battery, semiconductor devices.

4. Define inductor and capacitor
Inductor is an energy storage device, which can store the energy in its magnetic field.
Capacitor is an energy storage device, which can store the energy in its static electric field.

5. How do you detect inductor and capacitor using d.c. Supply?
Inductor offers very small resistance for the flow of d.c. and the current in that branch will be maximum indicating the presence of inductor
Capacitor blocks d.c. so we will observe zero current the branch containing capacitor.
Resistances shows linear trend with the increasing voltage and obeys Ohm's law.

6. How do you detect inductor, capacitor and resistor using a.c. supply?

If the a.c. current decreases with the increasing frequency (a.c. voltage may increase or remains constant), then the terminal should be inductor.

If an a.c. current increases with in the increasing frequency (a.c voltage may decrease or remains constant) in the circuit, they the terminal must be capacity

Resistors are independent on a.c., so if there is not change in a.c. current or voltage with the increasing frequency, the terminal must be resistor.

7. What is meant by self-induction?

The phenomenon in which an emf induced in the coil due to a change of current through it is known as self-induction.

8. What is mean by self-inductance?

It is the property of a coil or conductor by virtue of which it opposes a change in current through it.

9. What is the unit of self-inductance? and define it.

Henry is the unit of self-inductance. The self inductance are the co efficient of self induction is said to be 1 henry if 1 V of emf is induced in the coil when the current through it changes at the rate of 1 ampere / second.

10. What is meant by capacitance of a capacitor? and define farad

It is defined as the ratio of charge on either conductor to the potential difference between the conductors forming the capacitor.

Capacitance of capacitor is said to be 1 farad if the addition of 1 coulomb charge raises its potential by 1 volt.

OPTICAL FIBER

1. What is the basic principle of an optical fiber?

Optical fiber works based on the principle of total internal reflection [TIR]

2. What is an optical fiber?

An optical fiber is a wave guide system through which light signals are carried over longer distances without loss of energy.

3. What is Numerical aperture (NA)?

The light gathering capacity of an optical fiber is called Numerical Aperture.

NA= Sin θ_0 Where θ_0=acceptance angle.

4. What is an acceptance angle of an optical fiber?

It is the maximum angle of incidence at the core of an optical fiber so that the light can be guided through the fiber. Acceptance angle $\theta_0 =\text{Sin}^{-1}(NA)$.

5. Why optical fibers do not pick up electricity?

Optical fibers are made by pure non-metallic materials hence they won't allow electricity.

6. What is Total Internal Reflection (TIR)?

Total internal reflection is the phenomenon in which complete reflection of a light ray occurs into the same medium, when a propagated wave strikes a medium boundary at an angle larger than a critical angle with respect to the normal to the surface.

7. What is an acceptance angle?
The angle θ0 is called the wave guide acceptance angle or the acceptance cone half-angle which is the maximum angle from the axis of optical fiber at which light ray may enter the fiber so that it will propagate in core by total internal reflection.

8. What is an attenuation in optical fiber?
The total power loss offered by the total length of the fiber in the transmission of light is called attenuation.

9. What are the different types of optical fiber?
The optical fibers are classified under three categories. They are 1) Single Mode Step Index Fiber, 2) Step Index Multi Mode Fiber and 3) Graded index Multi Mode Fiber

DIELECTRIC CONSTANT

1. What is Capacitor?
    A Capacitor is a passive component used to store energy in the form of an electrostatic field.

2. What are passive elements?
    The circuit element which cannot deliver any electrical power and does not performs the operations like amplification, rectification etc., are called passive elements.

3. What are active elements?
    The circuit elements which can deliver electrical power to the system and can perform the operations like amplification, rectification, etc., are called active elements.

4. What is meant by capacitance of a capacitor?
    It is defined as the ratio of charge on either conductor to the potential difference between the conductors forming the capacitor. It is the ability of the device to hold charge

5. How Capacitance of the capacitor can be increased?
    Capacitance of a capacitor can be increased by i) introducing a dielectric material of high density between the two parallel plates of the capacitor 2) increasing the area of the plates and decreasing the gap between the plates.

6. How is the value of the capacitance of a parallel plate capacitor determined from its dimensions?
    In SI units $C = \varepsilon A/d$, where C is the capacitance, ε is the absolute permittivity of the material between the plates, A is the area of one of each plate, and d is the distance between the plates.

7. What is the charge on the capacitor when the voltage across it is V?
    $Q = CV$ coulomb, when C is expressed in farad and V in volt.

8. With respect to the discharge of a capacitor, define time constant
   The time constant is the time in which the charge on the capacitor decays to 1/e of its maximum value.

9. With respect to the charging of a capacitor, define time constant
   The time constant is the time in which the charge on the capacitor decays to $1 - 1/e$ of its initial value

10. What would happen time of leakage if the capacitor is very large or very small?
    The time of leakage is determined by the time constant τ ($\tau = CR$) of the circuit. For R approximately equal to a few MΩ, if C is very large, say, 1F then the leakage time will be very large (approximately equal to 10^6 s.). On the other hand, if C is very small (approximately equal to 10^{-3} μF), the time of leakage will be very small (approximately equal to millisecond) and cannot be measured by a stop watch Thus, when R is of the order of a few MΩ, C is required to be 1μF or so.

11. Are the time constant for charging and discharging the capacitor the same in your experiment?
    No. The time constant for discharging the capacitor is larger than that for its Charging.

12. Define Static Dielectric constant?
    The static dielectric constant is the factor by which the capacitance of a capacitor is increased when vacuum is substituted by a dielectric medium which fills the entire region where electric field would be set up on subjecting the capacitor to a static electric potential.

13. What are the factors that Dielectric constant depends?
    Dielectric constant mainly depends on the nature of the material and does not depends on the size or shape of a capacitor or dielectric material

14. What is polarization of dielectrics?
    The process of acquiring charges by a dielectric when placed in an electric field is called polarisation.

15. What is the unit of Dielectric constant?
    Dielectric constant is a dimension less constant hence it has no unit.

16. Give examples of Dielectric material
    Paper, wax, mica, ceramics, some electrolytes, etc.

17. What is Dielectric Strength?
    The limiting electric field above which the dielectric breakdown occurs is called Dielectric strength.

18. Give applications of Dielectrics?
    Dielectrics can be used as a dielectric medium in capacitors, as an insulator in power transmission, as a heating material in microwave oven (cooking rice in microwave oven).

THERMISTOR

1. What is a thermistor?
   Thermistor is a temperature sensitive resistor made up of a semiconductor.

2. Name the applications of a thermistor.
   Thermistors are commonly found in digital thermometers, automotive electronics.

3. What are Negative Temperature Coefficient (NTC)
   NTC thermistors decrease their resistance as temperature increases.

FERMI ENERGY

1. What is Fermi energy of a metal?
   It is the energy of the highest occupied level at absolute zero temperature..

2. What is meant by Fermi factor?
   It is the probability of occupation of given energy state by a charge carrier.

3. What is meant by Fermi temperature T_F? What is the relation between E_F & T_F?
   It is the temperature at which the average thermal energy of the free electrons in a solid becomes equal to the Fermi energy at $0°K$. $E_F = k_B T_F$

4. What is meant by Fermi velocity?
   It is the velocity of those electrons which occupy the Fermi level. It is given by
   $$E_F = \frac{1}{2} mv_F^2$$

5. What is Fermi Dirac distribution?
   It gives distribution of electrons / fermions among the various available energy levels of a material under thermal equilibrium conditions.

6. What are the factors on which E_F depend?
   E_F depends on the material and the temperature.

7. How many electrons will be there in each energy level?
   According to Pauli's exclusion principle, there will be two electrons in each energy level.

8. State Pauli's exclusion principle?
   It states that no two electrons can have all the four quantum numbers same.

9. What is meant by free electron?
   Free electron is the electron which moves freely 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.