TRANSISTOR CHARACTERISTICS (expEYES-17)

Graph plotting with GNUPLOT

Go to respective folder in which the file is saved.

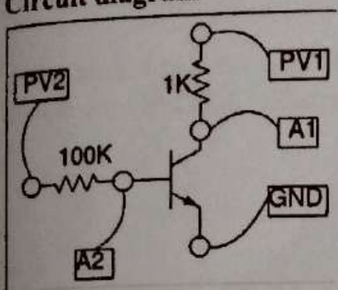
Right click at the empty area and select **'open in terminal'**

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
```

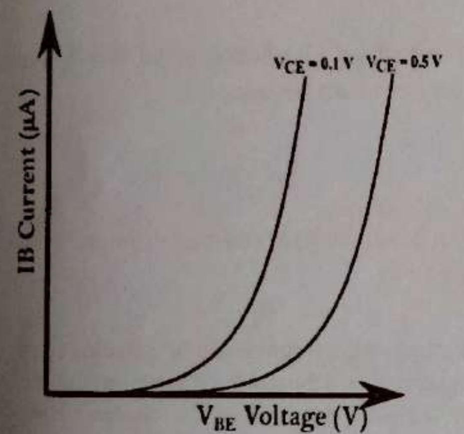
OBSERVATIONS

Circuit diagram

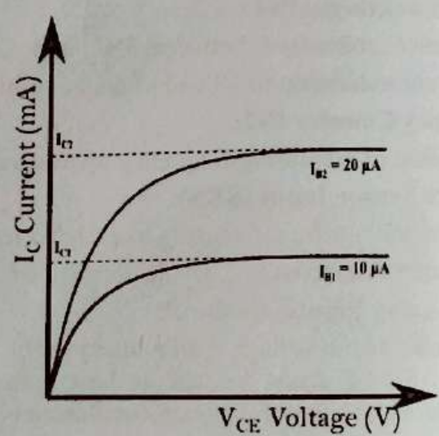


Model Graph

Input characteristics



Output characteristics



Tabular Column $[I_{B_1} = 4.00\,\mu A, I_{B2} = 9.85\,\mu A]$

Input characteristics				Output characteristics			
V_{BE}(V)	I_B(μA)	V_{BE}(V)	I_B(μA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)
0	0.8	0.01	0.78	-0.06	0.06	-0.06	0.06
0.11	0.91	0.21	1.0	0	0.15	0	0.3
0.21	1.01	0.43	1.2	0.05	0.45	0.02	0.53
0.33	1.12	0.59	1.54	0.11	0.69	0.1	1.45
0.43	2.2	0.63	2.33	0.99	0.76	1	1.65
0.45	4.24	0.67	5.25	3.00	0.76	3.01	1.65

Calculations:

To calculate transistor parameters α and β from output characteristics

$$\beta = \left[\frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}}\right]_{V_{CE}} = \frac{(1.65 - 0.76)\times 10^{-3}}{(9.85 - 4)\times 10^{-6}} = 150$$

Using the value of β, $\alpha = \frac{\beta}{\beta + 1} = \frac{150}{151} = 0.993$

Result: Current gain (β) in Common Emitter configuration is 150

Current gain (α) in Common Base configuration is 0.993

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:

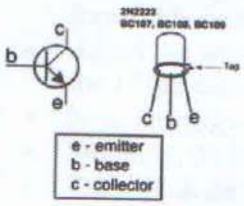
- Make the connections of NPN transistor provided with the kit as shown in the diagram.
- Enter the V_{CE} value as 0.1 volt
- Run the experiment by clicking the Start button.
- Enter the V_{CE} value as 0.5 volt and click on Start button
- save the data values by using the "Save Data" button

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 _____ & ______.

$V_{CE} = 0.1$ V

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OBSERVATION / DATA SHEET

Date 26-03-24 Name Aditya Bhandari

Dept./Lab Physics Lab - 01 Class CD Expt./No. 1

Title Transistor Characteristics

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

Apparatus: Transistor SL100, 1k and 100k Ω resistors, breadboard, connecting wires, ExpEyes Kit.

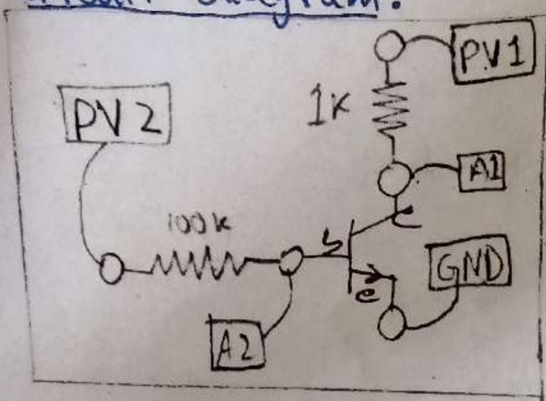
SCHEME OF EVALUATION

Particulars	Max Marks	Marks Obtained	Faculty Sign
Experimental Set up + Vivas	4+6	4+6	sy
Experiment	10	5+4	sy
Substitution & Accuracy	05	9	sy
Total Marks	25	28	sy

Signature of Teacher Incharge

Observations:

Circuit diagram:



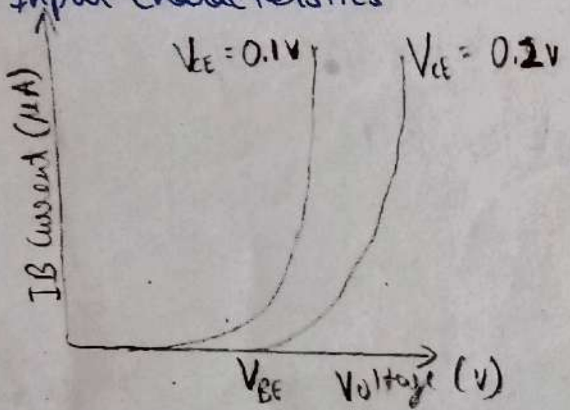
Graph plotting with GNUPLOT:

Open root directory in terminal and

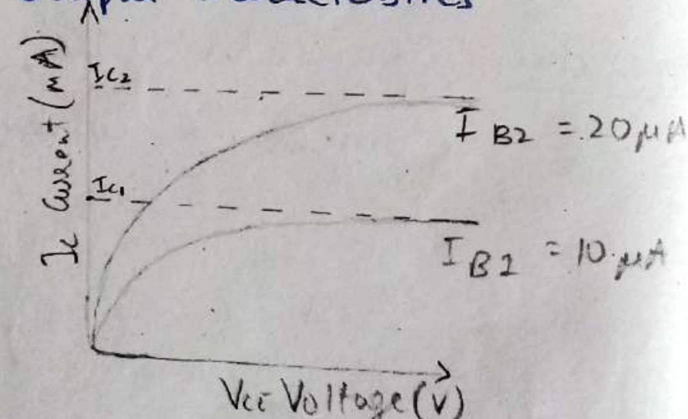
```
gnuplot
set timestamp
set title 'Transistor Characteristics'
set xlabel 'Voltage in Volts'
set ylabel 'Current in A'
plot 'Transistor-input.txt' w lp
plot 'Transistor-output.txt' w lp
```

Model graph:

Input Characteristics



Output characteristics



Tabular Column:

(I_{B1} = 4.00 μA) (I_{B2} = 9.85 μA)

Input Characteristics				Output Characteristics			
V_{BE} (V)	I_B (μA)	V_{BE} (V)	I_B (μA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (m
0	0.8	0.01	0.78	-0.06	0.06	-0.06	0.0
0.11	0.91	0.21	1.0	0	0.15	0	0.3
0.21	1.01	0.43	1.2	0.05	0.45	0.02	0.5
0.33	1.12	0.59	1.54	0.11	0.69	0.1	1.
0.43	2.2	0.63	2.33	0.99	0.76	1	1.6
0.45	4.24	0.67	5.25	3.00	0.76 $\Rightarrow I_{C_1}$	3.01	1.6

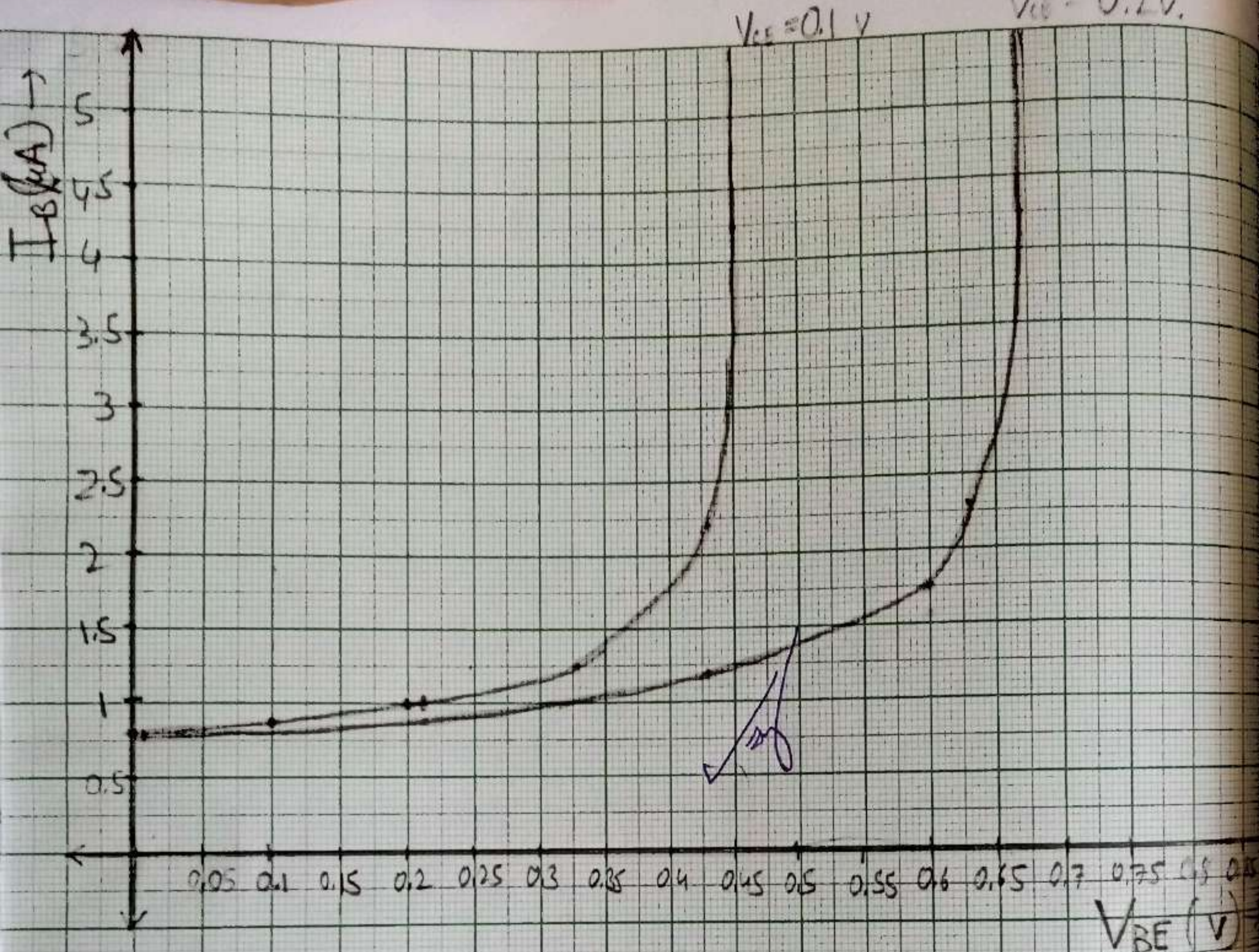
Calculations:

$$\beta = \left[\frac{I_{C2}-I_{C1}}{I_{B2}-I_{B1}}\right]_{V_{CE}} = \frac{\frac{1.65-0.76}{(9.85-4)}\times 1000}{} = \underline{150} \Rightarrow \alpha = \frac{\beta}{\beta+1} = \frac{150}{151} = \underline{0.993}$$

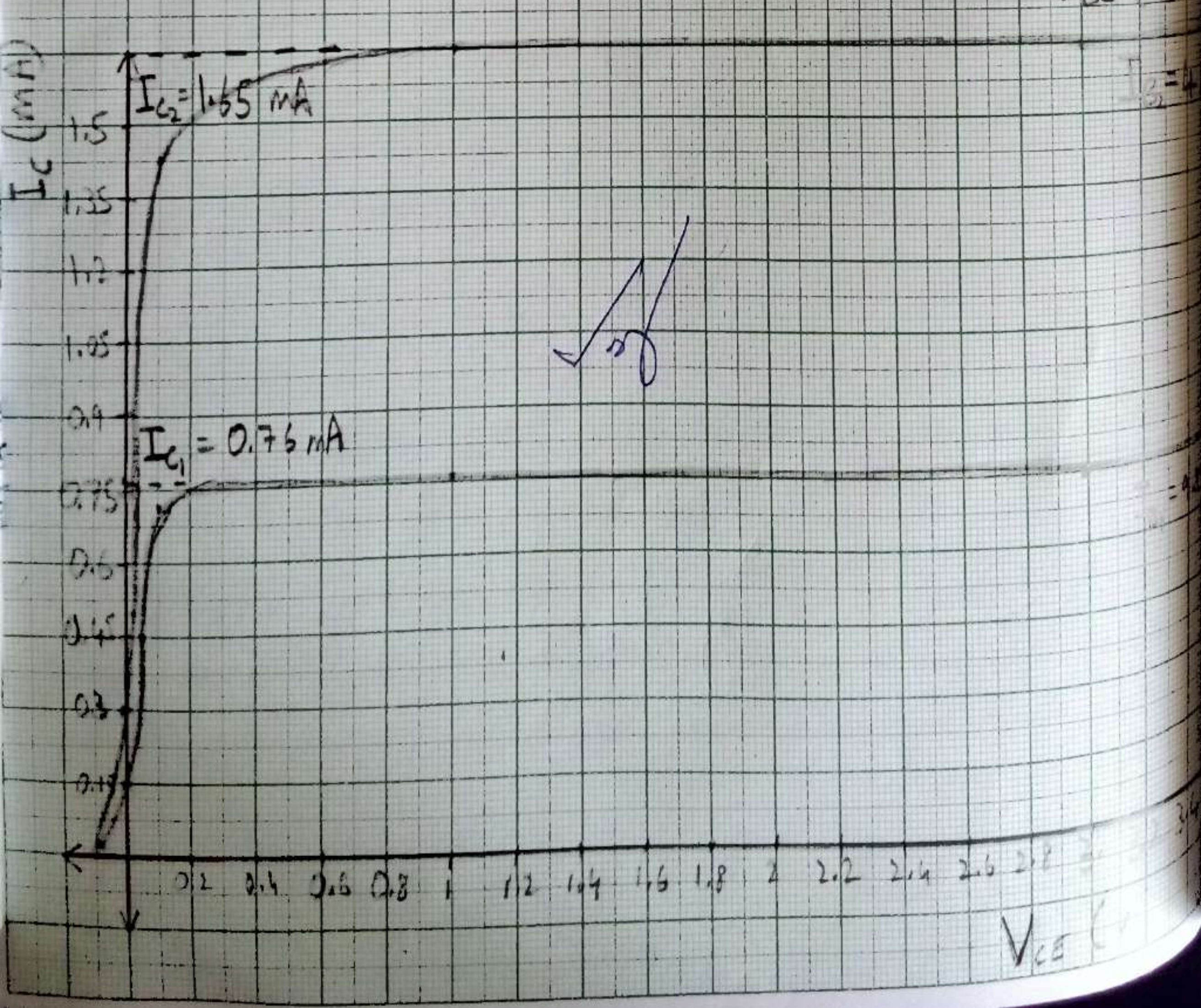
Result:

Current gain (β) in Common Emmiter configuration = 150

Current gain (α) in Common Base configuration = 0.993



V_CE = 0.1 V
V_CE = 0.2 V.
I_B (μA)
V_BE (V)



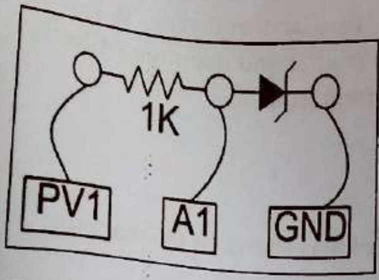
I_C (mA)
I_C2 = 1.55 mA
I_C1 = 0.76 mA
V_CE

ZENER DIODE CHARACTERISTICS

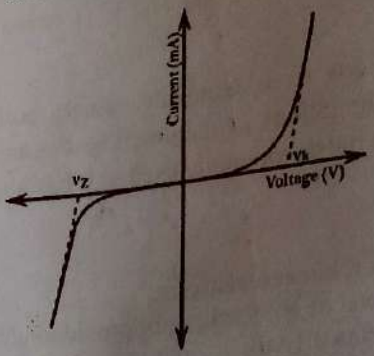
(expEYES-17)

OBSERVATIONS:

Circuit Diagram:



Model Graph:



Forward bias fit:
x-intercept = 0.64
y-intercept = -41.3
Slope = 63.8

Reverse bias fit:
x-intercept = -3.07
y-intercept = 8.86
Slope = 2.88

Calculations:

The forward resistance is calculated by

$$R_f = \frac{\Delta V_f}{\Delta I_f} = \frac{1}{Slope} = \frac{1}{63.8} = 0.015\,\Omega$$

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

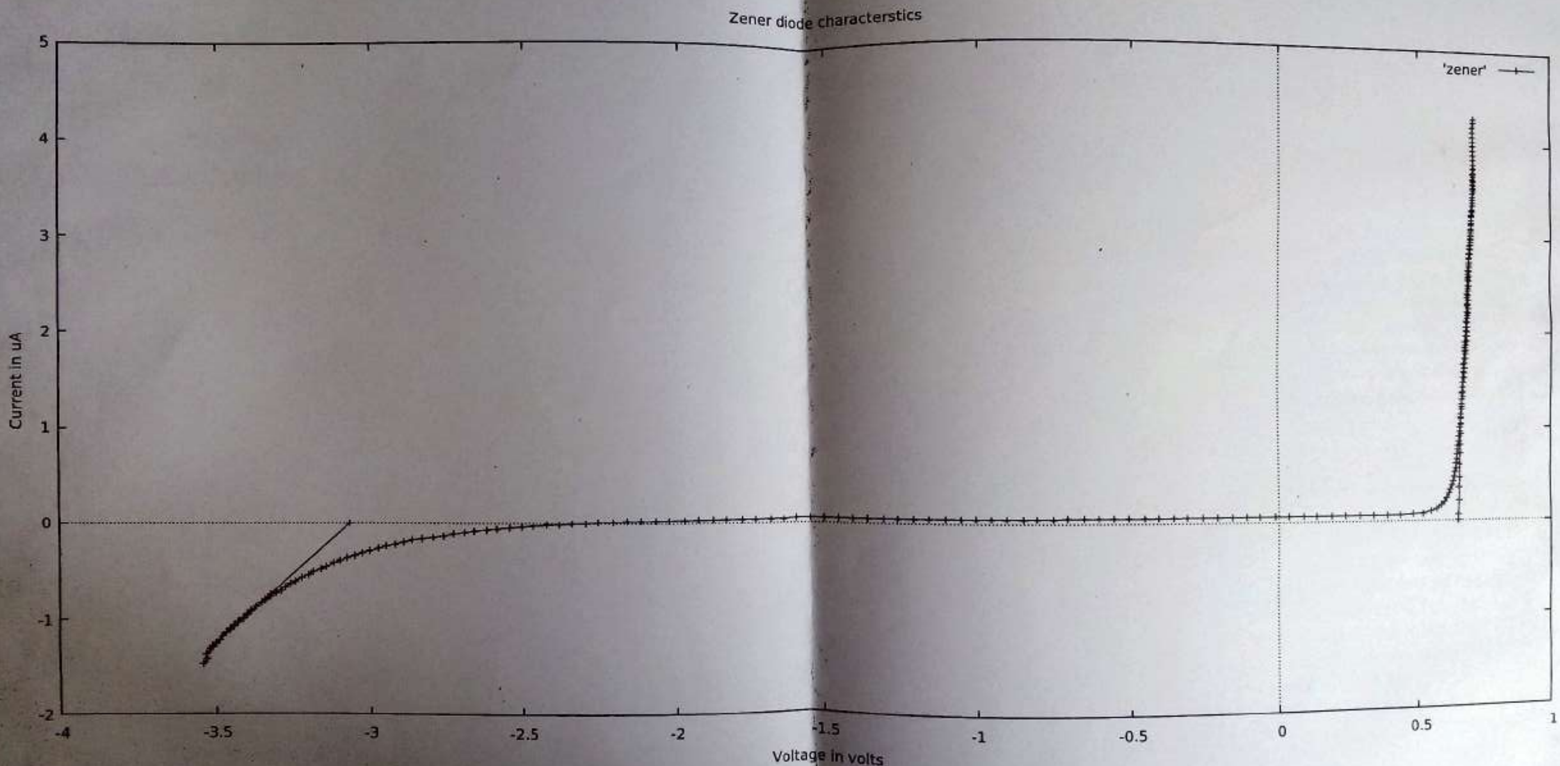
```
set timestamp
set zeroaxis
set title 'Zener Diode Characteristics-Rajesh'
set xlabel 'Voltage in Volts'
set ylabel 'Current in mA'
plot 'zener.txt' w lp
```

Results:

The Knee voltage: 0.64 V

The breakdown voltage: -3.07 V

The forward bias resistance: 0.015 Ω



Thu Mar 28 13:00:14 2024

R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

ate 26-03-24 Name Aditya Bhandari

ept./Lab Physics Lab-1 Class CD Expt./No. 2

le Zener diode characterstics.

m: To study forward and reverse bias characterstics of zener diode and hence to determine forward bias resistance, knee voltage and zener breakdown voltage.

paratus: expEYES-17 hardware, zener diode, resistor, wires

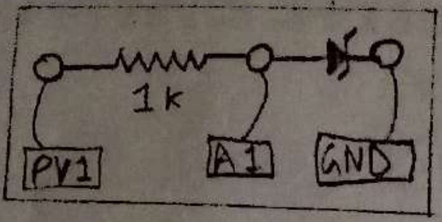
SCHEME OF EVALUATION

Particulars	Max Marks	Marks Obtained	Faculty Signature
Data Sheet + Experimental Set up + Vivas	4+6	4+6	
Conduction of Experiment	10	4+5	
Substitution, Calculation & Accuracy	05.	8	
Total Marks	25	27	

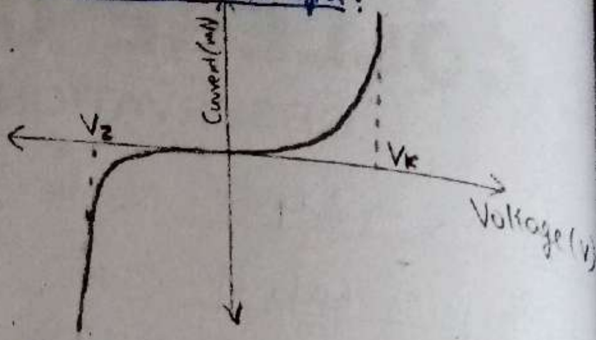
Signature of Teacher Incharge

Observations:

Circuit diagram:



Model Graph:



Forward bias fit:

x-intercept = ~~3.09~~ 0.64

y-intercept = ~~9.27~~ -41.3

Slope = 63.8

Reverse bias fit:

x-intercept = -3.07

y-intercept = 8.86

slope = 2.88

Calculations:

Forward resistance:

$$R_f = \frac{\Delta V_f}{\Delta I_f} = \frac{1}{slope} = \frac{1}{63.8} = 0.015\ \Omega$$

Graph plotting with GNUPLOT:

```
set timestamp
set zeroaxis
set title 'Zener diode characteristics'
set xlabel 'Voltage in volts'
set ylabel 'Current in mA'
plot 'zener.txt' w lp
```

Results:

Knee Voltage = 0.64 V

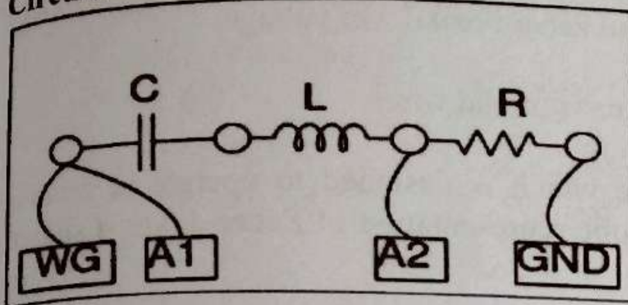
Breakdown Voltage = -3.07 V

forward bias resistance = 0.015 Ω

SERIES L-C-R CIRCUIT

OBSERVATIONS:

Circuit:



Graph plotting with GNUPLOT

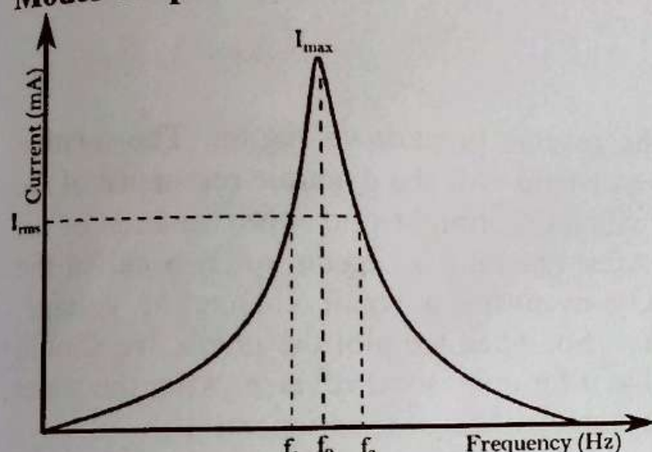
Go to respective folder in which the file is saved. Right click at the empty area, select **'open in terminal'** and Run the following commands:

```
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

Model Graph:



Formulae

I_{max} = 13.16 mA

$I_{rms} = I_{max}/\sqrt{2}$ = 9.30 mA

Resonant Frequency f_0 = 220.75 Hz

Lower Cut off frequency f_1 = 190.36 Hz

Upper Cut off frequency f_2 = 238.00 Hz

Band width $\Delta f = f_2 - f_1$ = 47.64 Hz

Quality Factor $Q = f_0/\Delta f$ = 4.63

Capacitance C = 474 nF

$$L = \frac{1}{4\pi^2 f_0^2 C} = \quad = 1.09 \text{ H}$$

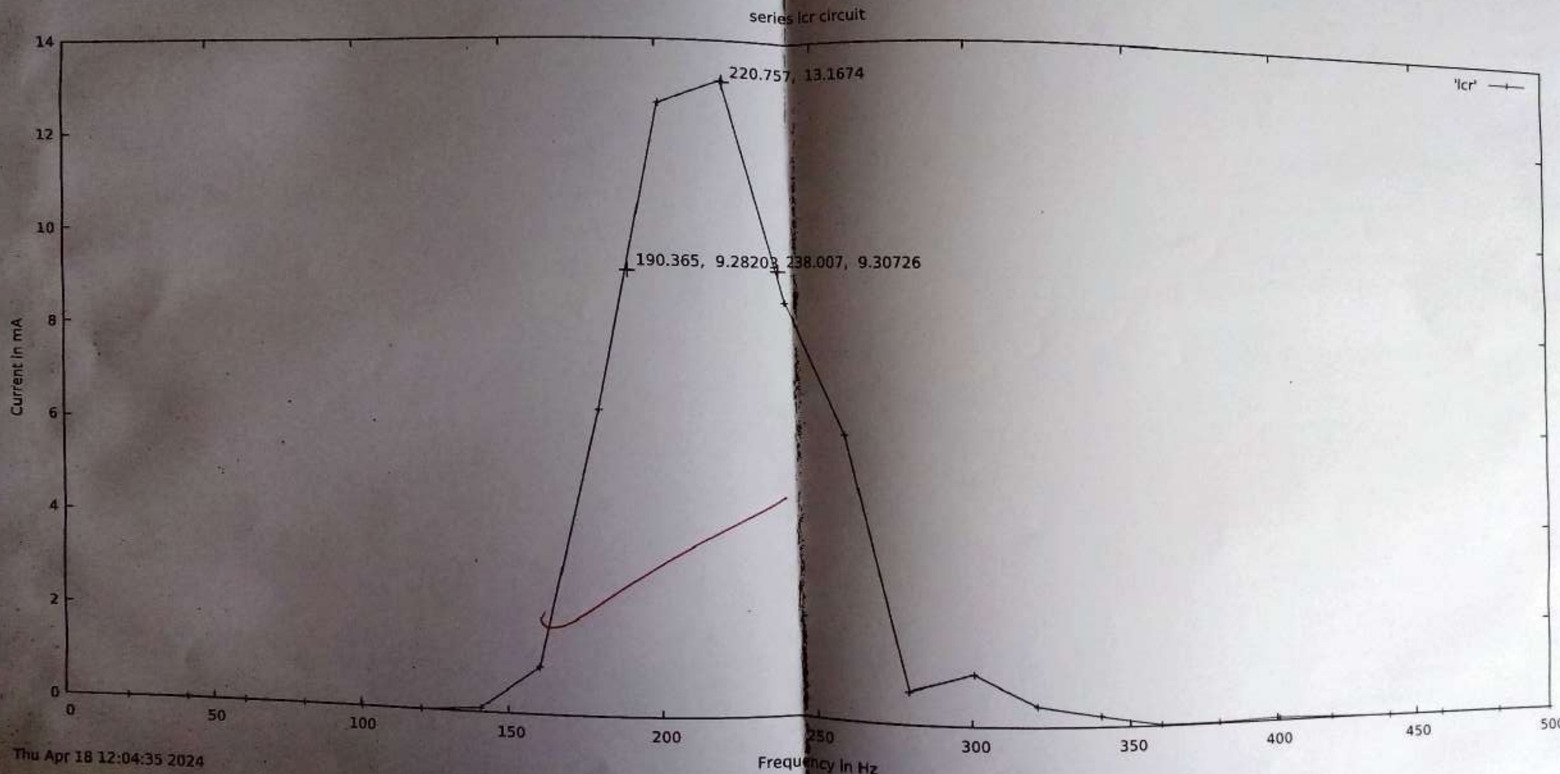
Calculations:

$\Delta f = f_2 - f_1 = 47.64$ $\Rightarrow L = \frac{1}{4\pi^2 f_0^2 C} : 1.09$

$Q = \frac{f_0}{\Delta f} = \frac{22.75}{47.64} \simeq 4.63$

Result:

1.	Resonant frequency of the circuit f_0	220.75	Hz
2.	Self-inductance of the given coil L	1.09	H
3.	Quality factor from graph Q	4.63	
4.	Band width $\Delta f = f_2 - f_1$	47.64	Hz



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R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date 26-03-24 Name Aditya Bhandari

Dept./Lab Physics lab-1 Class CD Expt./No. 3

Title Series LCR circuit

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

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

SCHEME OF EVALUATION

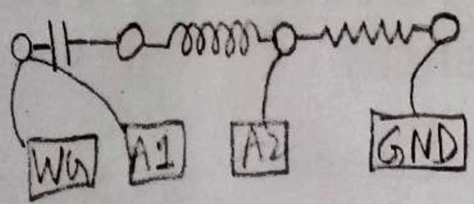
Particulars	Max Marks	Marks Obtained	Faculty Signature
Data Sheet + Experimental Set up + Vivas	4+6	4+6	
Conduction of Experiment	10	5+4	
Result Calculation & Accuracy	05	10	
Total	25	29	

18/4

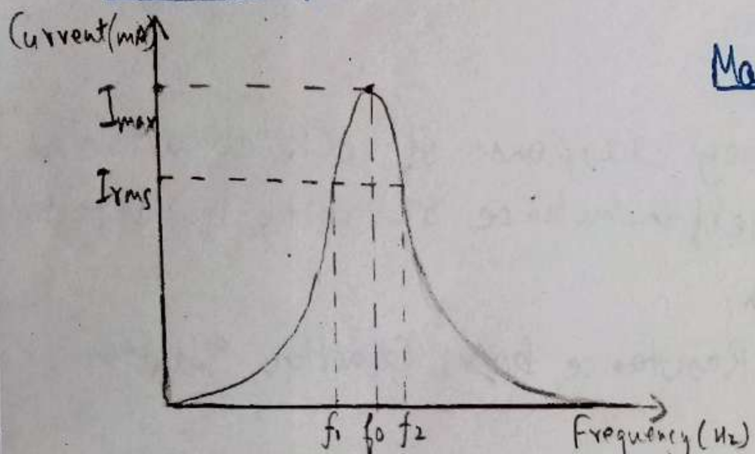
Signature of Teacher Incharge

Observations:

Circuit:



Model Graph:



Formulae:

I_{max} $= 13.16$ mA

$I_{rms} = I_{max}/\sqrt{2}$ $= 9.30$ mA

Resonant frequency, f_0 $= 220.75$ Hz

Lower frequency, f_1 $= 190.36$ Hz

Upper frequency, f_2 $= 238.00$ Hz

Band width, $\Delta f = f_2 - f_1$ $= 47.64$ Hz

Quality factor, Q $= 4.63$

Capacitance, C $= 474$ nF

$$L = \frac{1}{4\pi^2 f_0^2 C} = 1.09 \text{ H}$$

Graph plotting with GNUPLOT:

```
set timestamp
set title 'Series LCR circu
set xlabel 'Frequency in Hz
set ylabel 'Current in mA
plot 'lcr.txt' w Lp
```

Marking points on the gra

- Take cursor to tip of t
- Press scroll button on
- Note down the resona and I max
- Find I rms
- Press the scroll button at I
- (Both at left and right side
- Note down f_1 and f_2
- Export the file as pdf.

Calculations:

$\Delta f = f_2 - f_1 = 47.64$

$Q = \frac{f_0}{\Delta f} = \frac{220.75}{47.64}$

$L = \frac{1}{4 \times (3.14 \times 220.75)^2 \times 47}$

$= \underline{1.09}$

Results:

Resonant frequency, f_0 $=$ 220.75 Hz

Self-inductance of coil, L $=$ 1.09 H

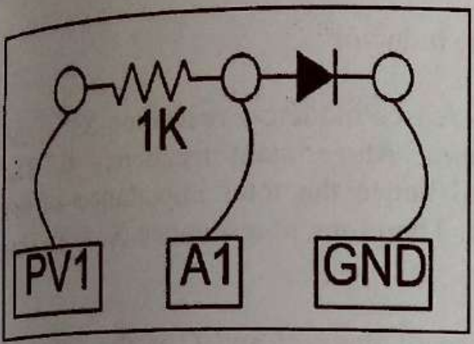
Quality factor, Q $=$ 4.63

Band width, $\Delta f = f_2 - f_1$ $=$ 47.64 Hz

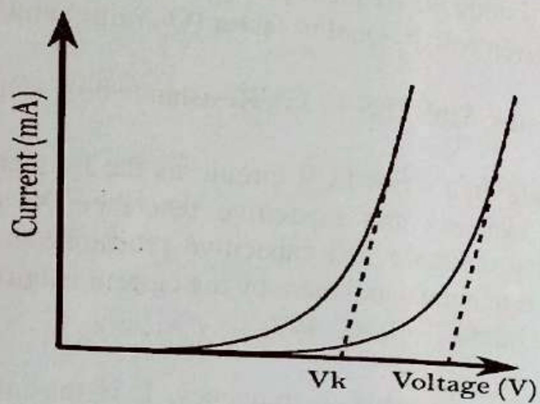
WAVELENGTH OF LED (expEYES-17)

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
Orange	1.76	709
Blue	2.51	494
Green	2.20	564
White	2.54	488

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

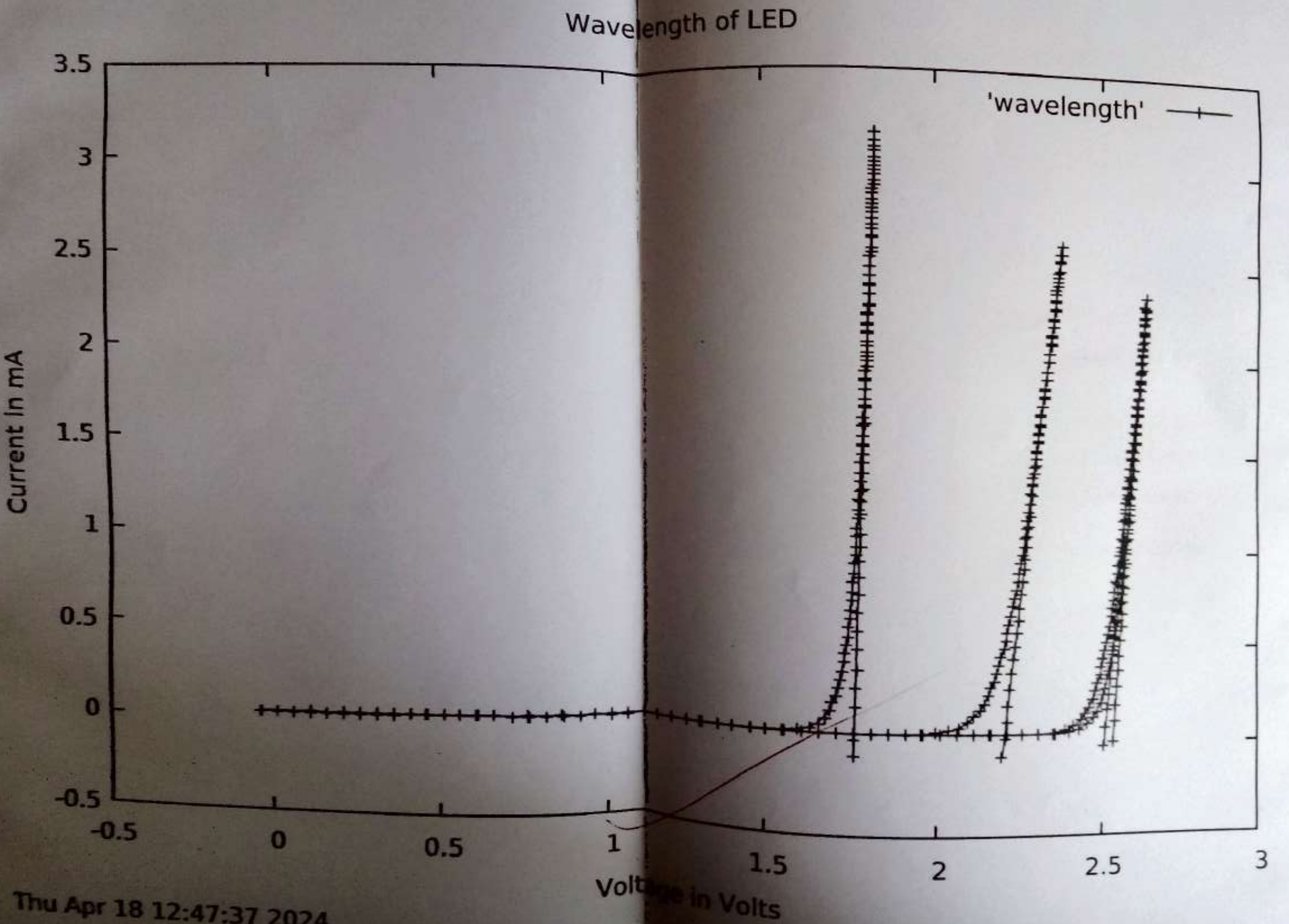
```
gnuplot
set timestamp
set title 'Wavelength of LED-Rajesh'
set xlabel 'Voltage in Volts'
set ylabel 'Current in mA'
plot 'led.txt' w lp
```

Calculations:

$$\lambda = \frac{hc}{e}\left(\frac{1}{V}\right) = \frac{1.24\times10^{-6}}{V}$$

$\Rightarrow \lambda_1 = 709\ nm,\ \lambda_2 = 494\ nm,\ \lambda_3 = 564\ nm,\ \lambda_4 = 488\ nm$

Result: Wavelength of given LED's are determined.



Thu Apr 18 12:47:37 2024

.V. COLLEGE OF ENGINEERING ®

OBSERVATION / DATA SHEET

e ~~Aditya Bhandari~~ 26-03-24 Name Aditya Bhandari

t./Lab Physics Lab - 1 Class CD Expt./No. 4

Wavelength of LED's

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

aratus: expEYES-17 hardware, LED's, 1K Ω resistor, wires.

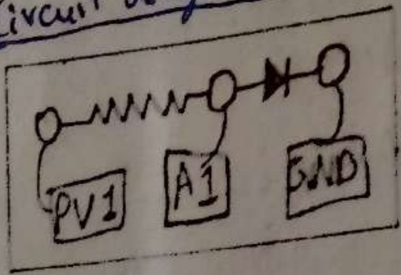
SCHEME OF EVALUATION

Particulars	Max Marks	Marks Obtained	
...t + Experimental Set up + Vivas	4+6	4+6	
...of Experiment	10	5+4	
...calculation & Accuracy	05	10	
	25	29	

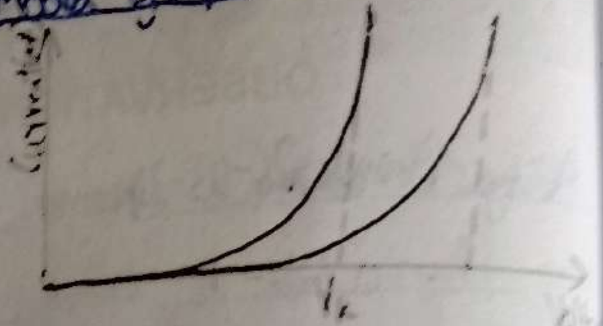
Signature of
Teacher Incharge

Observations:

Circuit diagram:



Model graph:



Formula:

Energy of photons emmitted by LED = $E = \frac{hc}{\lambda} = eV_k$

Wavelength of LED is $\lambda = \frac{hc}{eV_k}$ nm .

Table:

Colour of LED	Knee Voltage, V_k	Wavelength, λ (in n
Orange	1.76	704
Blue	2.51	494
Green	2.20	564
White	2.54	488

Graphplotting with GNUPLOT:

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

Calculations:

$\lambda = \left(\frac{hc}{e}\right)\frac{1}{V}$

$= \frac{1.24\times10^{-6}}{V}$

$\therefore \lambda_1 = \frac{1.24\times10^{-6}}{1.76} =$

$\therefore \lambda_2 = 494$ nm

$\lambda_3 = 564$ nm

$\lambda_4 = 488$ nm

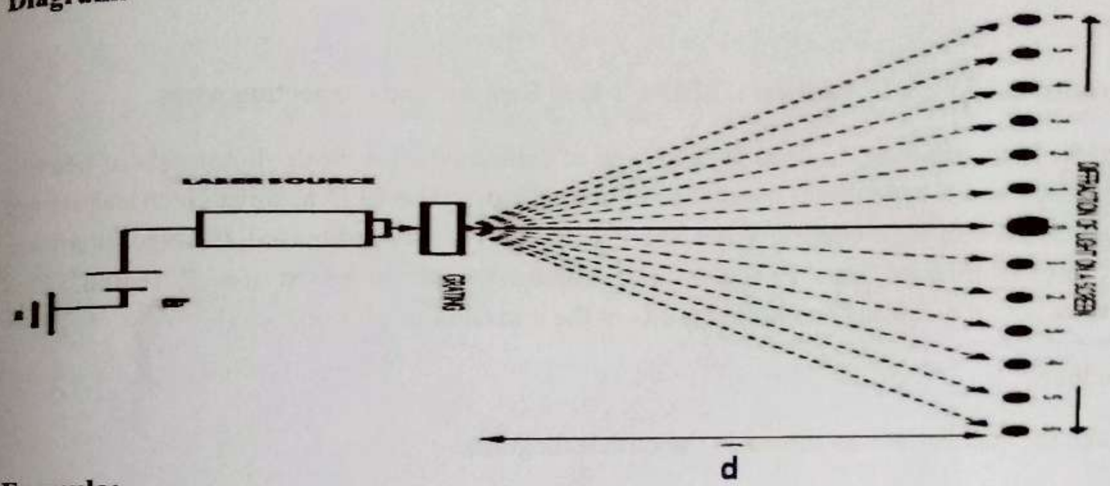
Result:

Wavelength of given LED's are determined.

LASER DIFFRACTION

OBSERVATIONS:

Diagram:



Formula:

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

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

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

Distance between the grating and the screen, d = 64 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.	1.7	0.85	0.76°	673
2.	3.3	1.65	1.47°	651
3.	5.0	2.50	2.23°	658
4.	6.7	3.35	2.99°	662
5.	8.5	4.25	3.79°	752
6.	10.1	5.05	4.51°	745

Calculations:

$\theta_1 = \tan^{-1}(0.85/64) = \underline{0.76°}$, $\lambda_1 = \dfrac{5.08\times10^{-5}\times\sin 0.76°}{1} = \underline{6.73\times10^{-7}}$

$\lambda_{avg} = \dfrac{673+651+658+662+752+745}{6} = \underline{690}$ nm

Result: The wavelength of laser light is found to be.........690.................nm

Experiment No:

LASER DIFFRACTION

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 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 '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 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……………………………nm

R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date 26-03-24 Name Aditya Bhandari

Dept./Lab Physics lab- Class CD Expt./No. 10

Title Laser Diffraction

Aim: To determine the wavelength of a given laser beam.

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

SCHEME OF EVALUAT..N

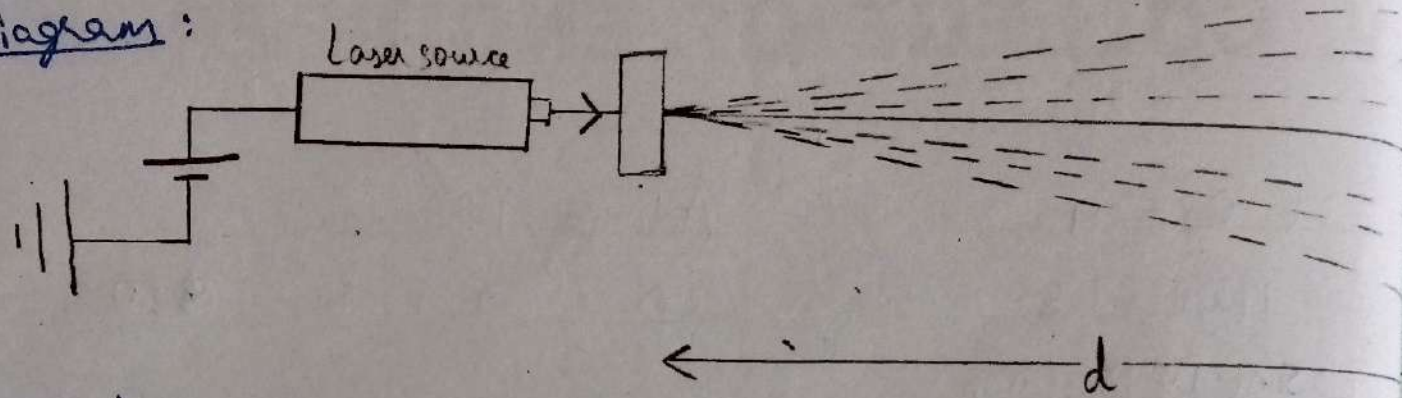
...culars	Max Marks	Marks Obtained	Faculty ...
...a Sheet + Experimental Set up + Vivas	4+6	4 +6	
...duction of Experiment	10	8	
...lution, Calculation & Accuracy	05	9	
...Marks	25	27	

16/5

Signature of Teacher Incharge

Observations :

Diagram :



Formula :

Wavelength of laser source $\lambda = \dfrac{C \cdot \sin\theta_n}{n} = \dfrac{5.08\times10^{-5}\sin\theta_n}{n}$ nm

where C is grating constant, n is order of maximum and θ is angle of diffraction.

Grating constant $c = \dfrac{1 \text{ inch}}{\text{No. of lines per inch}} = \dfrac{2.54\times10^{-2}}{500} = \underline{5.08\times10^{-5}}$ m

Dist between the grating and screen, d = ___64___ cm.

Table :

Diffraction order, (n)	Distance, $2X_n$ (cm)	Distance, X_n (cm.)	Diffraction angle, $\theta_n = \tan^{-1}\left(\frac{X_n}{d}\right)$	Wavelength, $\lambda = \frac{C\cdot\sin\theta_n}{n}$ (nm)
1	1.7	0.85	$0.013^c = 0.76^\circ$	673
2	3.3	1.65	$0.025^c = 1.47^\circ$	651
3	5.0	2.50	$0.039^c = 2.23^\circ$	658
4	6.7	3.35	$0.052^c = 2.99^\circ$	662
5	8.5	4.25	$0.066^c = 3.79^\circ$	752
6	10.1	5.05	$0.078^c = 4.51^\circ$	745

Calculations:

$\theta_1 = \tan^{-1}\left(\frac{0.85}{64}\right) = 0.76^\circ$, $\theta_6 = \tan^{-1}\left(\frac{1.01}{64}\right) = 4.51^\circ$

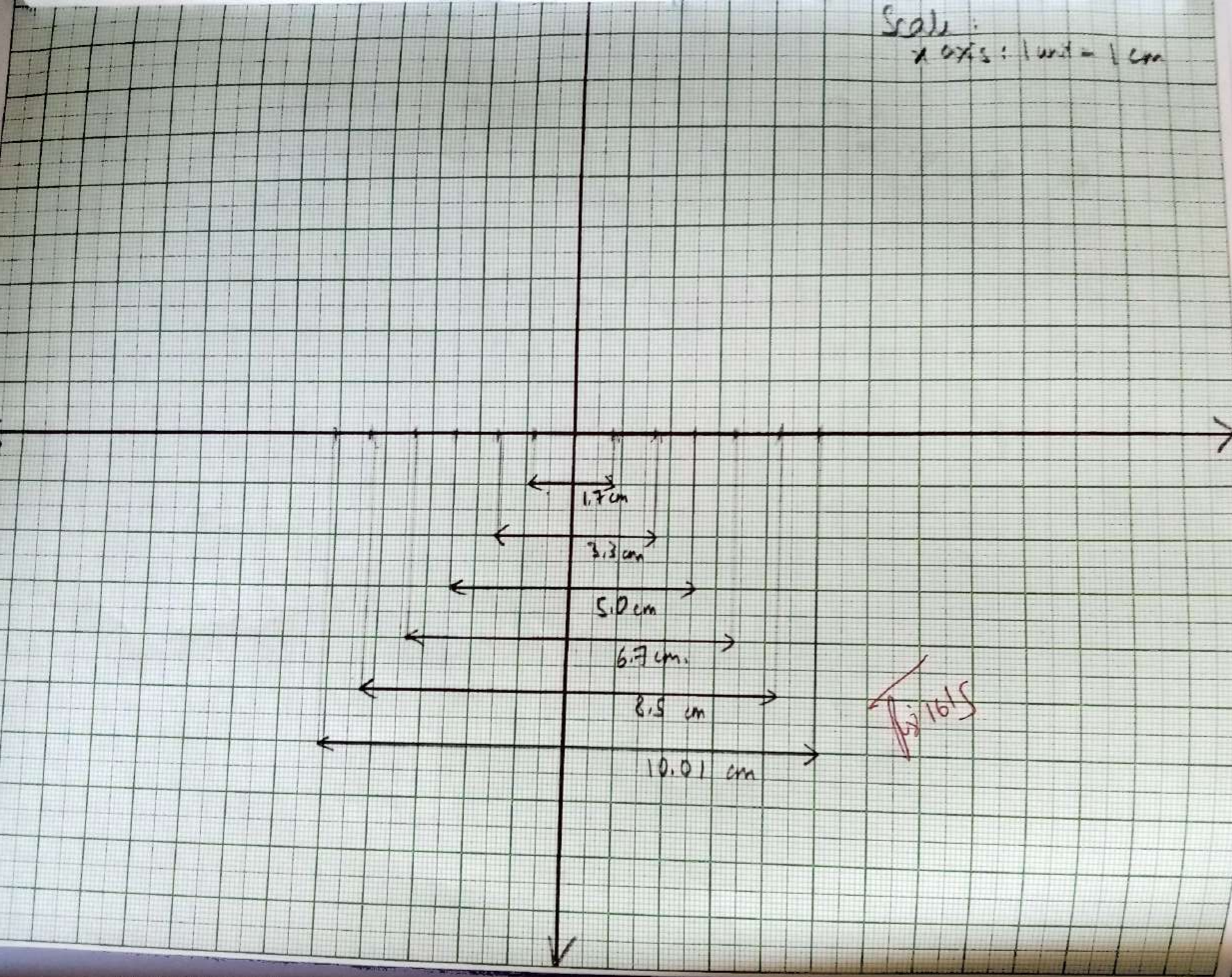
$\lambda_1 = \dfrac{5.08\times10^{-5}\cdot\sin(0.76^\circ)}{1} = 6.73\times10^{-7}$, $\lambda_6 = \dfrac{5.08\times10^{-5}\cdot\sin(4.51^\circ)}{6} = 7.45\times10^{-7}$

$\lambda_{avg} = \dfrac{673+651+658+662+752+745}{6} = \underline{\underline{690}}$

Result :

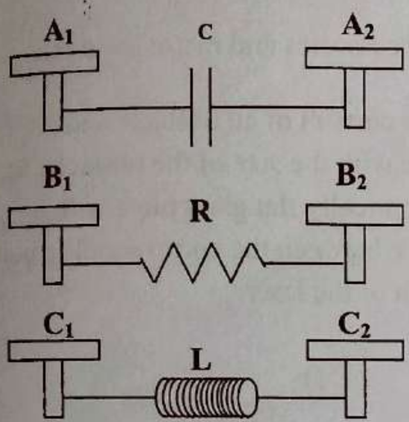
Wavelength is found to be ___690___ nm.

Scale:
x axis: 1 unit = 1 cm

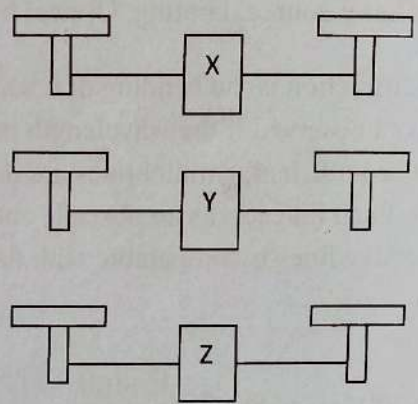


BLACK BOX

OBSERVATIONS:

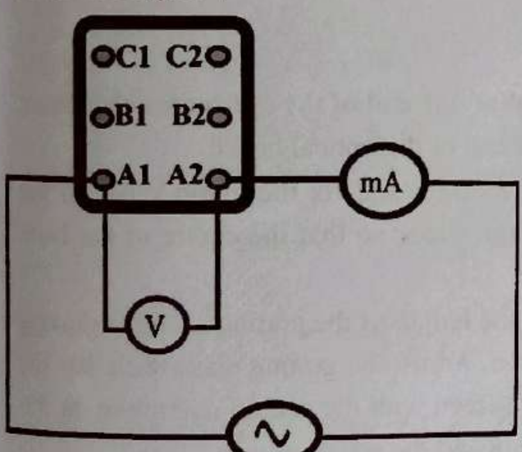


Example



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

Circuit Diagram



Tabular column

TERMINALS A_1 AND A_2

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)	Component value (Ω)
100	6.7	6.7	1000
200	6.7	6.7	1000
300	6.6	6.7	980
400	6.6	6.7	980
500	6.6	6.7	980
600	6.6	6.7	980

Calculations:

$\frac{0.98 \times 4 + 2}{6} = 0.986$, $\frac{6.6}{6.7} = 0.98$

$\frac{0.15 + 0.19 + .20 + .21 + .22 + .21}{6} = 0.2$

Terminals A1 and A2 correspond to Resistor.
The average value of the component is 986 Ω

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

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 B_1 AND B_2

Frequency (Hz)	Voltage, V (Volts)	Current I (mA)	Component value (H)
100	6.8	16.3	0.66
200	7.0	6.1	0.91
300	7.0	4.0	0.92
400	7.0	3.0	0.92
500	6.9	2.3	0.95
600	6.9	1.9	0.96
-	-	-	-

Terminals B1 and B2 correspond to Inductor
The average value of the component is 0.89 H

Calculations:

$$\frac{6.8}{2\pi \times 100 \times 16.3 \times 10^{-3}} = 6.66$$

$$\frac{0.7 \times 10^{-3}}{2\pi \times 1000 \times 7} = 0.15$$

$$\frac{.66 + .91 + .92 + .92 + .95 + .96}{6} = \underline{0.89}$$

TERMINALS C_1 AND C_2

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)	Component value (μF)
100	7.0	0.7	0.15
200	7.0	1.7	0.19
300	7.0	2.7	0.20
400	7.0	3.7	0.21
500	6.9	4.7	0.21
600	6.9	5.7	0.21
-	-	-	-

Terminals C1 and C2 correspond to Capacitor.
The average value of the component is 0.2 μF

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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

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

$$C = \frac{1}{2\pi f X_c} = \frac{I}{2\pi f V}\ \mu F,$$ 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 Resistor of value 986 Ω is connected across terminals A_1 and A_2.
2. The component Inductor of value 0.89H is connected across terminals B_1 and B_2
3. The component Capacitor of value 0.2µF is connected across terminals C_1 and C_2

28/30 915

R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date 27-03-24 Name Aditya Bhandari

Dept./Lab Physics Lab-1 Class CD Expt./No. 6

Title Black box

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

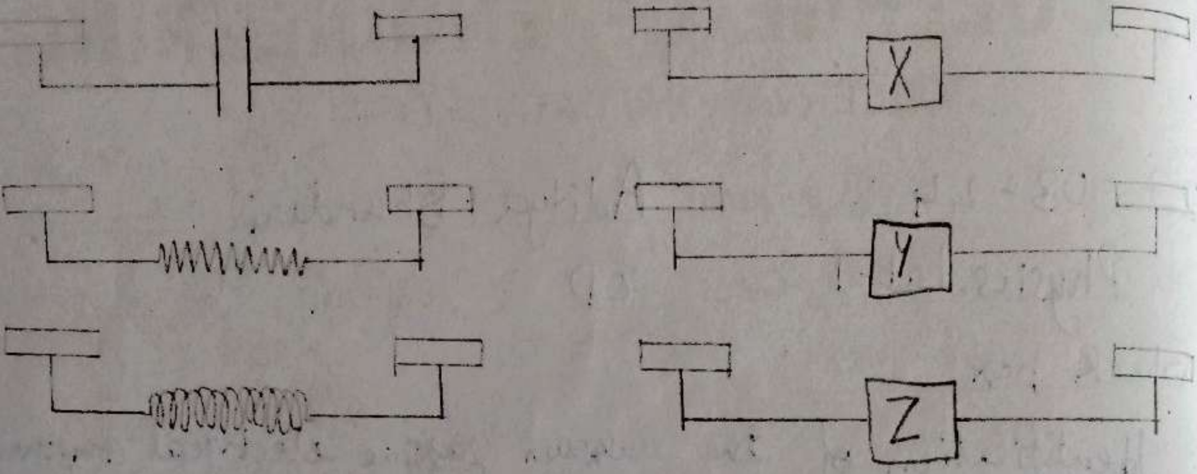
Apparatus: Black box, audio frequency oscillator, ac milliammeter (0-20 mA) and ac voltmeter (digital multimeter in ac mode)

SCHEME OF EVALUATION

...rs	Max Marks	Marks Obtained	
... + Experimental Set up + Vivas	4+6	4+6	10
...n of Experiment	10	9	8
...., Calculation & Accuracy	05	9	8
	25	28	

Signature of Teacher Incharge

Observations :



Circuit diagram:

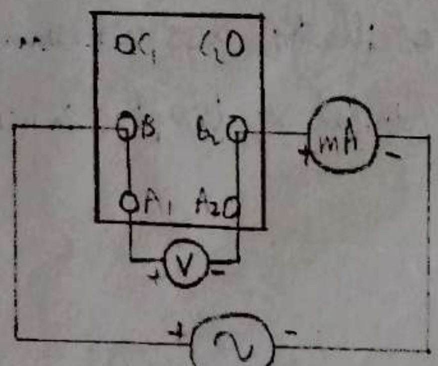


Table:
In terminals A_1 & A_2

Frequency (Hz)	Voltage, V (Volts)	Current, I (mA)	Comp va
100	6.7	6.7	
200	6.7	6.7	
300	6.6	6.7	0
400	6.6	6.7	0
500	6.6	6.7	0
600	6.6	6.7	0

Calculations :

$$\frac{0.98\times4+2}{6} = \underline{\underline{0.986}} \qquad \frac{6.6}{6.7} = \underline{\underline{0.98}}$$

$$\frac{0.15+.19+.20+.21+.21+.21}{6} = \underline{\underline{0.2}}$$

Results:

Terminals A1 & A2 correspond to Resistance

Average value of the component is 0.986 kΩ = 9860 Ω minals B_1 & B_2:

ncy)	Voltage, V (volts)	Current I (mA)	Component value (H)
	6.8	16.3	0.66
	7.0	6.1	0.91
	7.0	4.0	0.92
	7.0	3.0	0.92
	6.9	2.3	0.95
	6.9	1.9	0.96

inals B_1 & B_2 correspond to
uctor

ge value of the component is 0.89 H

Terminals C_1 & C_2:

Frequency (Hz)	Voltage, V (volts)	Current, I (mA)	Component Value (μF)
100	7.0	0.7	0.15
200	7.0	1.7	0.19
300	7.0	2.7	0.20
400	7.0	3.7	0.21
500	6.9	4.7	0.21
600	6.9	5.7	0.21

Terminals C_1 & C_2 correspond to capacitor

Average value of the component is 0.2 μF

pculation:

$$\frac{6.8}{2\pi \times 100 \times 16.3 \times 10^{-3}} = 0.66$$

$$\frac{0.7 \times 10^{-3}}{2\pi \times 100 \times 7} = 0.15$$

$$\frac{.66 + .91 + .92 + .92 + .95 + .96}{6} = 0.89$$

rmulae:

Resistance : $R = \frac{V}{I}$ (Ω)

Inductance : $L = \frac{V}{2\pi f I}$ (H)

Capacitance : $C = \frac{I}{2\pi f V}$ (μF)

ults:

Component Resistor of value 986 Ω is connected across A_1 & A_2

Component Inductor of value 0.89 H is connected across B_1 & B_2

Component Capacitor of value 0.2 μF is connected across C_1 & C_2

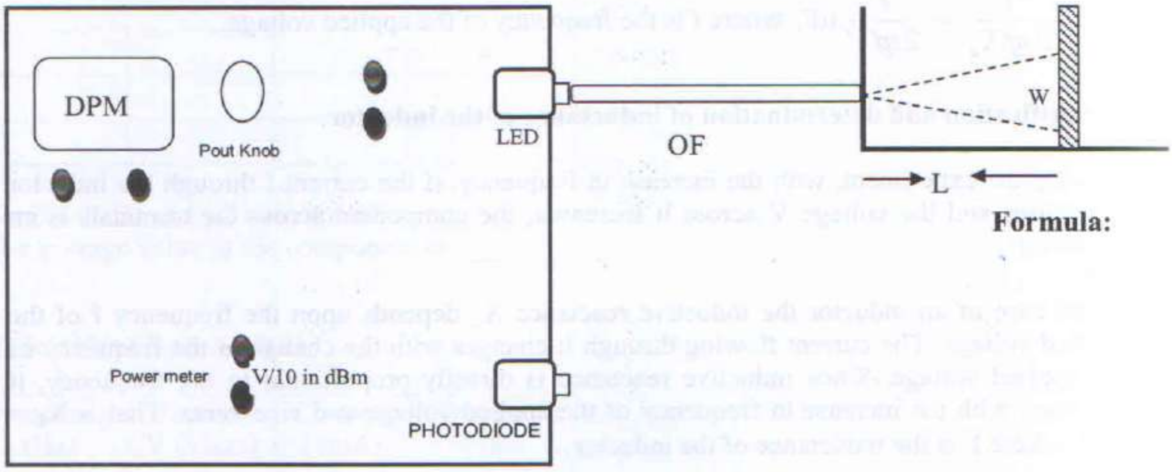
Paste the data sheets here

NUMERICAL APERTURE AND ATTENUATION COEFFICIENT OF AN OPTICAL FIBER

OBSERVATIONS:

Diagram: Experimental Setup:

Part A: Numerical aperture measurement

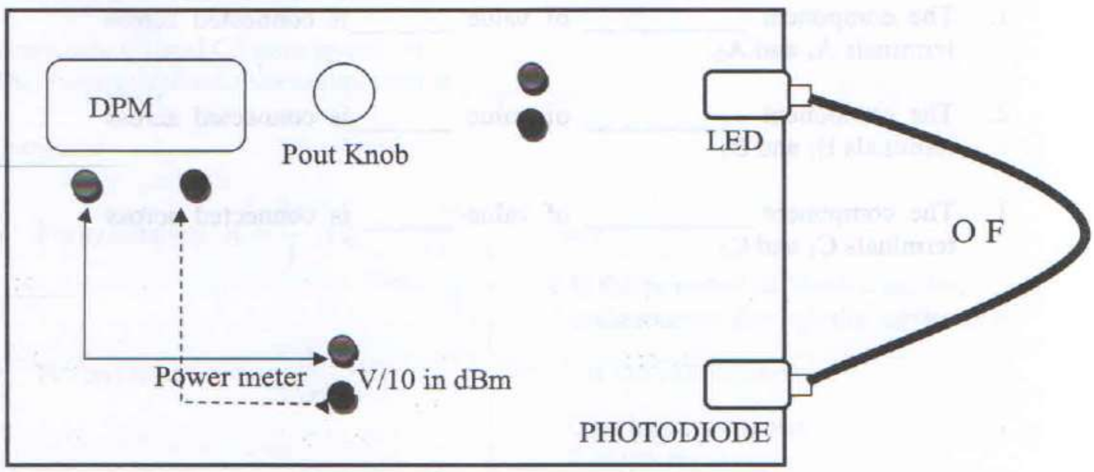


Formula:

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: 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.

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

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

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.

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.	42	22			0.25	13.29
2.	50	24			0.23	14.47
3.	58	26			0.21	12.12
4.	66	30			0.22	12.80

Avg: 0.23 Avg: 13.17

Table B:

Length (m)	(A) Attenuation in ~~dB~~ mW	Length (m)	(B) Attenuation in ~~dB~~ mW	(B-A) Attenuation for 4m length in dB
1	2.16	2	1.97	−0.19

Attenuation coefficient: Attenuation per unit length (α)

$$\alpha = \frac{\text{Attenuation loss}}{Length} = \frac{\cancel{-0.19}}{\cancel{1}} = \cancel{-0.19}\ \cancel{dB}\ mW/m = \cancel{-190}\ \cancel{dB}\ mW/km$$

CALCULATIONS:

$$\alpha = \frac{-10 \log(P_{out}/P_{in})}{L} = \frac{-10 \log\left(\frac{1.97}{2.16}\right)}{1} = 0.399 \approx 0.4\ dB/m$$

Result:

1.	The numerical aperture of the given optical fibre is	0.23
2.	The acceptance angle θ is	13.17°
3.	The attenuation coefficient of the fibre α	0.4 dB/m

R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date 27-03-24 Name Aditya Bhandari

Dept./Lab Physics lab-01 Class CD Expt./No. 7

Title Numerical aperture and attenuation coefficient of optical fiber.

Aim:

Part A: To determine the numerical aperture of the optical fiber

Part B: To measure attenuation coefficient of the optical fiber.

Apparatus: Optical fiber kit, optical fiber cables, In-line adapter, Numerical aperture jig.

SCHEME OF EVALUATION

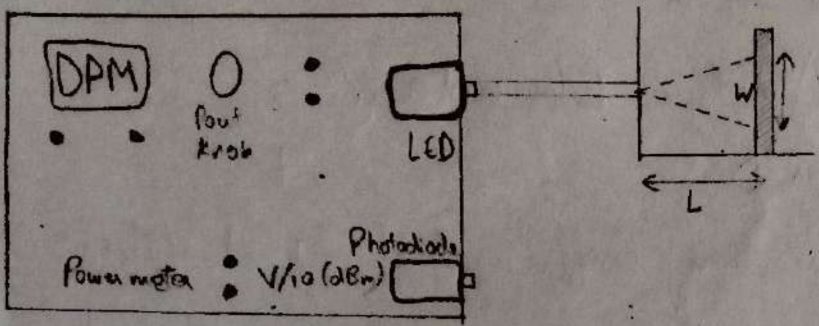
s	Max Marks	Marks Obtained
Experimental Set up + Vivas	4+6	3+6
Experiment	10	9
culation & Accuracy	05	9
	25	27

Signature of Teacher Incharge

Observations :

Diagram :

Part - A :



Part-B :

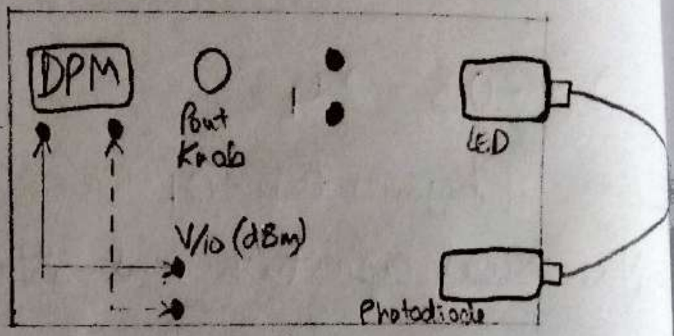


Table - A :

Sl. no.	L (mm)	W_1 (mm)	~~W_2 (mm)~~	~~$W = \frac{W_1+W_2}{2}$ (mm)~~	Numerical Aperture, NA	Acceptance angle, θ $\theta = \sin^{-1}(NA)$
1	50	24			0.23	13.29
2	42	22			0.25	14.47
3	58	26			0.21	12.12
4	66	30			0.22	12.80
					Avg : 0.23	Avg : 13.17

Table-B :

Length (m)	Attenuation of A (~~dB~~) mW	Length (m)	Attenuation of B (~~dB~~) mW	Attenuation for 4 m length B−A (dB)
1	2.16	42	1.97	−0.19

Numerical aperture, N.A. = $\sin\theta_0 = \frac{W}{\sqrt{4L^2+W^2}}$

~~Attenuation coefficient, $\alpha = \frac{\text{Attenuation loss}}{\text{Length}}$ = ____ = ____ dB/m = ____~~

Calculations:

$$\alpha = \frac{-10\cdot\log(P_{out}/P_{in})}{L} = \frac{-10\cdot\log(1.97/2.16)}{1} = \underline{+0.4}\ \text{dB/m}$$

Result :

- Numerical Aperture of given optical fiber is = 0.23
- The acceptance angle θ = 13.17°
- Attenuation coefficient of fiber, α = 0.4 dB/m

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

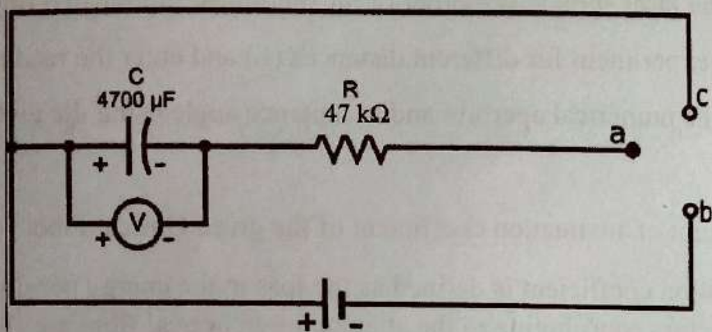
Data:

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

DIELECTRIC CONSTANT

OBSERVATIONS

Circuit diagram:



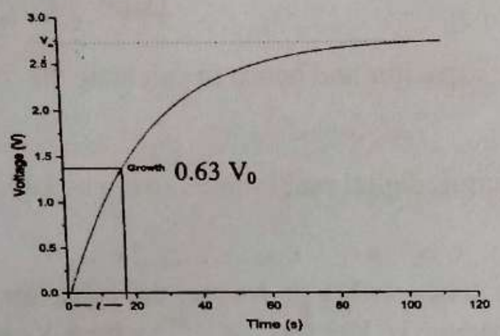
R = 47 KΩ

Battery voltage=__________**Volt**

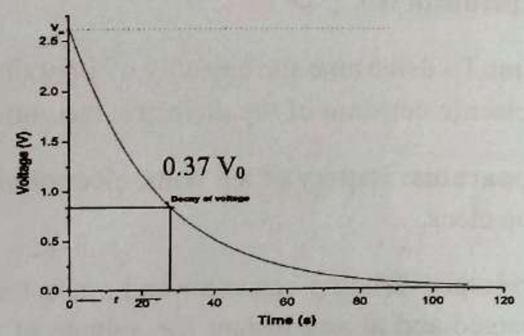
Time in seconds (s)	Voltage during charging (V)	Voltage during discharging (V)
0	0	1.80
30	0.26	1.57
60	0.45	1.37
90	0.63	1.19
120	0.78	1.03
150	0.91	0.90
180	1.03	0.78
210	1.12	0.68
240	1.21	0.59
270	1.28	0.51
300	1.34	0.43
330	1.40	0.39
360	1.46	0.34
390	1.50	0.30
420	1.54	0.26
450	1.57	0.23
480	1.60	0.20
510	1.63	0.17
540	1.65	0.15
570	1.67	0.13
600	1.69	0.11
630	1.70	0.10
660	1.71	0.09
690	1.72	0.08
720	1.73	0.07
750	1.74	0.06
780	1.75	0.05
810	1.76	0.04

Time in seconds (s)	Voltage during charging (V)	Voltage during discharging (V)
840	1.78	0.04
870	1.79	0.03
900	1.79	0.03
930	1.80	0.02
960	1.80	0.02
990	1.80	0.01
1020	1.80	0.01
1050	1.80	0.01

(I) Charging Curve



(II) Discharging Curve:



Charging time constant $\tau_1 =$ 210 s

Discharging time constant $\tau_2 =$ 216 s

Average time constant $\tau = \frac{\tau_1 + \tau_2}{2} =$ 213 s

Capacitance of the capacitor $C = \frac{\tau}{R}$ = 4610μF

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)	8×10^{-5}
Area of each plate A (m^2)	1.375×10^{-2}

$V_0 = 1.8$

$V_0 \times 0.63 = 1.134$

$V_0 \times 0.37 = 0.666$

$\Rightarrow C = \frac{\tau}{R} = \frac{213}{4700} = 4.61 \times 10^{-3}$

$\varepsilon_r = 3.029$

Result:

1. Capacity of parallel plate capacitor C = 4.61×10^{-3} F
2. Dielectric constant of the given dielectric material ε_r = 3.029

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 = 4.61×10^{-3} F
2. Dielectric constant of the given dielectric material ε_r = 3.029

28/30 2.5.24

R.V. COLLEGE OF ENGINEERING ®

OBSERVATION / DATA SHEET

Date 27-03-24 Name Aditya Bhandari

Dept./Lab Physics lab-01 Class CD Expt./No. 5

Title Dielectric Constant

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

Apparatus: Battery of 10 V, electrolytic capacitor, digital multimeter, 2-way key, stop clock.

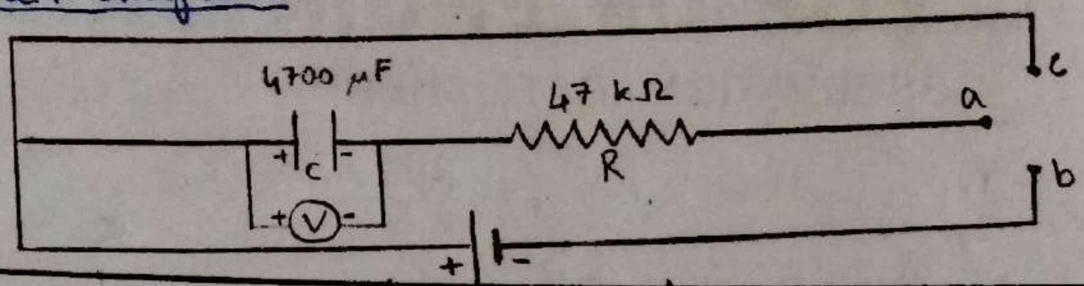
SCHEME OF EVALUATION

Particulars	Max Marks	Marks Obtained	Sig
- Experimental Set up + Vivas	4+6	4+6	
Experiment	10	9	
...n & Accuracy	05	9	
	25	28	

Signature of Teacher Incharge

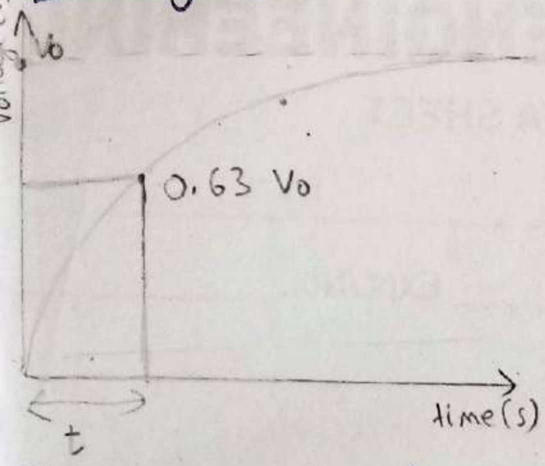
Observations:

Circuit diagram:

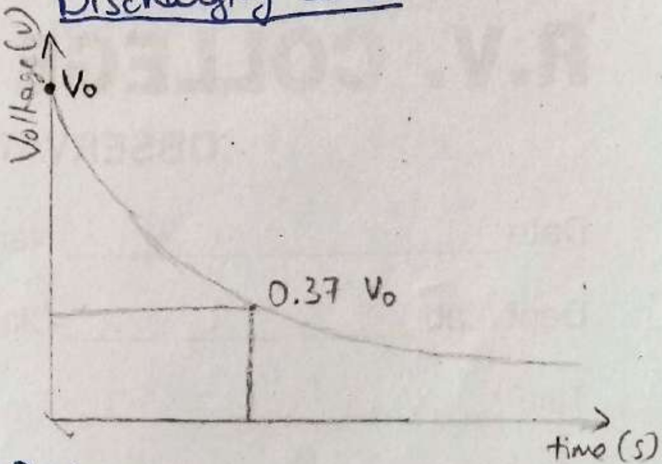


Time (s)	Voltage during charging (V)	Voltage during discharging (V)
0	0	1.80
30	0.26	1.57
60	0.45	1.37
90	0.63	1.19
120	0.78	1.03
150	0.91	0.90
180	1.03	0.78
210	1.12	0.68
240	1.21	0.59
270	1.28	0.51
300	1.34	0.45
330	1.40	0.39
360	1.46	0.34
390	1.50	0.30
420	1.54	0.26
450	1.57	0.23
480	1.60	0.20
510	1.63	0.17
540	1.65	0.15
570	1.67	0.13
600	1.89	0.11
630	1.70	0.10
660	1.71	0.09
690	1.72	0.07
720	1.73	0.06
750	1.74	0.06
780	1.75	0.05
810	1.76	0.04
840	1.78	0.04
870	1.78	0.03
900	1.79	0.03
930	1.79	0.02
960	1.80	0.02
990	1.80	0.01
1020	1.80	0.01
1050	1.80	0.01

Charging curve



Discharging curve



Charging time constant, τ_1 = 210 s. Discharging ~~charg~~ time constant, τ_2 = 216 s

Average time constant $\tau = \frac{\tau_1 + \tau_2}{2}$ = 213 s.

Capacitance of capacitor, $C = \frac{\tau}{R}$ = 4610 μF

$$\varepsilon_r = \frac{C\,d}{\varepsilon_0 A}$$

Thickness of dielectric medium, d (m) = 8×10^{-5} m

Area of each plate, A = 1375×10^{-2} m^2

alculation:

$V_0 = 1.8$

$C = \frac{\tau}{R} = \frac{213}{47000} = 4.61 \times 10^{-3}$

$\Rightarrow V_0 \times 0.63 = 1.134$

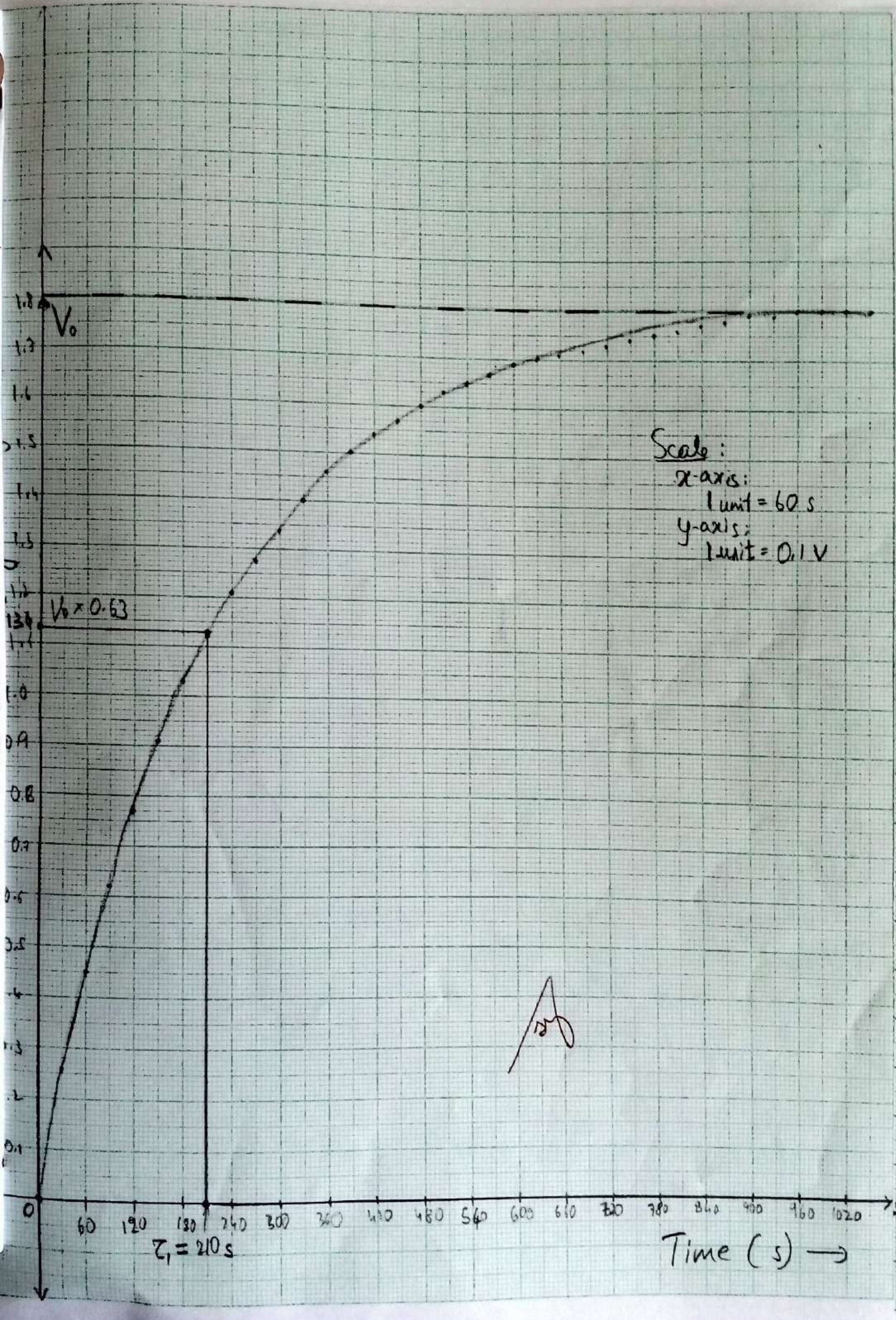
$V_0 \times 0.37 = 0.666$

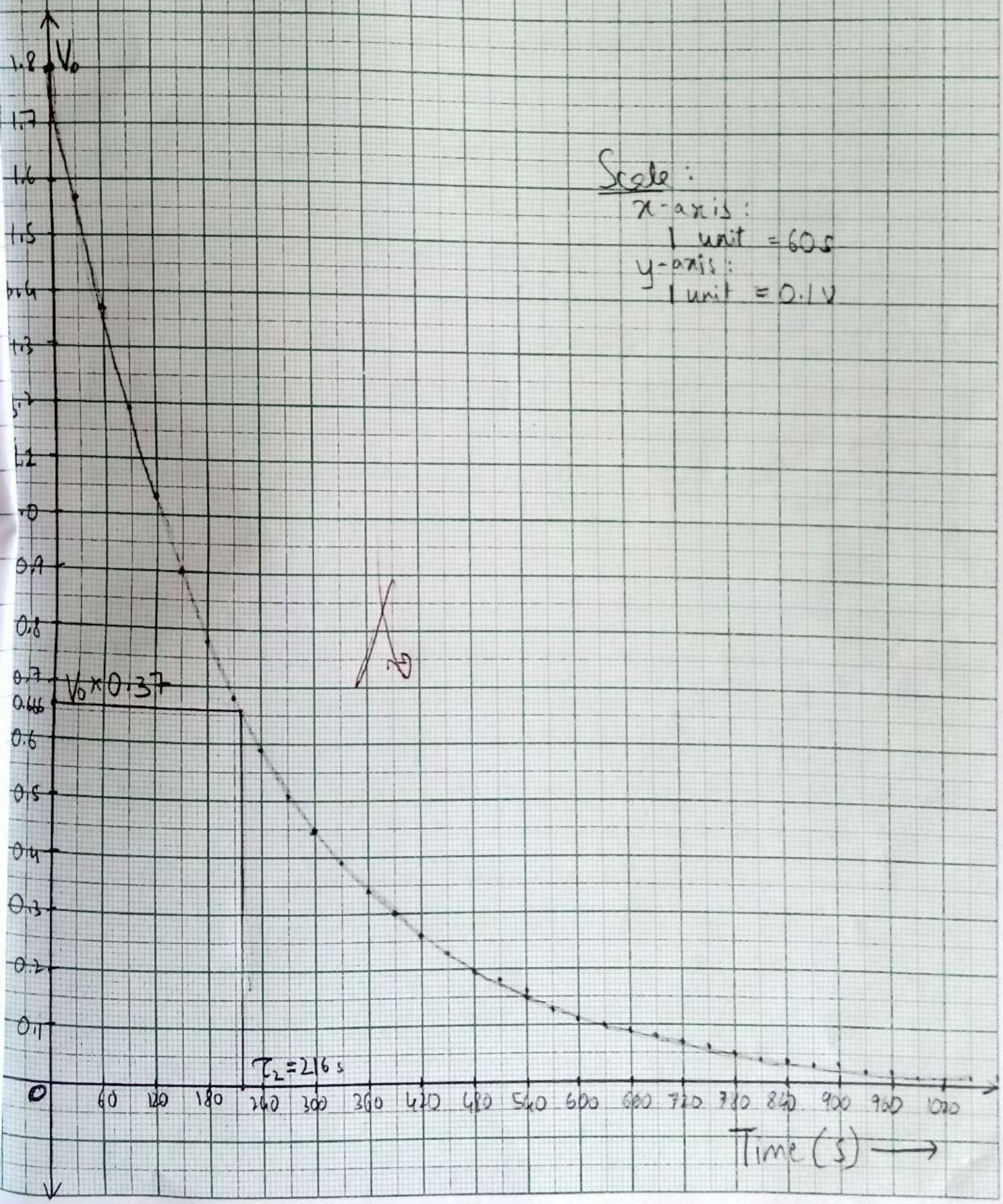
$$\varepsilon_r = \frac{4.61 \times 10^{-3} \times 8 \times 10^{-5}}{8.85 \times 10^{-12} \times 1.375 \times 10^{-2}} \times 10^{-6} = \underline{\underline{3.029}}$$

esult:

Capacity of parallel plate capacitor, C = 4.61×10^{-3} F

Dielectric constant, ε_r = 3.029


1.8
V_0
1.7
1.6
1.5
1.4
1.3
1.2
$V_0 \times 0.63$
1.1
1.0
0.9
0.8
0.7
0.5
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
$\tau_1 = 210$ s
Time (s) →
Scale:
x-axis:
1 unit = 60 s
y-axis:
1 unit = 0.1 V



V_0
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.666
0.6
0.5
0.4
0.3
0.2
0.1
0
$V_0 \times 0.37$
$\tau_2 = 216$ s
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
Time (s)
Scale :
x-axis :
1 unit = 60 s
y-axis :
1 unit = 0.1 V

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 = 1.381×10^{-23} J/K.

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

Procedure:

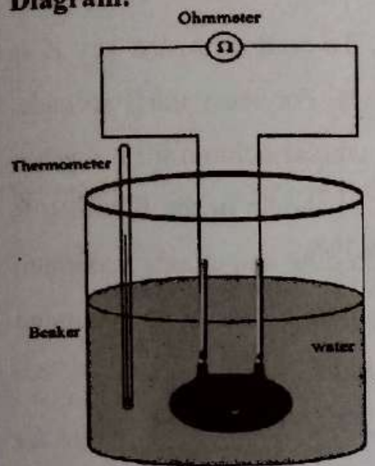
- Make the circuit connection as shown in the figure.
- Keep the multi meter in resistance mode (200 Ω range).
- Insert the thermometer in a beaker containing tap water, thermistor and note down the resistance at room temperature.
- Immerse the thermistor in hot water at about 90°C.
- Note down the resistance 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.

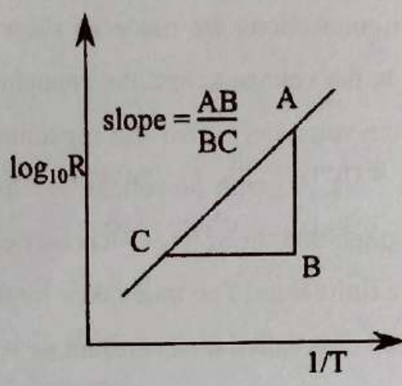
BAND GAP OF A THERMISTOR

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 ($\times 10^{-3}$ K^{-1})
Room Temp	27.1	301.1	33.9	1.53	3.32
1.	78	351	6.6	0.819	2.84
2.	76	349	6.9	0.83	2.86
3.	74	347	7.2	0.85	2.88
4.	72	345	7.6	0.88	2.89
5.	70	343	7.9	0.89	2.91
6.	68	341	8.3	0.91	2.93
7.	66	339	8.7	0.93	2.94
8.	64	337	9.2	0.96	2.96
9.	62	335	9.8	0.99	2.98
10.	60	333	10.4	1.01	3.00

CALCULATIONS:

$\log 33.9 = 1.53$

$\frac{1}{301.1} = 3.32 \times 10^{-3}$

$\Rightarrow E_g = \frac{4.606\, k\, m}{1.6 \times 10^{-19}} = \frac{4.606 \times 1.38 \times 10^{-23} \times 1.2}{1.6 \times 10^{-19}}$

$= 0.477$

$m = \frac{0.36}{0.3} = 1.2$

Result: The energy gap (band gap) of the given thermistor is 0.477 eV.

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OBSERVATION / DATA SHEET

Date 27-03-24 Name Aditya Bhandari

Dept./Lab Physics Lab-01 Class CD Expt./No. 9

Title Band gap of thermistor

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

Apparatus: Glass beaker, thermistor, multimeter, thermometer.

SCHEME OF EVALUATION

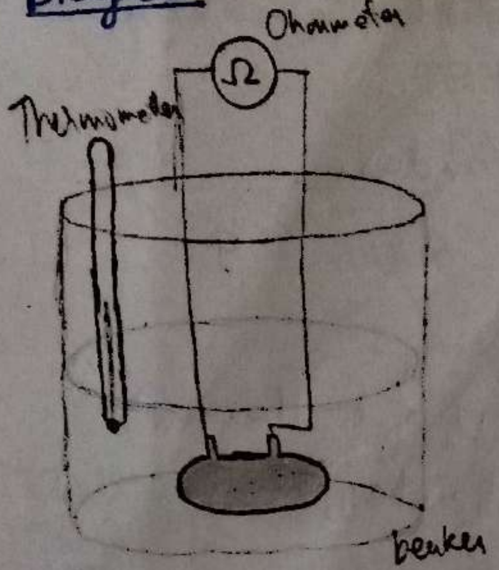
...iculars	Max Marks	Marks Obtained	... Sig...
...a Sheet • Experimental Set up • Vivas	4+6	4+6	
...tion of Experiment	10	9	
...alculation & Accuracy	05	9	
	25	28	

8/6/5

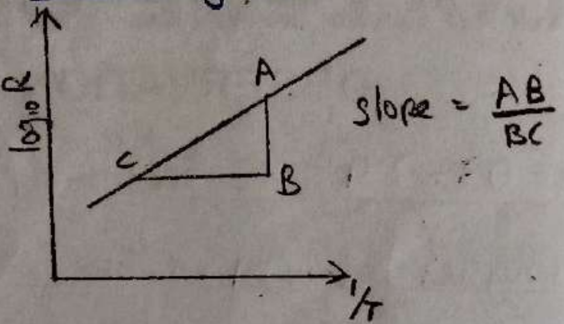
Signature of Teacher Incharge

Observations:

Diagram:



Model graph



$$E_g = \frac{4.606(km)}{1.6 \times 10^{-19}} \text{ eV}$$

$m =$ [illegible]1.2

Table:

Sl. no.	Temperature, T (°C)	T (K)	R (Ω)	log R	1/T ($\times 10^{-3}$ K)
1	~~33.9~~ 27.1	301.1	33.9	1.53	3.32
2	78	351	6.6	0.819	2.84
3	76	349	6.9	0.83	2.86
4	74	347	7.2	0.85	2.88
5	72	345	7.6	0.88	2.89
6	70	343	7.9	0.89	2.91
7	68	341	8.3	0.91	2.93
8	66	339	8.7	0.93	2.94
9	64	337	9.2	0.96	2.96
10	62	335	9.8	0.99	2.98
	60	333	10.4	1.01	3.00
	58	331	11.1	1.04	3.02
	56	329	11.8	1.07	3.03
	54	327	12.7	1.10	3.05
	52	325	13.5	1.13	3.07

Calculations:

$\log 33.9 = \underline{1.53}$

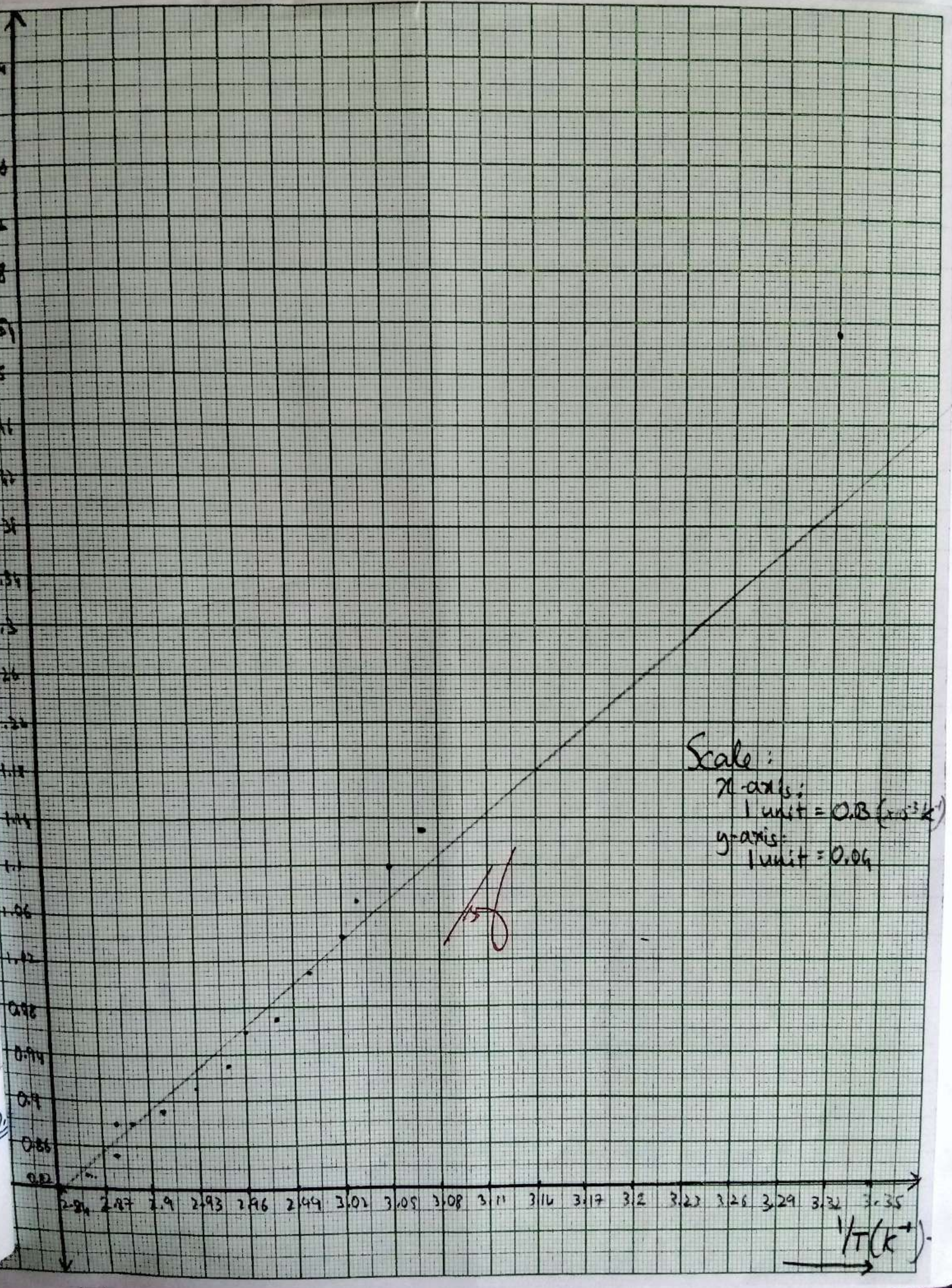
$\frac{1}{301.1} = 3.32 \times 10^{-3}$

$\Rightarrow \log 13.5 = \underline{1.13}$

$$E_g = \frac{4.606\, km}{1.6 \times 10^{-19}} =$$

Result:

Energy gap of thermistor is 0.477 eV


1.74
1.7
1.66
1.62
1.58
1.54
1.5
1.46
1.42
1.38
1.34
1.3
1.26
1.22
1.18
1.14
1.1
1.06
1.02
0.98
0.94
0.9
0.86
0.82
2.84
2.87
2.9
2.93
2.96
2.99
3.02
3.05
3.08
3.11
3.14
3.17
3.2
3.23
3.26
3.29
3.32
3.35
1/T(K^-1)
Scale:
x-axis:
1 unit = 0.03 (×10^-3 K^-1)
y-axis:
1 unit = 0.04

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.

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

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, $e = 1.602 \times 10^{-19}$ 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:

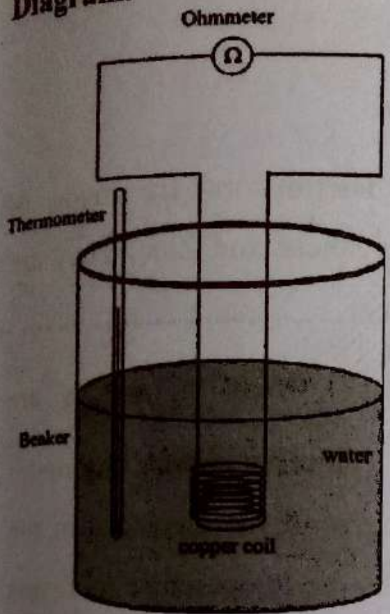
- Connect the copper coil to the digital multi meter.
- Set the multi meter to 200 Ω mode.
- Immerse the copper coil in a beaker containing cold water, note down the resistance in multi meter and enter the readings in the tabular column.
- Immerse the copper coil in a beaker containing hot water at about 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.

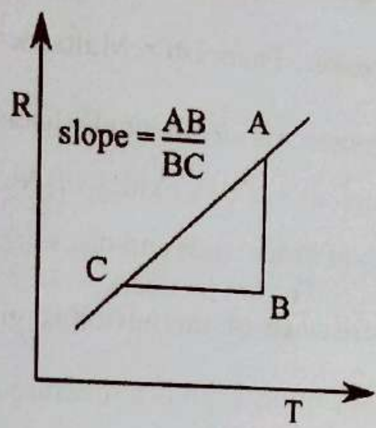
FERMI ENERGY OF COPPER

OBSERVATIONS:

Diagram:



Model Graph:



Formula:

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

$$E_F = \frac{1.36\times10^{-15}\sqrt{\frac{\rho A m}{l}}}{1.6\times10^{-19}} = 6.36 \ eV$$

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

Tabular Column:

Sl. No	Temp (^{0}C) (x)	R (Ω) (y)	x^2	xy
Room Temp	28.5	10.0	812.25	285
1.	80	12.0	6400	960
2.	75	11.8	5625	885
3.	70	11.6	4900	812
4.	65	11.4	4225	741
5.	60	11.2	3600	672
6.	55	11.0	3025	605
Sums	Σx = 603.5	Σy = 121.3	Σx^2 = 35937.25	Σxy = 6762

Calculations:

$$m = \frac{11\times6762 - 603.5\times121.3}{11\times35937.25 - 603.5^2} = 0.03$$

$$c = \frac{121.3\times35937.25 - 603.5\times6762}{11\times35937.25 - 603.5^2} = 8.94$$

x	$y = mx + c$
30	9.84
80	11.34

$$E_F = 1.36\times10^{-15}\sqrt{\frac{8960\times\pi\times(10^{-4})^2\times0.03}{15}} = 1.02\times10^{-18} \ J$$

Result: The Fermi energy of copper is E_F = 1.02×10^{-18} J, 6.36 eV

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OBSERVATION / DATA SHEET

Date 27-03-24 Name Aditya Bhandari

Dept./Lab Physics Lab-01 Class CD Expt./No. 8

Title Fermi energy of Copper

Aim: To determine the fermi energy of Copper

Apparatus: Multimeter, Beaker, thermometer, copper wire

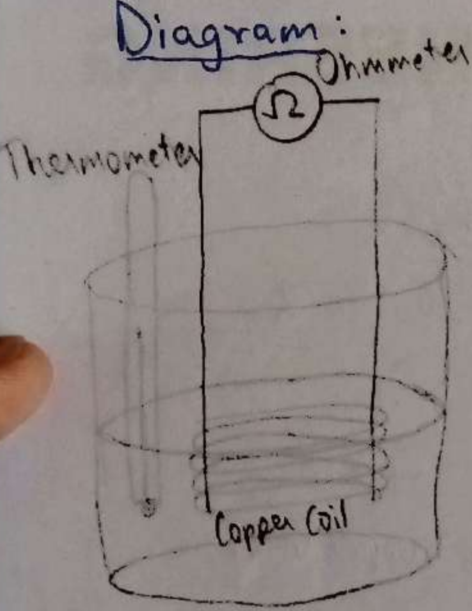
SCHEME OF EVALUATI[illegible]N

Particulars	Max Marks	Marks Obtained	Si[illegible]
Experimental Set up + Vivas	4+6	4+6	18
Experiment	10	9	
[illegible]tion & Accuracy	05	8	
	25	27	

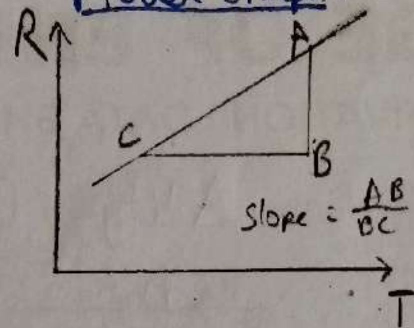
Signature of
Teacher Incharge

Observations:

Diagram:



Model Graph:



Formula:

$$E_F = 1.36 \times 10^{-15} \sqrt{\frac{\rho A}{L}}$$

$$E_F = \frac{1.36 \times 10^{-15} \sqrt{\frac{\rho A m}{L}}}{1.6 \times 10^{-19}} \text{ e}$$

Explain the term

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

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

Table:

Sl. no.	Temp (°C) [x]	R (Ω) [y]	x^2	xy
Room Temp.	28.5	10.0	812.25	285
1	80.0	12.0	6400	960
2	75.0	11.8	5625	885
3	70.0	11.6	4900	812
4	65.0	11.4	4225	741
5	60.0	11.2	3600	672
6	55.0	11.0	3025	~~33275~~ 605
~~Sums~~	~~Σx = 528.5~~	~~Σy =~~	~~Σx² = 33112.25~~	~~Σxy =~~
7.	50.0	10.8	2500	540
8.	45.0	10.7	2025	481.5
9.	40.0	10.5	1600	420
10.	35.0	10.3	1225	360.5
Sum:	$\Sigma x = 603.5$	$\Sigma y = 121.3$	$\Sigma x^2 = 35937.25$	$\Sigma xy = 6762$

x	y = mx…
30	9.84
80	11.34

$\Rightarrow E_F = 1.02$

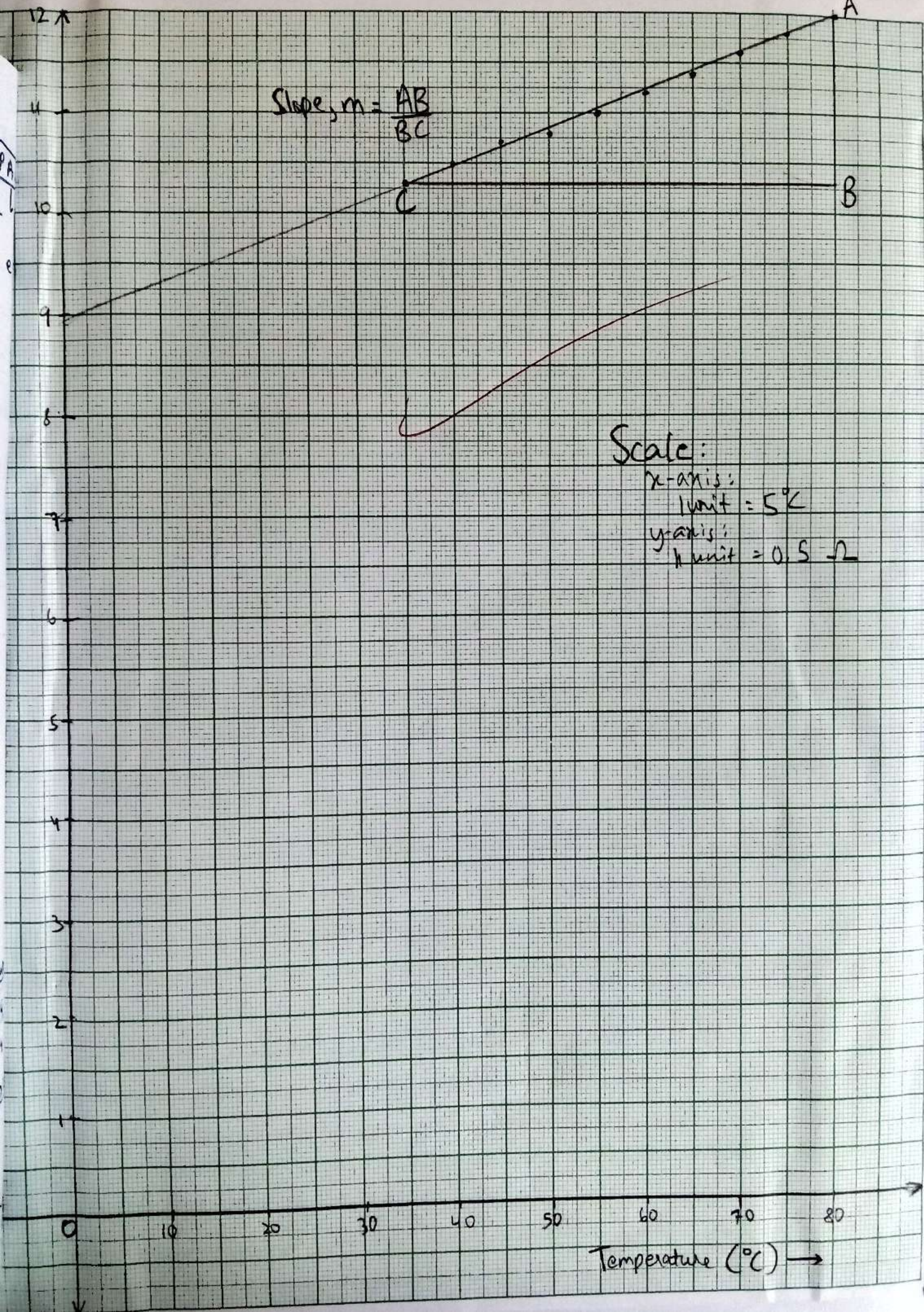
Calculations:

$$m = \frac{11\cancel{0} \times 6762 - 603.5 \times 121.3}{11\cancel{0} \times 35937.25 - 603.5^2} = \cancel{1.153} \quad 0.03, \quad c = \frac{121.3 \times 35937.25 - 603.5 \times 6762}{11\cancel{0} \times 35937.25 - 603.5^2} =$$

$$y_{80} = \cancel{0.24}\ 2.4 + 8.94 = 11.34$$

Result:

The fermi energy of Copper is $E_F = 1.02 \times 10^{-18}$ J = 6.36


12
11
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
70
80
A
B
C
Slope, m = AB/BC
Scale:
x-axis:
1 unit = 5°C
y-axis:
1 unit = 0.5 Ω
Temperature (°C) →

VIVA VOCE

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_γ and V_z ?
V_γ 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 (XL). $XL = \omega L = 2\pi fL$.

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

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 (τ = 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
   $$E_F = \frac{1}{2} m v_F^2$$

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.