MARKS SHEET

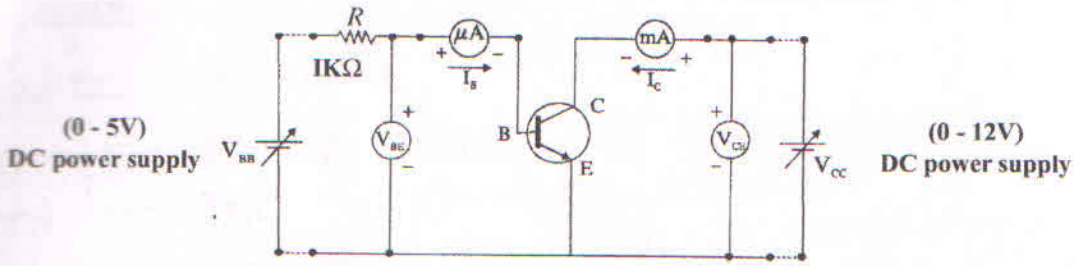
Name : Sec/Batch : USN/Roll No :

EXPT.NO	SET NO.	EXPERIMENTS	PAGE NO	DATE OF SUBMISSION	MARKS OBTAINED
1.	I	Transistor Characteristics			
2.	II	Zener diode and LED			
3.	III	Series LCR Circuit			
4.		Laser Diffraction			
5.	IV	Black box			
6.		Optical fiber			
7.	V	Band Gap of a Thermistor			
8.		Dielectrics Constant			
9.	VI	Fermi energy of copper / Hall effect			
		Average marks of the experiments 1 and 4 to 9			/30
		Average marks of the EL experiments 2 and 3			/10
		Lab test marks			/10
		Total Marks			/50
Signature of the faculty					

TRANSISTOR CHARACTERISITICS

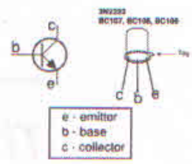
OBSERVATIONS

Circuit diagram



TABULAR COLOUMN

Input Characteristics



Trial 1
V_{CE} = 2V

Trail 2
V_{CE}= 4 V

V_{BE} (Volts)	I_B(μA)	V_{BE}(Volts)	I_B(μA)
0	0	0	0
0.703	5	0.706	5
0.727	10	0.730	10
0.729	15	0.745	15
0.730	20	0.753	20
0.731	25	0.754	25
0.732	30	0.755	30
0.732	35	0.755	35
0.733	40	0.756	40
0.734	45	0.756	45
0.735	50	0.757	50

TRANSISTOR CHARACTERISTICS

Experiment No: 06 Date: 1/2/2023

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

Apparatus: Transistor SL100, tag board, dc micro-ammeter (0-200μA), dc milli-ammeter (0-20 mA), voltmeter (digital multimeter in voltage mode) and dc power supply (0-30 V).

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:

Input Characteristics

Connections are made as shown in the circuit diagram. The output voltage between the collector and emitter, V_{CE}, is maintained at a constant value (say 2 & 4V) by adjusting the dc power supply V_{CC}. The base and emitter V_{BE} is varied and corresponding base current I_B is noted.

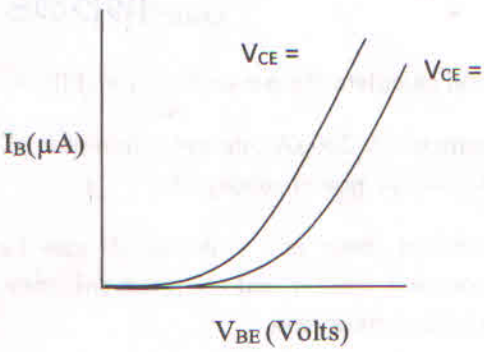
The experiment is repeated for different values V_{CE}. A graph of I_B versus V_{BE} is plotted for different V_{CE}. These graphs are called input characteristics. These graphs will be similar to that of a forward biased diode as the base emitter junction of the transistor is in forward bias.

Output characteristics

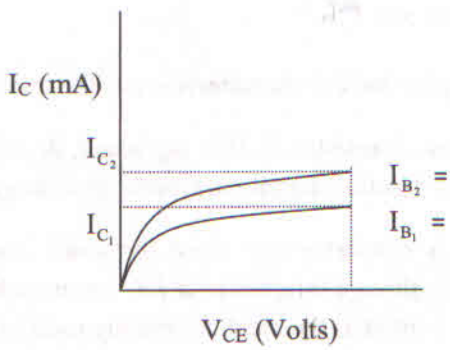
The input current I_B is kept at a constant value (say 20 μA or 40μA). The output voltage between the collector and emitter V_{CE} is varied and the corresponding current I_C noted down. The experiment is repeated for different values of I_B in μA.

A graph of I_C versus V_{CE} is plotted for different base current values. These graphs are called out put characteristics. From the graph the current gain β in Common Emitter mode is calculated using the formula. The current gain in common base mode α is

Input Characteristics



Output Characteristics

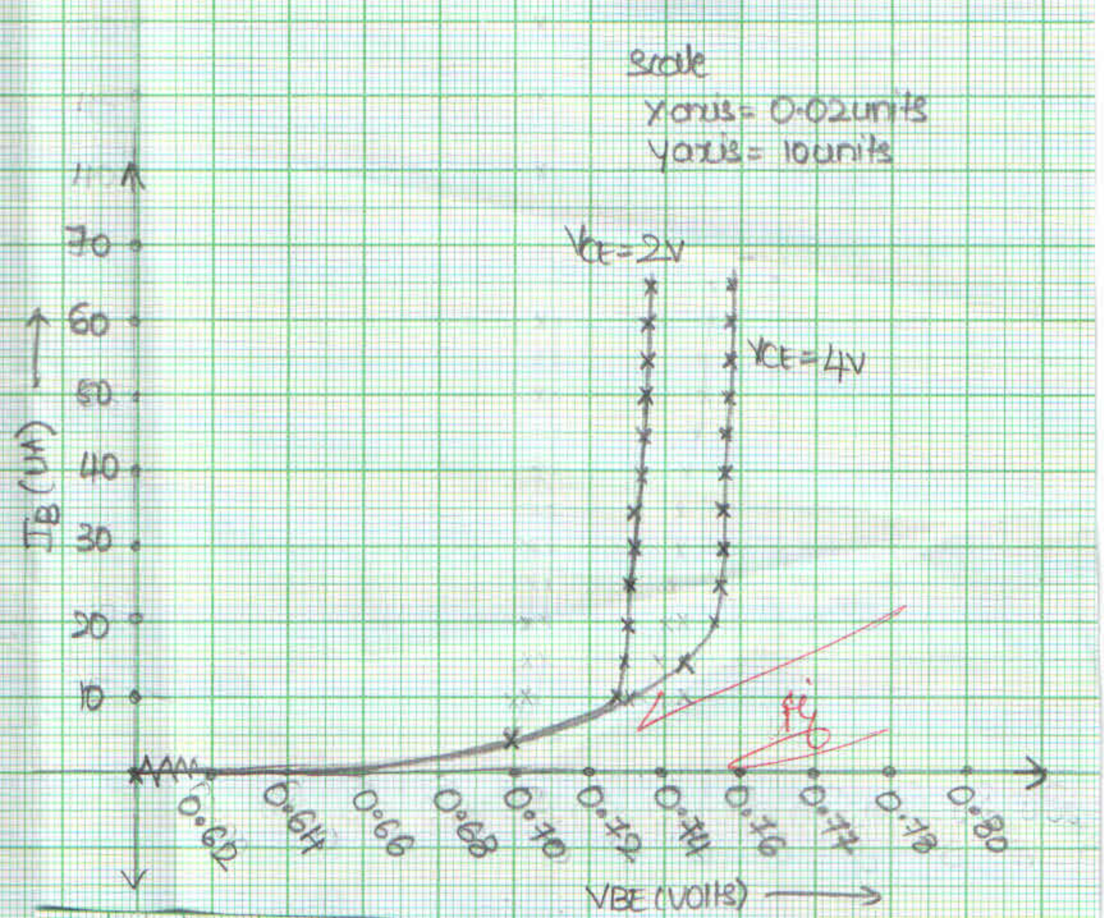


TABULAR COLOUMN:

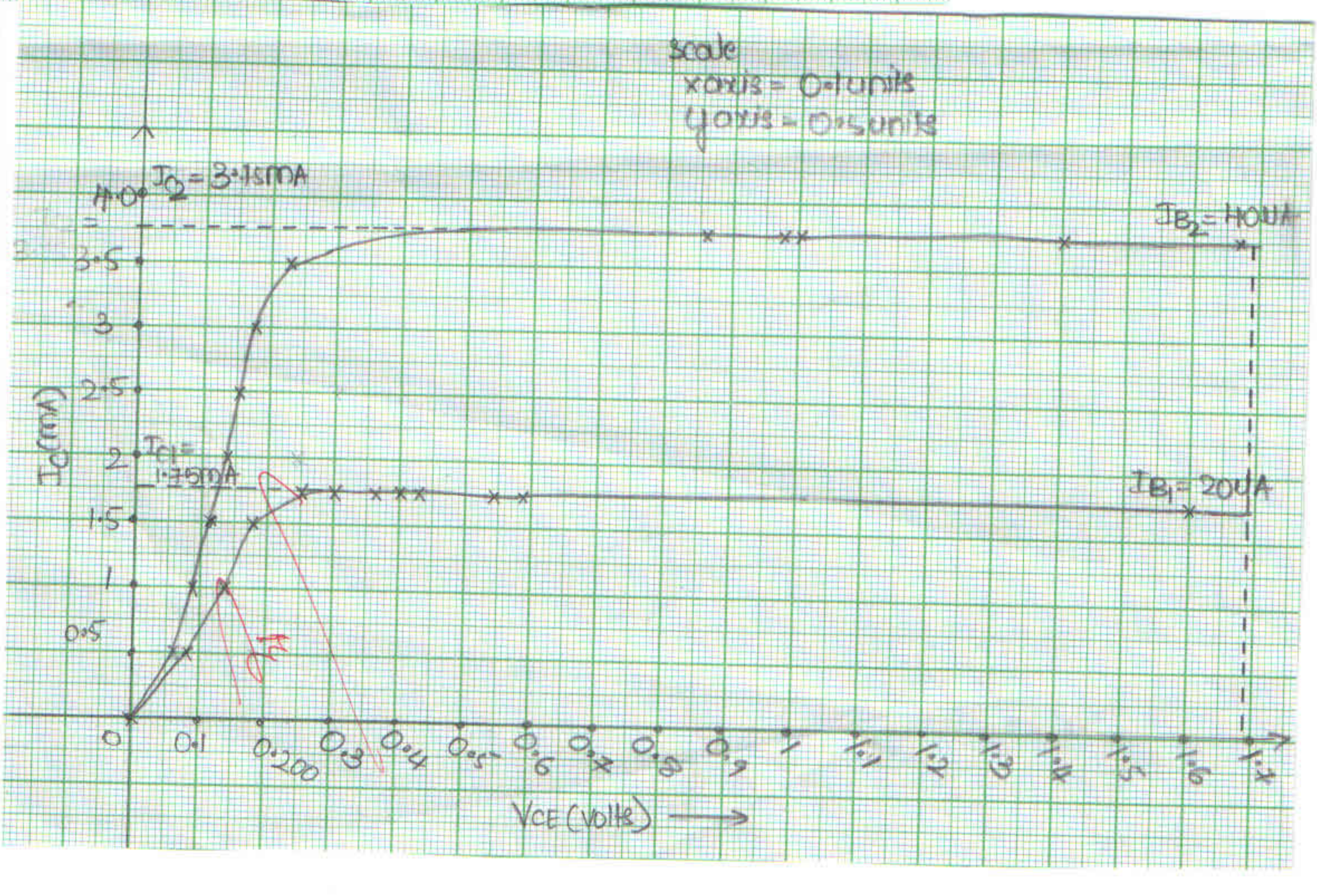
Output Characteristics

Trial 1: I_B = 20 µA　　　Trial 2: I_B = 40 µA

V_{CE} (Volts)	I_C(mA)	V_{CE}(Volts)	I_C(mA)
0	0	0	0
0.085	0.5	0.064	0.5
0.139	1.0	0.091	1
0.178	1.5	0.113	1.5
0.252	1.75	0.134	2
0.302	1.75	0.153	2.5
0.362	1.75	0.179	3
0.431	1.75	0.232	3.5
0.546	1.75	0.860	3.75



scale
x axis = 0.02 units
y axis = 10 units
VCE = 2V
VCE = 4V
IB (uA)
VBE (volts)



scale
x axis = 0.1 units
y axis = 0.5 units
IC2 = 3.75mA
IC1 = 1.75mA
IB2 = 40uA
IB1 = 20uA
IC (mA)
VCE (volts)

Calculations:

To calculate transistor parameters α and β

The current gain in common emitter mode is the ratio of the change in collector current to the change in base current at constant collector- emitter voltage and it is denoted by β. The current gain in common base mode is the ratio of the change in collector current to the change in base current at constant base- emitter voltage and it is denoted by α.

From output characteristics

1. $\beta = \left[\frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}}\right]_{V_{CE}}$ = 100.

2. $\alpha = \frac{\beta}{\beta + 1}$ = 0.9901.

Current gain in Common Emitter configuration is= 100

Current gain in Common Base configuration is = 0.9901

$I_{C1} = 1.75mA$

$I_{C2} = 3.75mA$

$I_{B1} = 20\mu A$

$I_{B2} = 40\mu A$

$\beta = \left[\frac{I_{C2} - I_{C1}}{I_{B1} - I_{B2}}\right] = \left(\frac{3.75 - 1.75}{40 - 20}\right)\frac{m}{\mu}$

$= \frac{2m}{20\mu} = \frac{10^3}{10} = 100$

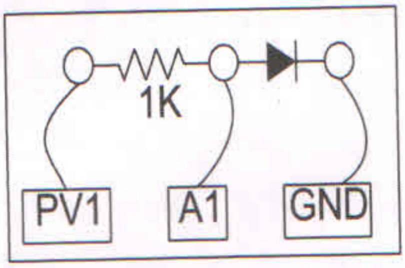
$\alpha = \frac{\beta}{\beta + 1} = \frac{100}{101} = 0.9901$

RESULT: The input and output characteristics have been plotted.

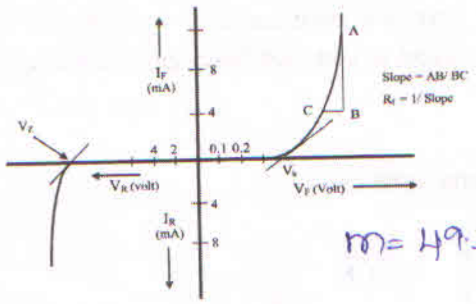
ZENER DIODE CHARACTERISTICS
(expEYES-17)

OBSERVATIONS:

Circuit Diagram:



Model Graph:



$m = 49.3 \times 10^{-3}$

Formula:
The forward resistance is given by

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

Where ΔV_f Change in forward voltage in Volts.

ΔI_f Change in forward current in Ampere.

Note: Graph plot procedure using GNUPLOT

Go to respective folder/directory on the desktop where file is stored.

Step 1: click on the right button of the mouse, **select open in terminal**

Step 2: In terminal window path will be displayed as shown:

dept-physics@dept-physics-rvce:~$ cd Desktop

Step 3: For graph plotting, type the software name : **gnuplot**

dept-physics@dept-physics-rvce:~/Desktop$ gnuplot

Step 5: Type command line for title of the graph

gnuplot> set title "student name: experiment name"

Step 6: Type command line for labeling x-axis and y-axis of the graph

gnuplot > set xlabel "X-axis variable"

gnuplot> set ylabel "Y-axis variable"

Step 7: Type command line for graph plotting

gnuplot> plot "filename1.txt" w lp

$m = 49.3 \times 10^{-3}$

Results:

The Knee voltage: 0.663 V
The breakdown voltage: -2.57 V
The forward bias resistance: 20.3 Ω

ZENER DIODE CHARACTERISTICS

Experiment No: 07 Date: 8/2/2023

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 $V_Z = V_{Z0}+I_Z r$, 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.
- Then save the data and save the file in .txt form (example: zener.txt) and plot current versus voltage I/V characteristics using GNUPLOT.
- Note down the knee voltage and breakdown voltage by extending the linear portion of the curve on voltage axis in the first and third quadrant.
- In the first quadrant for the linear portion of the curve find the slope.
- The reciprocal of the slope gives the forward resistance.

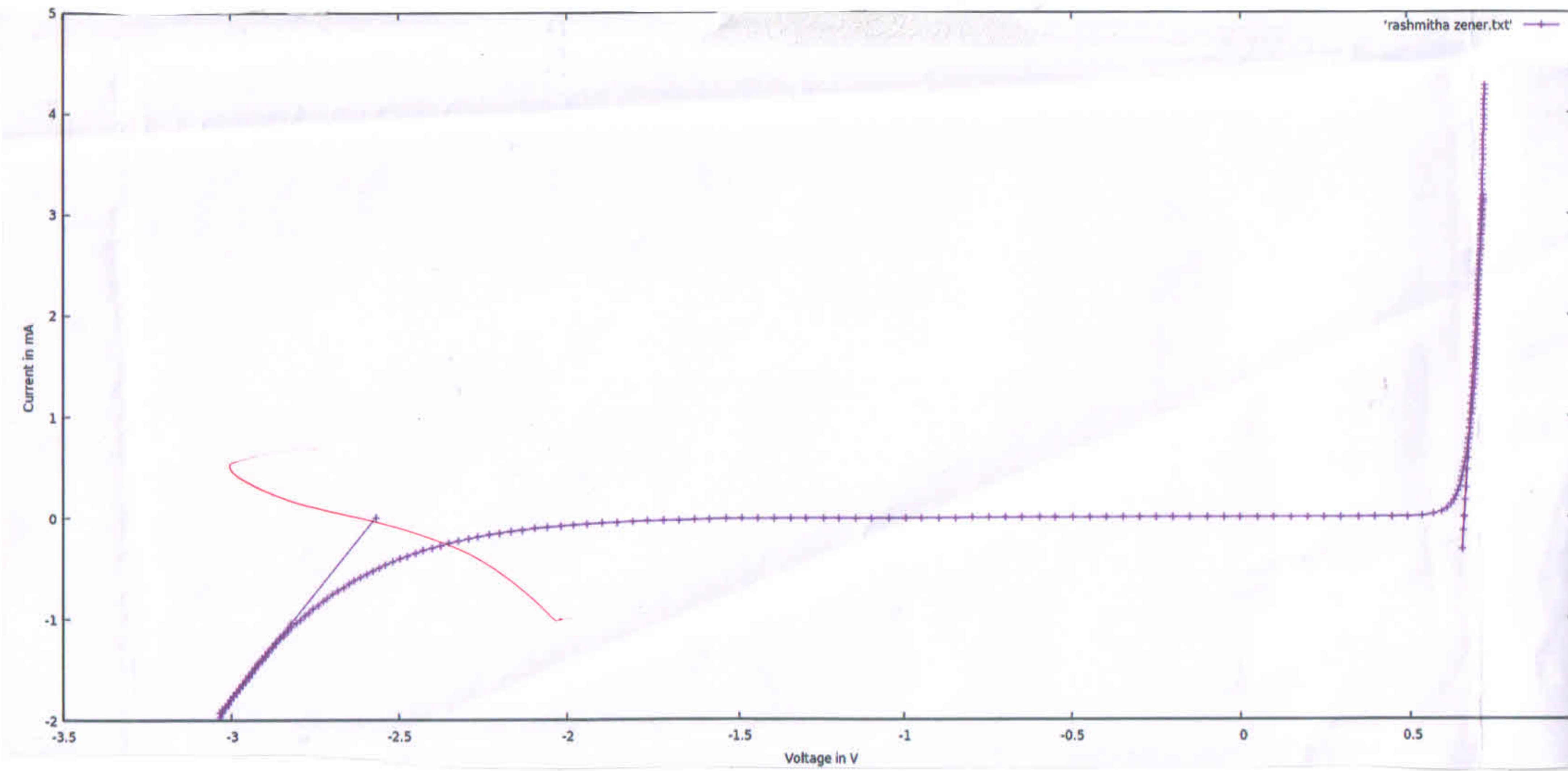
Results:

The Knee voltage: 0.663 V

The breakdown voltage: -2.57 V

The forward bias resistance: 20.3Ω

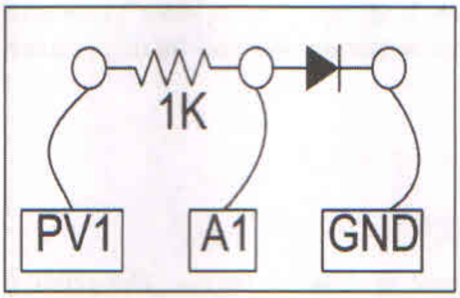
30/30 18/2


'rashmitha zener.txt'
Current in mA
5
4
3
2
1
0
-1
-2
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
Voltage in V

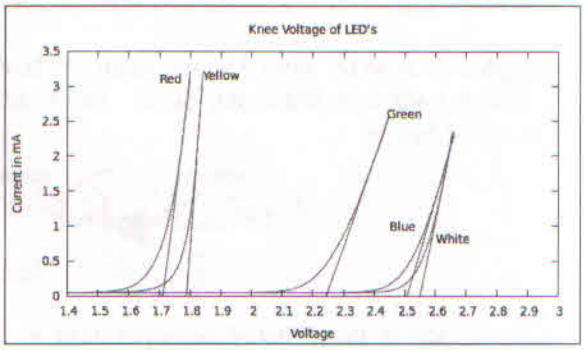
WAVELENGTH OF LED (expEYES-17)

OBSERVATIONS:

Circuit Diagram:



Model Graph:



Formula: Energy of the photons emitted by LED = $E = \frac{hc}{\lambda} = eV_K$

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

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

Calculations:

$\lambda_{yellow} = \frac{19.89 \times 10^{-26}}{2.8996 \times 10^{-19}} = 685.96 nm$

$\lambda_{green} = \frac{19.89 \times 10^{-26}}{4.021 \times 10^{-19}} = 494.65 nm$

$\lambda_{Blue} = \frac{19.89 \times 10^{-26}}{4.1171 \times 10^{-19}} = 483.11 nm$

$\lambda_{white} = \frac{19.89 \times 10^{-26}}{4.1812 \times 10^{-19}} = 475.7 nm$

Result:

Colour of LED	Knee Voltage (V_K)	Wavelength(λ) in nm
Yellow	1.81 V	685.96 nm
Green	2.51 V	494.65 nm
Blue	2.57 V	483.11 nm
white	2.61 V	475.7 nm

WAVELENGTH OF LIGHT EMITTING DIODES

Date: 8|2|23

Experiment No: 08

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.

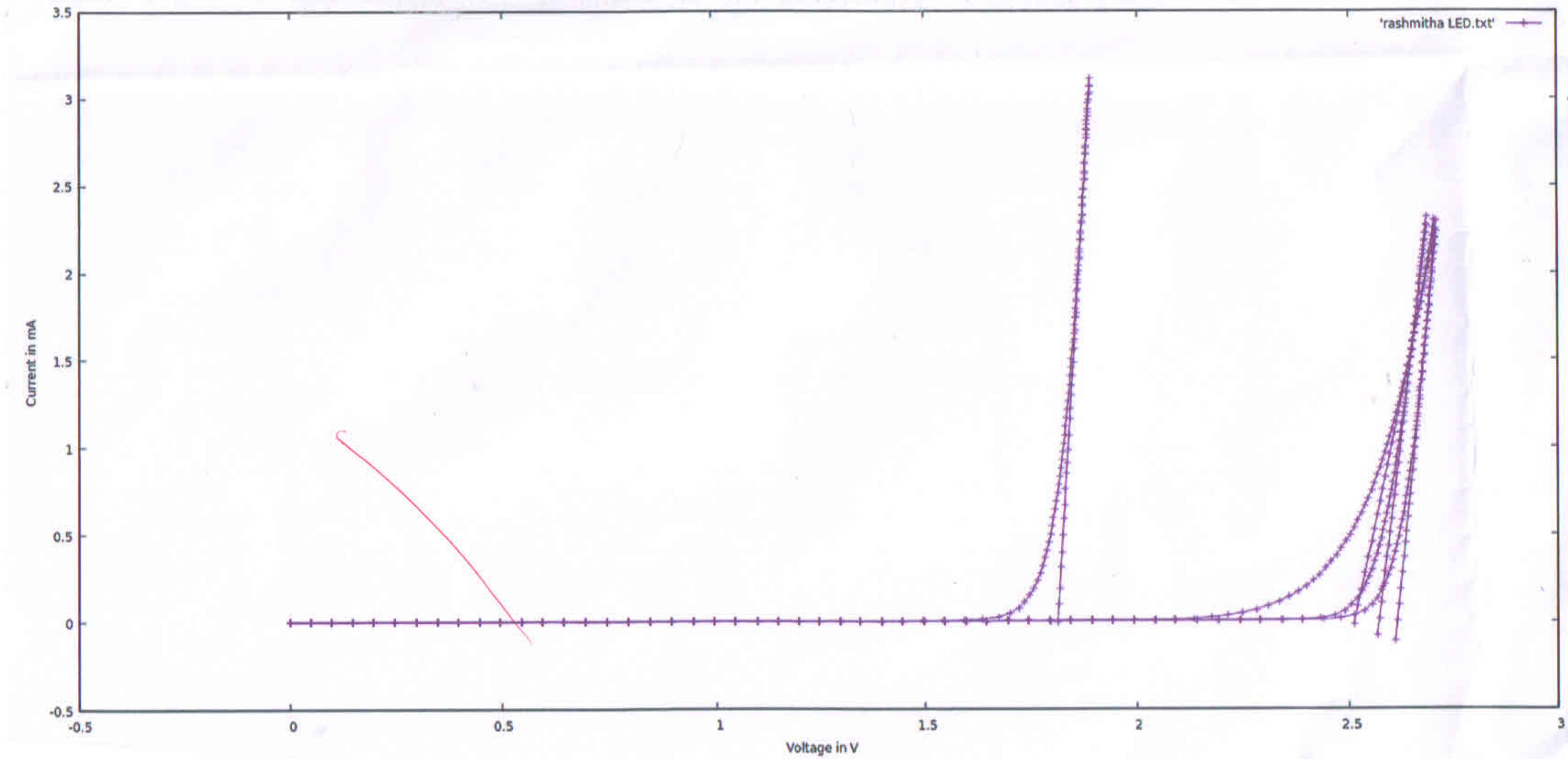
Principle: Light emitting diode is special type of semiconductor diode. It consists of heavily doped P type and N type direct band gap semiconductors. The LED absorbs electrical energy and converts it into light energy. When the PN junction is forward biased, the electrons from the N region migrate into 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, then analyse the data.
3. Repeat the experiment with three more LEDs.
4. Plot current versus voltage I/V graph of LEDs using GNUPLOT.
5. For each LED note down the knee voltage (V_k) from the graph and calculate the wavelength of the LED using the given formula.

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

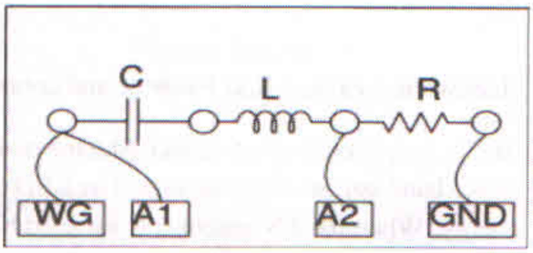
$\frac{30}{30}$


'rashmitha LED.txt'
Current in mA
Voltage in V
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-0.5
0
0.5
1
1.5
2
2.5
3

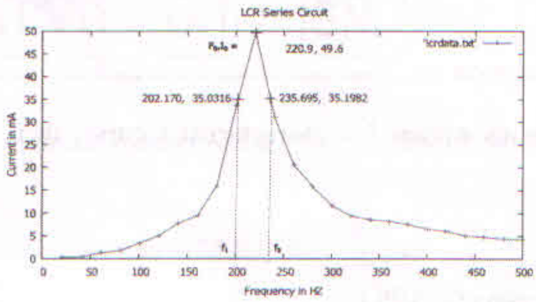
SERIES L-C-R CIRCUIT

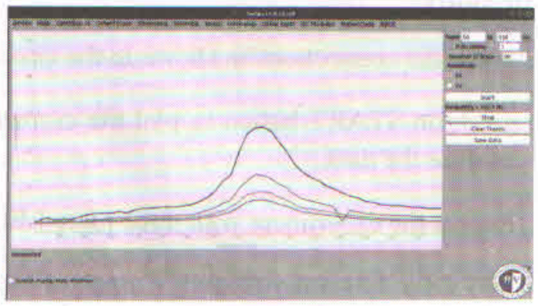
OBSERVATIONS:

Circuit:



Model Graph:





P A S T E T H E D A T A S H E E T S H E R E

Formulae

At resonance $X_L = X_C$,

$X_L = 2\pi f_0 L$; $X_C = 1/2\pi f_0 C$; $L = 1/4\pi^2 f_0^2 C$

I_{max} = 37.94 mA

$I_{rms} = I_{max}/\sqrt{2}$ = 26.79mA

Resonant Frequency f_0 = Hz = 195.856Hz

Lower Cut off frequency f_1 = 188.6Hz

Upper Cut off frequency f_2 = 226.5Hz

Band width $\Delta f = f_2 - f_1$ = 37.86 Hz

Quality Factor $Q = f_0/\Delta f$ = 5.1732

Calculations:

$I_{rms} = \frac{37.94}{1.4142} = 26.79mA$

$C = 4.7\mu F$

$L = \frac{1}{4\pi^2 f_0^2 C} = 1.39H$

Bandwidth = 226.481 − 188.621 = 37.86Hz

Q factor = $\frac{195.856}{37.86}$ = 5.1732

Result:

1.	Resonant frequency of the circuit f_0	195.85 Hz
2.	Self-inductance of the given coil L	1.39 H
3.	Quality factor from graph Q	5.1732
4.	Band width $\Delta f = f_2 - f_1$	37.86 Hz

1/3/23

SERIES L-C-R CIRCUIT

Experiment No: 09 Date: 15/2/23

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

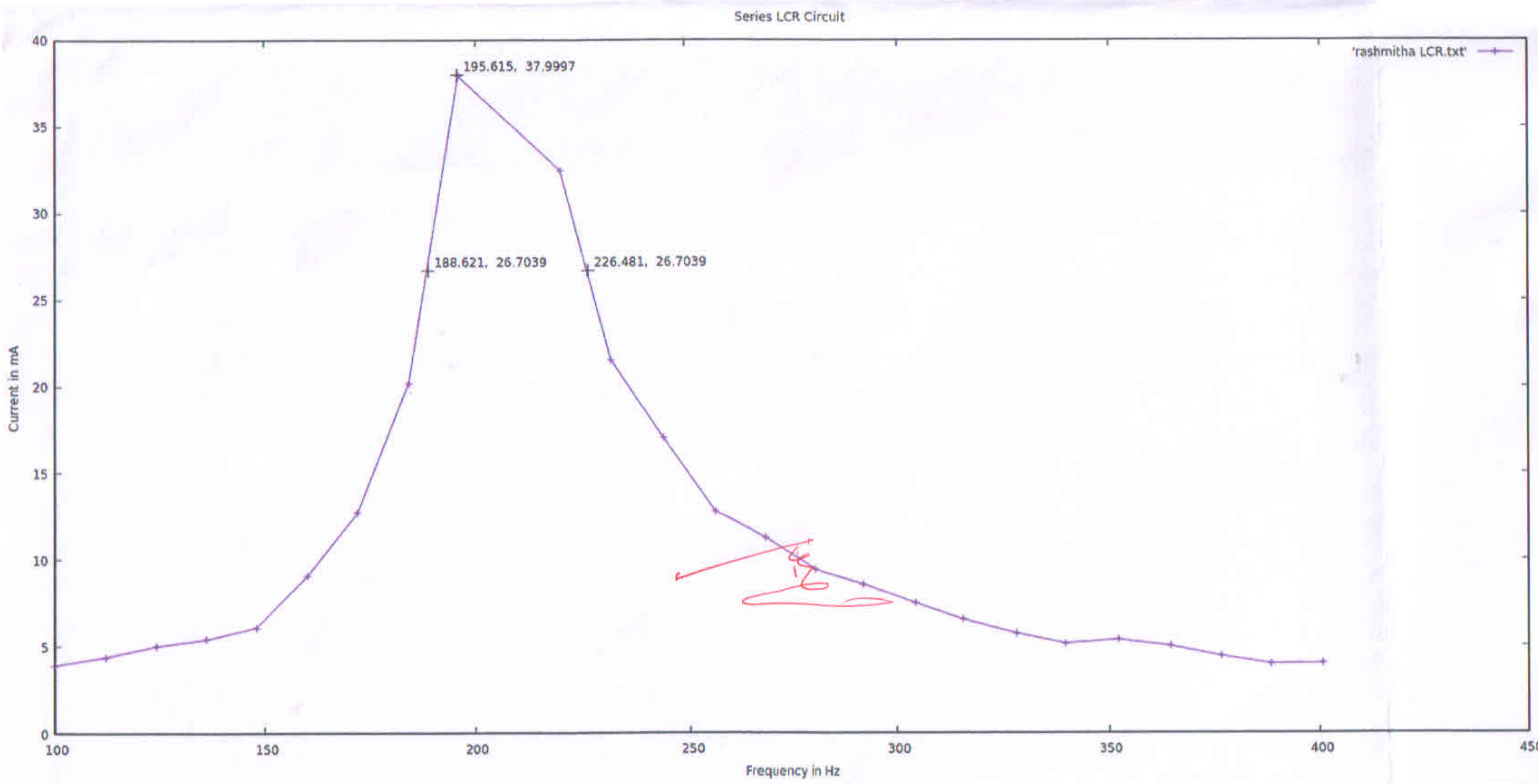
Apparatus: expEYES-17 kit, Resistance box, Capacitor, Inductor

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 df are calculated using the relevant formulae.

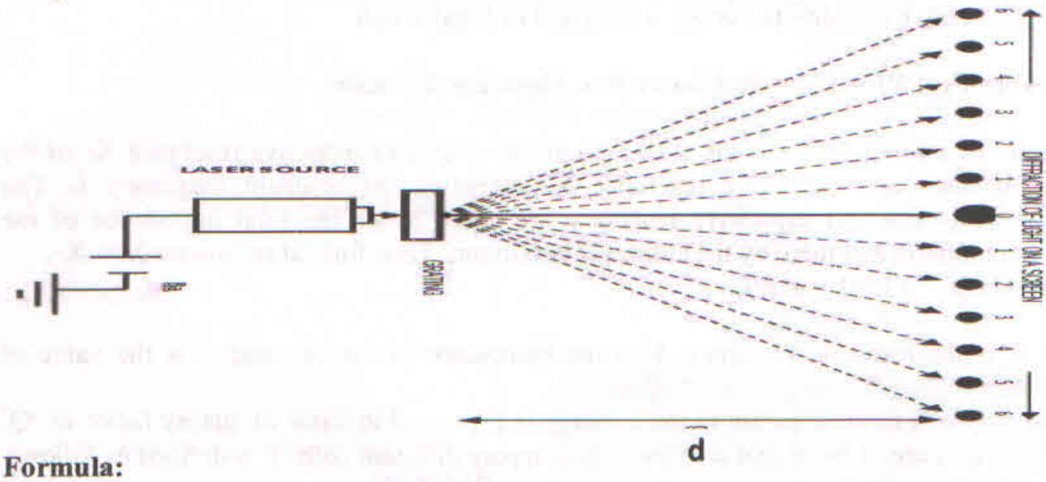

Series LCR Circuit
'rashmitha LCR.txt'
195.615, 37.9997
188.621, 26.7039
226.481, 26.7039
Current in mA
Frequency in Hz
0
5
10
15
20
25
30
35
40
100
150
200
250
300
350
400
450

Paste the data sheets here

LASER DIFFRACTION

OBSERVATIONS:

Diagram:



Formula:

Wavelength of Laser source $\lambda = \frac{C \sin\theta_n}{n}$ 686n m

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

Grating Constant: $C = \frac{1\ \text{inch}}{\text{No. of lines (N) per inch}} = \frac{2.54\times10^{-2}\,m}{500} = 5.08\times10^{-5}\,\text{m}$

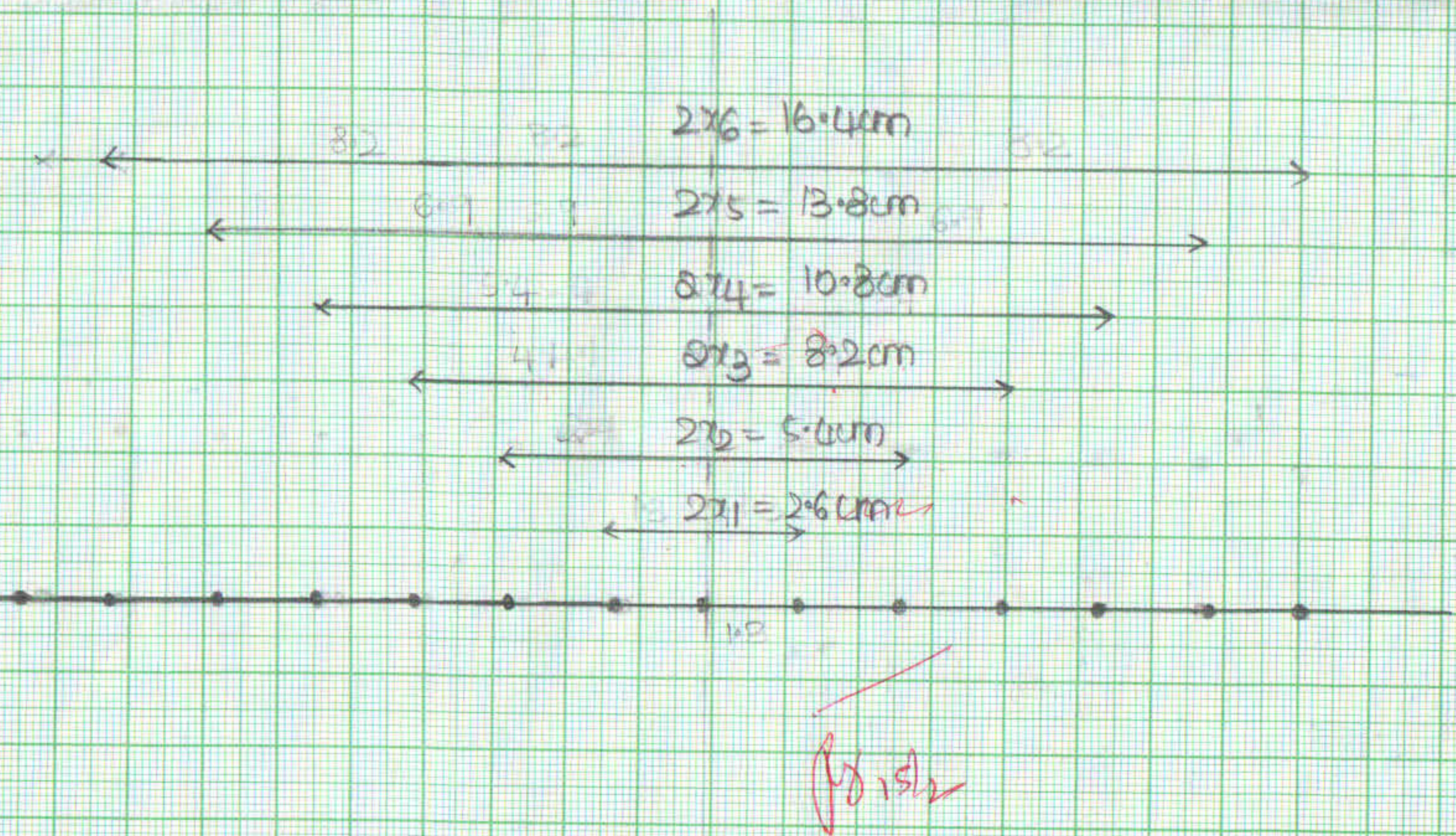
Distance between the grating and the screen, d = 100m cm

Table:

Diffraction order (n)	Distance $2X_n$(cm)	Distance X_n(cm)	Diffraction angle (θ_n) $\theta_n = \tan^{-1}\left(\frac{X_n}{d}\right)$	Wavelength λ (nm) $\lambda = \frac{C \sin\theta_n}{n}$
1.	2·6	1·3	0·7448	660nm
2.	5·4	2·7	1·5466	686nm
3.	8.2	4·1	2·3418	694nm
4.	10.8	5·4	3·091	685nm
5.	13.8	6·9	3·9472	699nm
6.	16·4	8·2	4·6878	692nm

$$\lambda_{avg} = \frac{660 + 686 + 694 + 685 + 699 + 692}{6} = 686\,nm$$

Result: The wavelength of laser light is found to be........686..................nm


2x6 = 16.4cm
2x5 = 13.8cm
2x4 = 10.8cm
2x3 = 8.2cm
2x2 = 5.6cm
2x1 = 2.6cm

LASER DIFFRACTION

Experiment No: 10

Date: 15/2/2023

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, $\lambda = \frac{C \sin\theta_n}{n}$ ……. 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 n^{th} maximum,

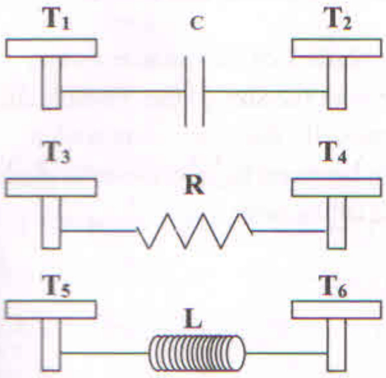
Procedure:

- 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 the origin 'O' at the centre of the graph sheet 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 2^{nd} 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.

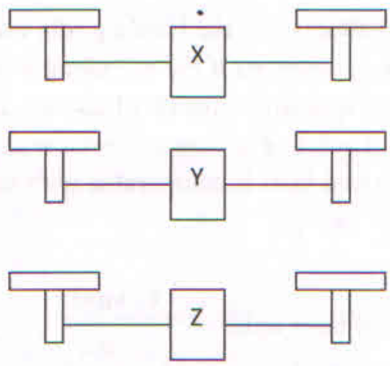
Result: The wavelength of laser light is found to be 686 **nm**

BLACK BOX

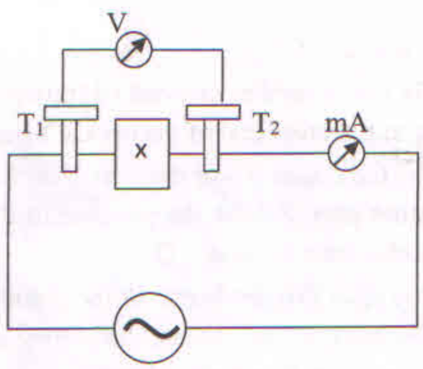
OBSERVATIONS:



One Example



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



Audio Oscillator

Tabular column

TERMINALS T_1 AND T_2

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)
300	9·6	5·8
500	9·3	10
600	9·1	12·1
800	8·9	16·2
1000	8·8	20·2

Terminals T_1 and T_2 correspond to capacitor

The average value of the component is 0·36μF

BLACK BOX

Date: 4/01/2023

Experiment No: 02

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 T_1 and T_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 T_3 and T_4 and then for the terminals T_5 and T_6.
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 $R = \frac{V}{I}\ \Omega$

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 T_3 AND T_4

Frequency (Hz)	Voltage, V (Volts)	Current I (mA)
300	8.6	0.6
500	8.5	0.6
600	8.5	0.6
800	8.4	0.6
1000	8.4	0.6

Terminals $T_3$and T_4 correspond to Resistor.

The average value of the component is 14133 Ω.

TERMINALS T_5 AND T_6

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)
300	7.3	9.4
500	7.3	4.9
600	7.3	3.9
800	7.3	2.7
1000	7.4	2.2

Terminals T_5 and T_6 correspond to Inductor

The average value of the component is 0.49144H.

Formulae

- For resistance: $R = \frac{V}{I}$ (Ω)
- For inductance: $L = \frac{V}{2\pi f I}$ (H)
- For capacitance: $C = \frac{I}{2\pi f V}$ (μF)

where

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

L is the inductance

C is the capacitance
R is the resistance

f is the frequency of applied signal

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OBSERVATION / DATA SHEET

Date 4/01/2023 Name Rashmitha Rani B.N

Dept./Lab Class Expt./No. 02

Title Black box

Calculation:-

for capacitor $C = \frac{I}{2\pi f V}$

trial 1 :- $\frac{5.8\times10^{-3}}{9.6\times2\times3.14\times300} = 0.3\,\mu F$

trial 2:- $\frac{10\times10^{-3}}{9.3\times2\times3.14\times600} = 0.3\,\mu F$

Illly, similarly

trial 3:- $C_3 = 0.4\,\mu F$

trial 4:- $C_4 = 0.4\,\mu F$

trial 5: $C_5 = 0.4\,\mu F$

average value $= 0.36\,\mu F$

for resistor

$R = \frac{V}{I}$

trial 1 :- $\frac{8.6}{0.6\times10^{-3}} = 14.33\,k\Omega$

trial 2:- $14.167\,k\Omega$

trial 3:- $14.167\,k\Omega$

trial 4:- $14\,k\Omega$

trial 5:- $14\,k\Omega$

average value :- $14.133\,k\Omega$

for Inductor:- $L = \frac{V}{I 2\pi f}$

trial 1:- $\frac{7.3}{9.4\times10^{-3}\times2\times\pi\times300} = 0.4122\,H$

Signature of
Teacher incharge

trial 2:- $\frac{7.3\times10^3}{4.9\times2\times3.14\times800}$ = 0.4745H

trial 3:- 0.4968H

trial 4:- 0.5382H

trial 5:- 0.5356H

Average Value = 0.4914H

Result:-

1) The component capacitor of value 0.36uF is connected accross T_1 and T_2

2) The component resistor of value 14.133kΩ is connected accross T_3 and T_4

3) The component inductor of value 0.4914H is connected across T_5 and T_6

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

$$C = \frac{1}{2\pi f X_c} = \frac{I}{2\pi f V}\ \mu\text{F},$$ 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

$$L = \frac{1}{2\pi f X_l} = \frac{V}{2\pi f I}$$

Results:

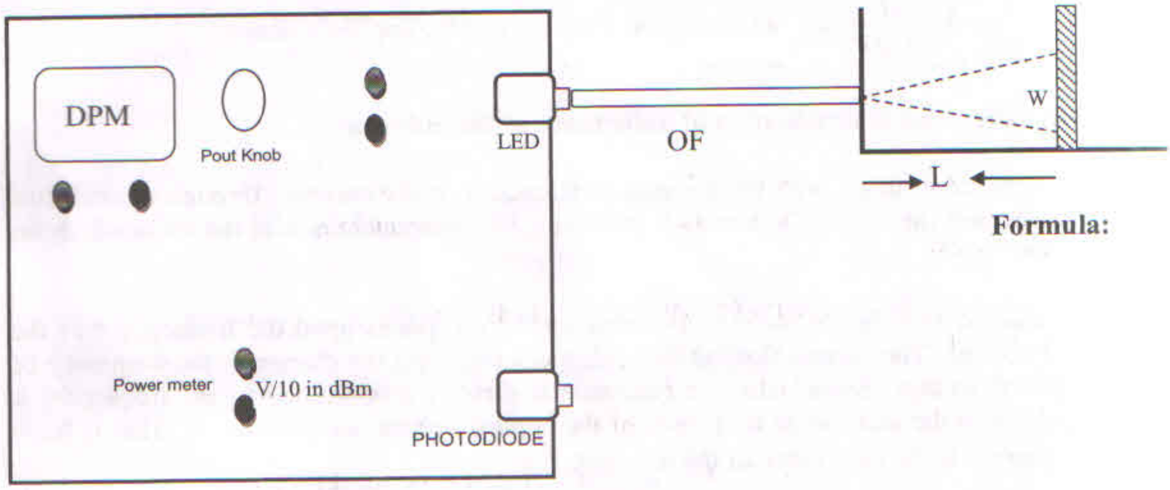
1. The component capacitor of value 0.36µF is connected across terminals T_1 and T_2.
2. The component Resistor of value 14133Ω is connected across terminals T_3 and T_4
3. The component Inductor of value 8.498H is connected across terminals T_5 and T_6

31/1/23

NUMERICAL APERTURE AND ATTENUATION COEFFICIENT OF AN OPTICAL FIBER

OBSERVATIONS:

Diagram: Experimental Setup:
Part A: Numerical aperture measurement

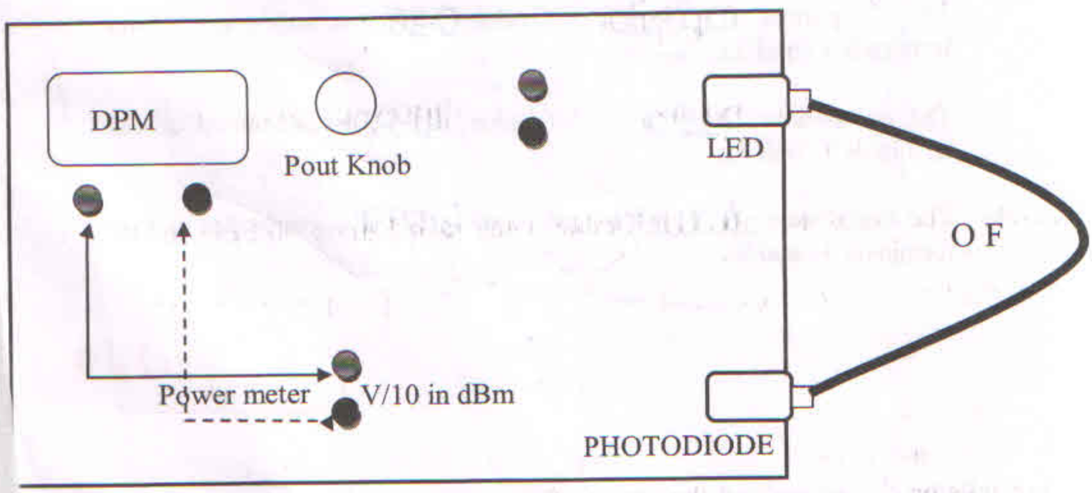


Formula:

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



NUMERICAL APERTURE AND ATTENUATION COEFFICIENT OF AN OPTICAL FIBER

Experiment No: 01

Date: 4|01|2023

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.

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

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

Where, W→ diameter of the beam spot, L→ 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.

Paste the data sheets here

Table A:

Sl. No	W_1 (mm)	W_2 (mm)	W= $(W_1+W_2)/2$	L(mm)	Numerical aperture(NA)	Acceptance angle, $\theta = \sin^{-1}(NA)$ in degree
1.	12	12	12	8	0·6	36·869°
2.	16	16	16	12	0·554	33·641°
3.	22	20	21	16	0·548	33·229°
4.	26	26	26	20	0·545	33·025°

Table B:

Length (m)	(A) Attenuation in dB	Length (m)	(B) Attenuation in dB	(B-A) Attenuation for 4m length in dB
1	+9·54	5	+11·57	2·03

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

$$\alpha = \frac{\text{Attenuation loss}}{\textit{Length}} = \frac{2.03}{4} = 0.5075 \text{ dB/m} = 507.5 \text{ dB/km}$$

CALCULATIONS:

Average value of NA = $\dfrac{0.6+0.554+0.548+0.545}{4} = 0.5$

Average value of $\sin^{-1}(NA) = \dfrac{36.869+33.641+33.229+33.025}{4}$

$= 34.191$

Result:

1.	The numerical aperture of the given optical fibre is	0·562
2.	The acceptance angle θ is	34·191°
3.	The attenuation coefficient of the fibre α	0·5075 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)

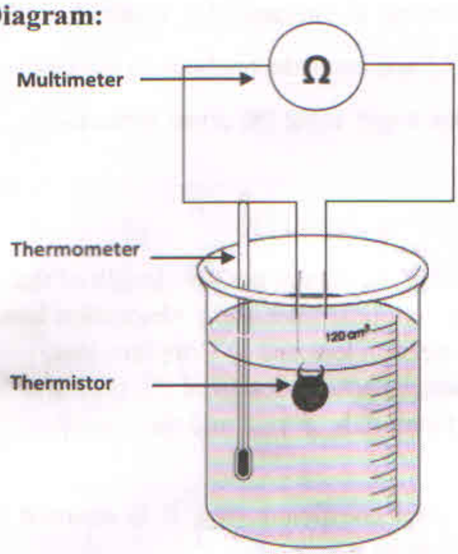
Result:

1.	The numerical aperture of the given optical fibre is	0.562
2.	The acceptance angle θ is	34.191 °
3.	The attenuation coefficient of the fibre α	0.5075 dB/m

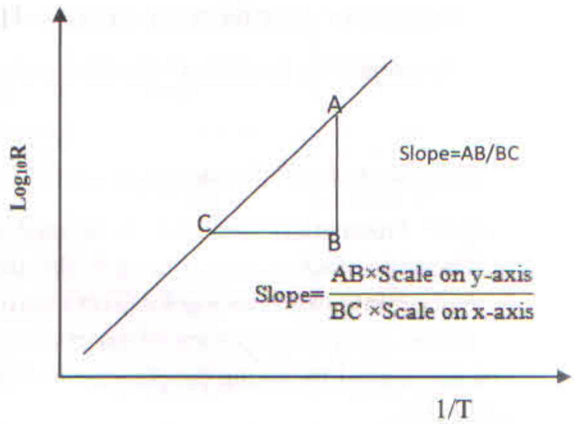
BAND GAP OF A THERMISTOR

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 = 1.381×10^{-23} J/K

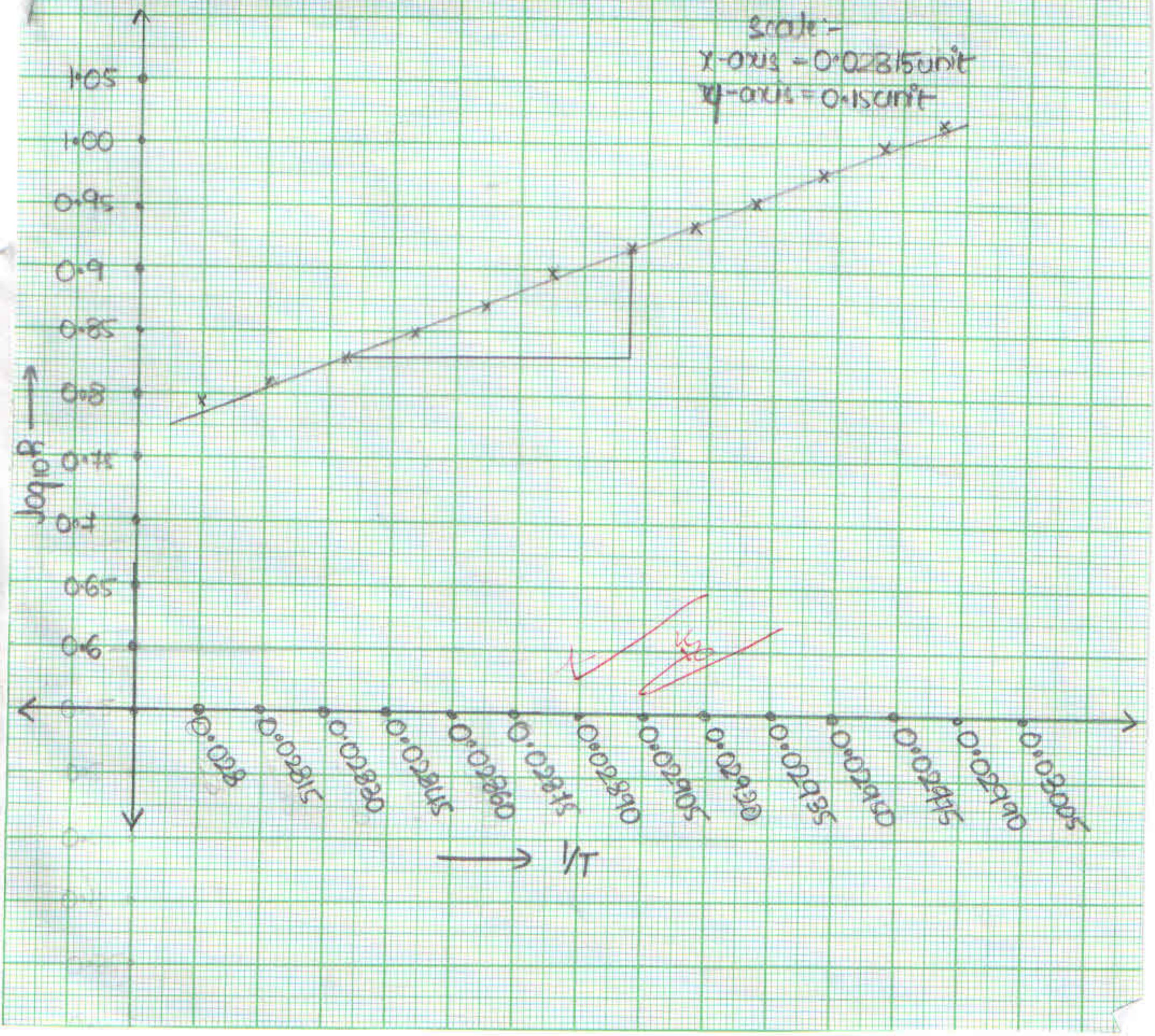
m = Slope of the graph

Table:

Sl. No	Temp t°C	Temp T(K)	R (Ω)	log R	1/T
1.	Room Temp 25·9	298.9	39·7	1·599	0·003345
2.	84	357	6·3	0·7993	0.002801
3.	82	355	6·6	0.8195	0.002816
4.	80	353	6·9	0.8388	0·002833
5.	78	351	7·1	0·8512	0.002849
6.	76	349	7·5	0.8750	0.002865
7.	74	347	8.0	0.9031	0·002881
8·	72	345	8·3	0.9190	0·002898
9·	70	343	8·7	0.9395	0.002915
10·	68	341	9·1	0.9590	0·002932

CALCULATIONS:

Result: The energy gap (band gap) of the given thermistor is 0·493 eV.


Scale:-
X-axis = 0.02815unit
Y-axis = 0.15unit
1.05
1.00
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
log10R
0.028
0.02815
0.02830
0.02845
0.02860
0.02875
0.02890
0.02905
0.02920
0.02935
0.02950
0.02975
0.02990
0.03005
1/T

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

Where, E_g = Energy gap of a given thermistor in eV, k = Boltzmann constant = 1.381×10^{-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.

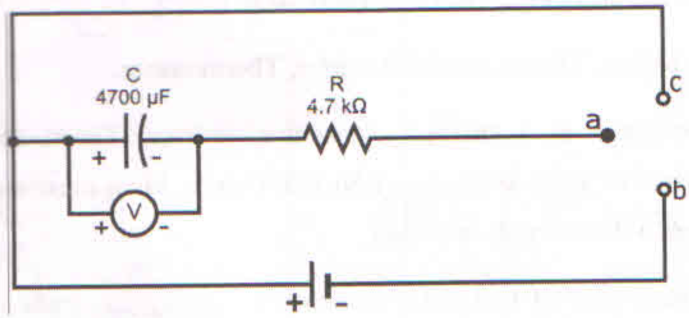
Result: The energy gap (band gap) of the given thermistor is 0.493 eV.

25/1/23

DIELECTRIC CONSTANT

OBSERVATIONS

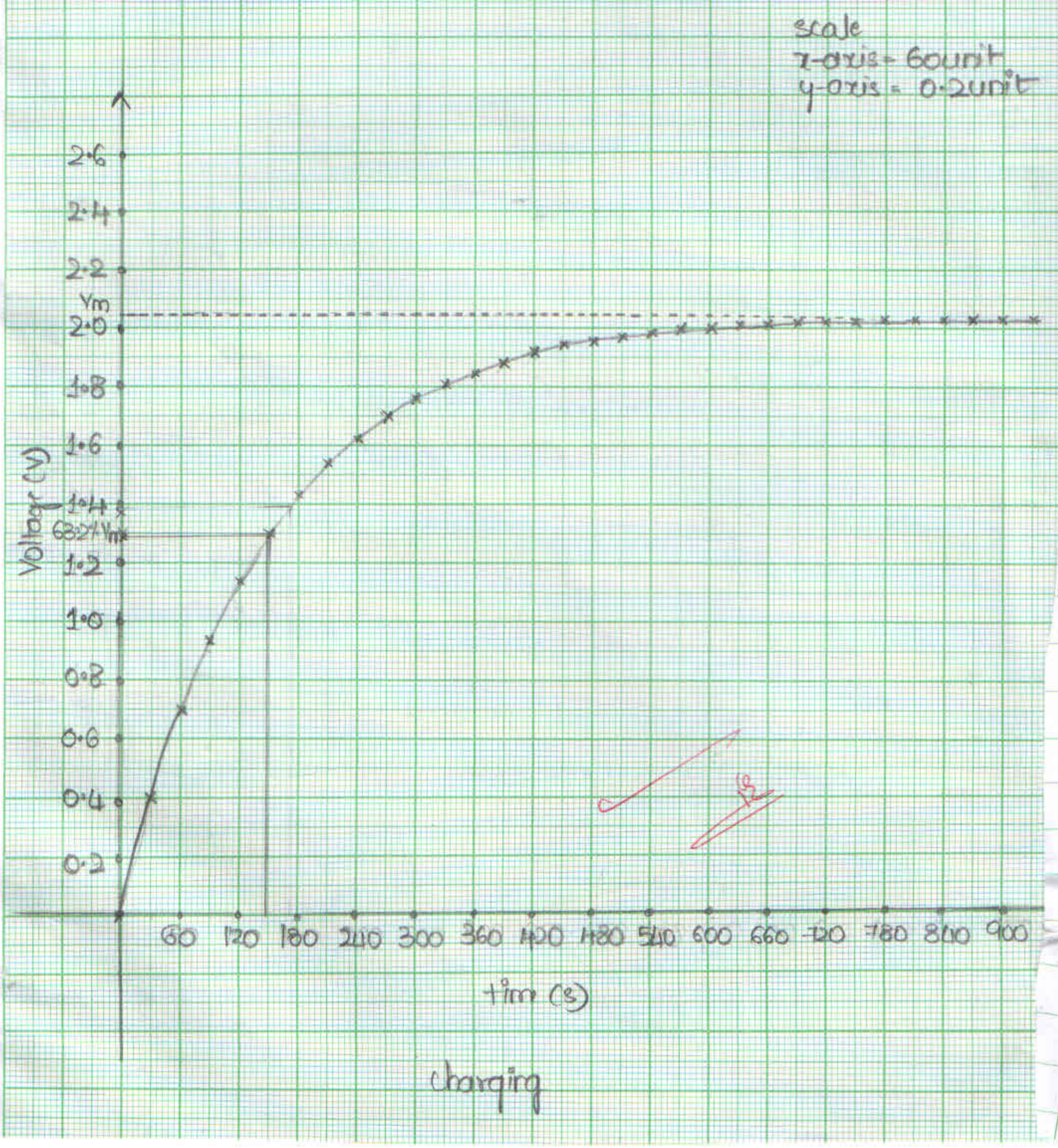
Circuit diagram:

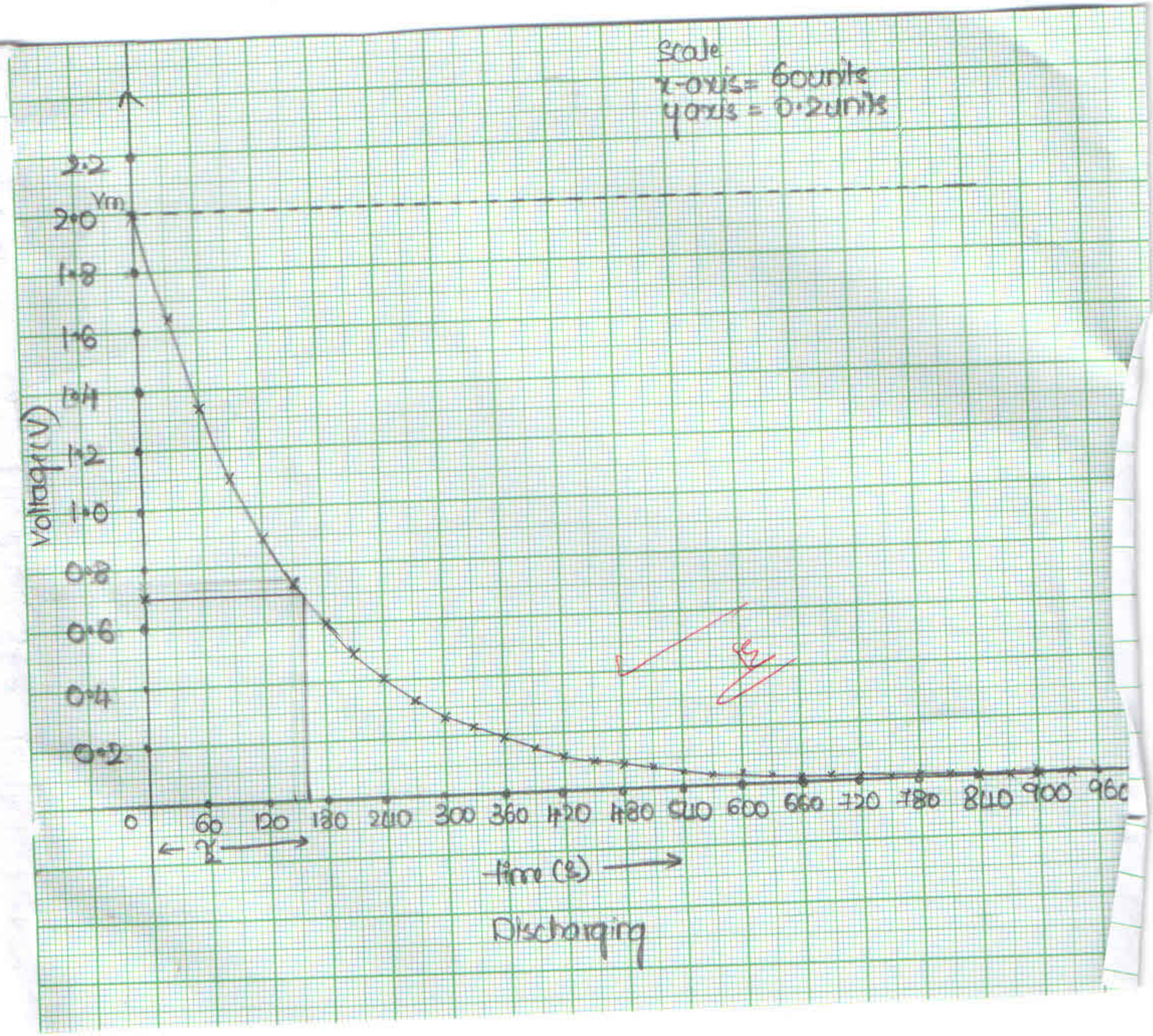


R = 47 KΩ   **Battery voltage=____________Volt**

Time in seconds (s)	Voltage during charging (V)	Voltage during discharging (V)
0	0	2.03
30	0.41	1.64
60	0.7	1.34
90	0.94	1.1
120	1.14	0.9
150	1.3	0.74
180	1.43	0.61
210	1.54	0.50
240	1.62	0.41
270	1.70	0.33
300	1.76	0.27
330	1.81	0.23
360	1.85	0.19
390	1.88	0.15
420	1.93	0.12
450	1.95	0.10
480	1.96	0.08
510	1.98	0.07
540	1.99	0.05
570	2.00	0.04
600	2.00	0.04
630	2.01	0.03
660	2.01	0.02
690	2.01	0.02
720	2.02	0.01
750	2.02	0.01

Paste the data sheets here


scale
x-axis = 60unit
y-axis = 0.2unit
Vm
68.2% Vm
Voltage (V)
time (s)
charging


Scale
x-axis = 60units
y axis = 0.2units
Vm
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Voltage (V)
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
τ
time (s)
Discharging

DIELECTRIC CONSTANT

Experiment No: 04 Date: 10/1/2023

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

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

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)

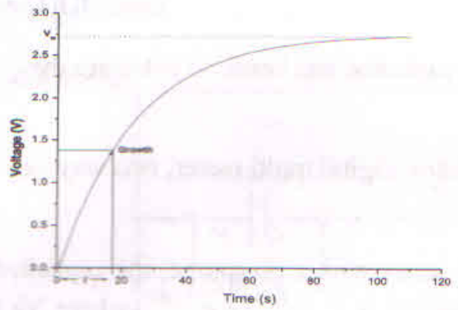
A: area of each plate (m^2).

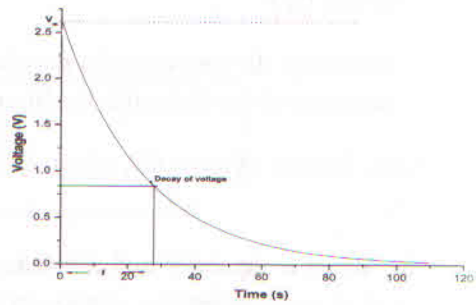
d: thickness of the dielectric (m).

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 $\tau_1 =$ 150 s   Discharging time constant $\tau_2 =$ 162 s

Average time constant $\tau = \frac{\tau_1 + \tau_2}{2} =$ 156 s

Capacitance of the capacitor $C = \frac{\tau}{R}$ = 3319µF

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

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

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)	80µm
Area of each plate A (m^2)	$70.5 \times 10^{-4} m^2$

$A = 4.7cm \times 1.5cm$
$= 70.5 \times 10^{-4} m$

$\varepsilon_r = \frac{Cd}{\varepsilon_o A} = \frac{3319µ \times 80µ}{70.5cm^2 \times 8.854 \times 10^{-12}}$
$= 4.25 \times 10^4$
$= 4.25 \times 10^6$

correction
in error $\rightarrow \times 10^{-6}$
$\varepsilon_r = 4.25 \times 10^6 \times 10^{-6} = 4.25$

Result:
1. Capacity of parallel plate capacitor C = 3319µ F
2. Dielectric constant of the given dielectric material ε_r = 4.25

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:

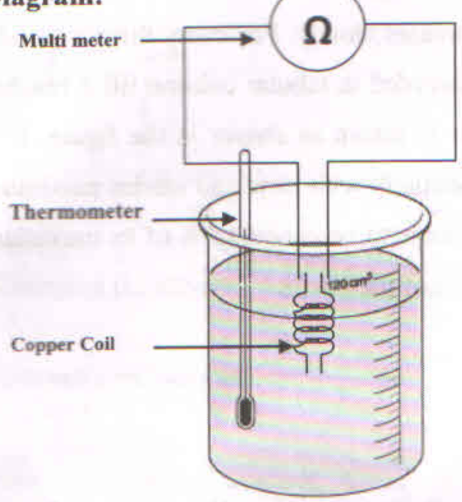
1. Capacity of parallel plate capacitor C = 3319 μ F
2. Dielectric constant of the given dielectric material ε_r = 4.25

25/1/23

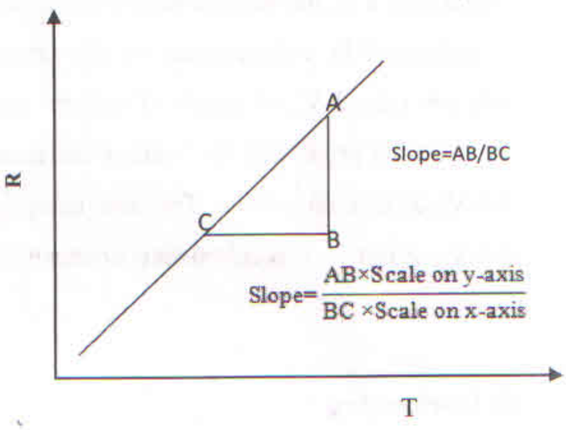
FERMI ENERGY OF COPPER

OBSERVATIONS:

Diagram:



Model Graph:



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Formula:

$$E_F = 1.36\times10^{-15}\sqrt{\frac{\rho A m}{l}}\ \text{J}$$

$$E_F = \frac{1.36\times10^{-15}\sqrt{\frac{\rho A m}{l}}\ \text{J}}{1.6\times10^{-19}C} = ...eV$$

Where
E_F is the Fermi energy (eV)
T is the temperature of the coil in K
A (πr^2) 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.
m is the slope of the straight line.
ρ is the density of copper = 8960 Kg/m^3

Least Square Fit formula:

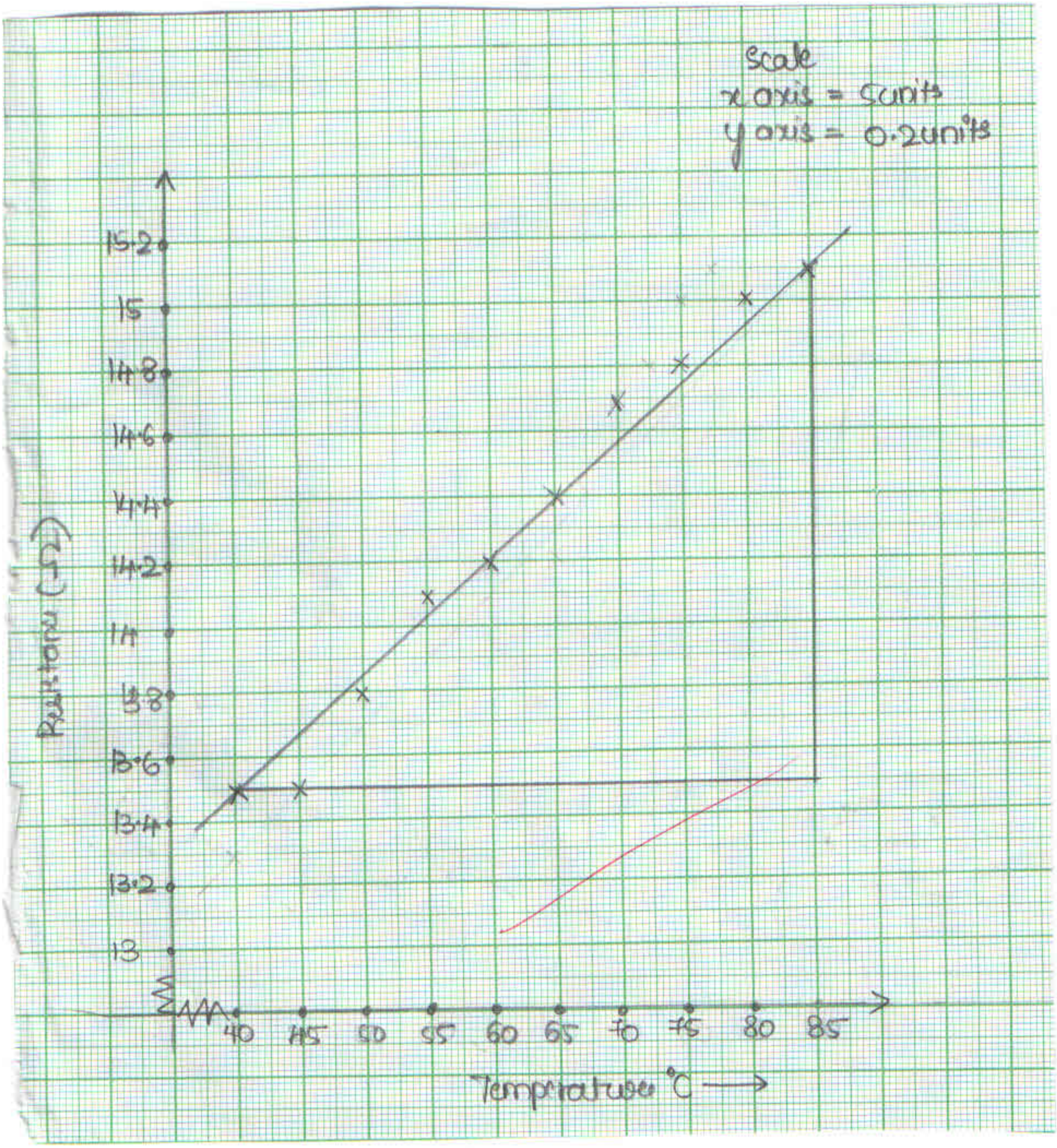
Slope = m = $n(\Sigma xy)-\Sigma_x\Sigma y \,/\, n(\Sigma x^2)(\Sigma x)^2$
Intercept = c = $(\Sigma y)(\Sigma x^2)-(\Sigma x)(\Sigma xy) \,/\, n(\Sigma x^2)-(\Sigma x)^2$

$$m = \frac{10\times9005.5 - 142.9\times625}{10\times41125 - (625)^2}$$

$$= 0.036$$

$$c = \frac{(142.9)(41125) - (625)(9005.5)}{20625}$$

$$= 12.04$$


Scale
x axis = 5units
y axis = 0.2units
15.2
15
14.8
14.6
14.4
14.2
14
13.8
13.6
13.4
13.2
13
40
45
50
55
60
65
70
75
80
85
Resistance (Ω)
Temprature °C

FERMI ENERGY OF COPPER

Experiment No: 05 Date: 25/1/23

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.

$$E_F = 1.36\times10^{-15}\sqrt{\frac{\rho\, A\, m}{l}}\ \text{J}$$

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 = 1.602×10^{-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.

Table:

Sl. No.	Temp ^0C		Temp K	R (Ω)
	Room Temp	25.3	398.3	11.4
1.	85		458	15.1
2.	80		453	15.0
3.	75		448	14.8
4.	70		443	14.7
5.	65		438	14.4
6.	60		433	14.2
7.	55		428	14.1
8.	50		423	13.8
9.	45		418	13.5
10.	40		413	13.5

Sl. No	T (x)	R (y)	x^2	xy
1.	85	15.1	7225	1283.5
2.	80	15.0	6400	1200
3.	75	14.8	5625	1100
4.	70	14.7	4900	1029
5.	65	14.4	4225	936
6.	60	14.2	3600	852
7.	55	14.1	3025	775.5
8.	50	13.8	2500	690
9.	45	13.5	2025	607.5
10.	40	13.5	1600	532
Sums	Σx = 625	Σy = 142.9	Σx^2 = 41125	Σxy = 9005.5

Paste the data sheets here

Sample Points:

x	85	15.1
y	40	13.48

$y = mx + c$

Result: The Fermi energy of copper is E_F = 11.175×10^{-19} J, 6.985 eV

CALCULATIONS:

When $x = 85$

$y = 0.036 \times 85 + 12.04 = 15.1$

When $x = 80$

$y = 0.036 \times 80 + 12.04 = 13.48$

$$m = \frac{18 \times 9005.5 - 142.9 \times 625}{10 \times 41125 - (625)^2}$$

$$= \frac{742.5}{20625} = 0.036$$

$$E_F = 1.36 \times 10^{-15} \sqrt{\frac{8960\,\frac{kg}{m^3} \times 3.14 \times (0.1\,mm)^2 \times 9.1 \times 10^{-31}\,kg}{15\,m}}$$

$$= 1.36 \times 10^{-15} \times \frac{\sqrt{8960 \times 3.14 \times (0.1)^2 \times 10^{-6} \times 9.1 \times 10^{-31}}}{\sqrt{15}}$$

$$= 1.36 \times 10^{-15} \times \sqrt{0.6752 \times 10^{-6}}$$

$$= 1.36 \times 10^{-15} \times 10^{-3} \times 0.8217\ J$$

$$= 11.175 \times 10^{-19}\ J$$

$$= \frac{11.175 \times 10^{-19}}{1.602 \times 10^{-19}}\ eV = 6.9844\ eV$$

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Result: The Fermi energy of copper is E_F = 11.175×10^{-19} J, 6.984 eV