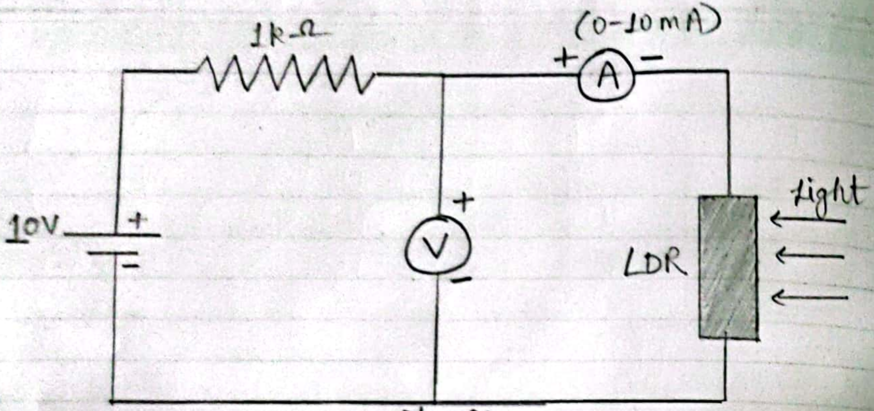
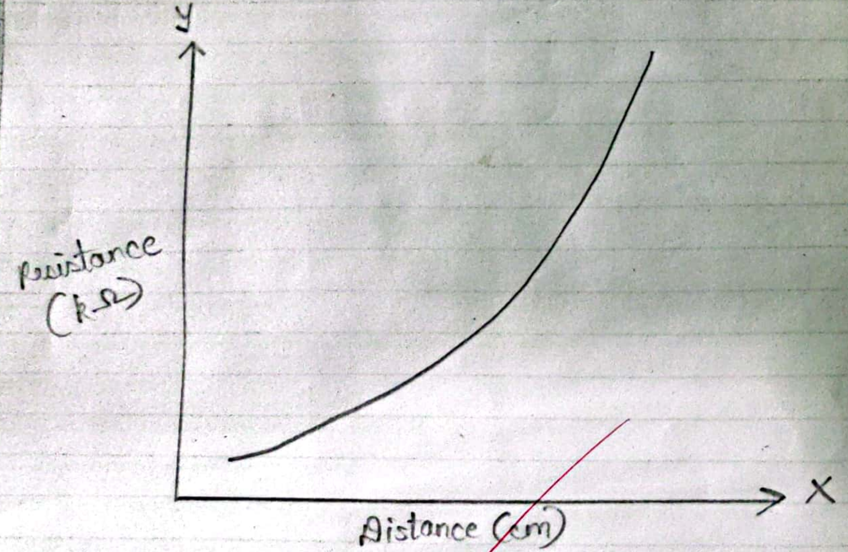


circuit Diagram



Model graph

Date 23/01/2023

Expt. No. 1 Page No. 1

Experiment - 1

To study V-I characteristics of a Light Dependent Resistor (LDR)

☆ Aim → To measure the photoconductive nature & the dark resistance of the given light dependent resistor (LDR) and to plot the characteristics of the LDR.

☆ Apparatus Required → LDR, Resistor (1 kΩ), ammeter (0-10 mA), voltmeter (0-10 V), light source, regulated power supply.

☆ Formula →

By ohm's law, $V = IR$ (or) $R = \left(\frac{V}{I}\right)$ ohm

where R is the resistance of the LDR i.e- the resistance when the LDR is closed.
V and I represents the corresponding voltage & current respectively.

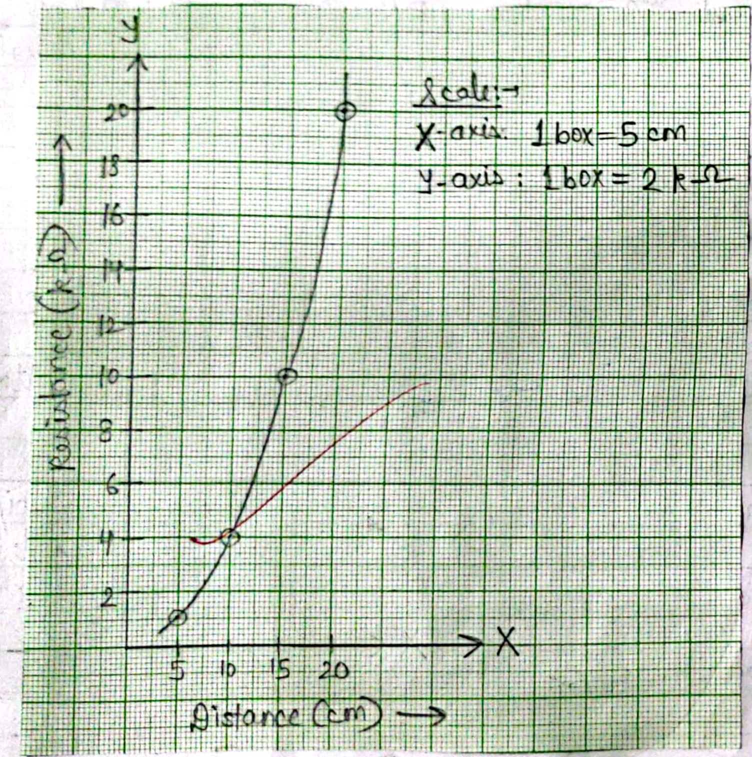
☆ Principle →

- The photoconductive device is based on the principle of decrease in the resistance of certain semiconductor materials when they are exposed to both infrared & visible radiation.

Teacher's Signature :

OBSERVATION TABLE

S.NO	Distance (cm)	Voltmeter Reading (V) (in volt)	Ammeter Reading (I) (in mA)	Resistance (in k-Ω)
1	5	4	4	1
2	10	4	1	4
3	15	4	0.4	10
4	20	4	0.2	20



Actual Graph

Date ______

Expt. No. ______ Page No. 2

- The photoconductivity is the result of carrier excitation due to light absorption and the figure of merit depends on the light absorption efficiency. The increase in conductivity is due to an increase in the number of mobile charge carriers in the material.

★ Observations →

- Least count of voltmeter $= \left(\frac{2}{10}\right) V = \underline{0.2\,V}$
- Least count of ammeter $= \left(\frac{2}{10}\right) mA = \underline{0.2\,mA}$
- Dark Resistance $= R = \frac{V}{I} = \underline{\infty}$ ohm

★ Calculations →

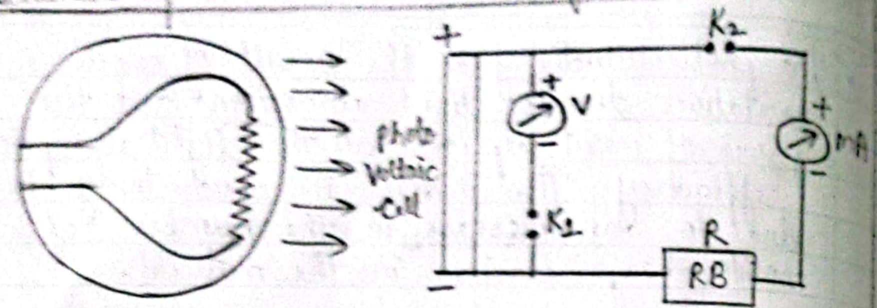
S.NO	Voltmeter Reading (V) (in volt)	Ammeter Reading (A) (in mA)	Resistance (R = (in k-Ω)
1	4	$4 = 4 \times 10^{-3}$ A	$\frac{4}{4\times10^{-3}} = 10^{3}\,\Omega = 1\,k\Omega$
2	4	$1 = 1 \times 10^{-3}$ A	$\frac{4}{1\times10^{-3}} = 4\times10^{3}\,\Omega = 4\,k\Omega$
3	4	$0.4 = 0.4 \times 10^{-3}$ A	$\frac{4}{0.4\times10^{-3}} = 10^{4}\,\Omega = 10$
4	4	$0.2 = 0.2 \times 10^{-3}$ A	$\frac{4}{0.2\times10^{-3}} = 2\times$ $= 2$

★ Result →

1) The characteristics of the LDR were studied & plotted.
2) The dark resistance of the given LDR is ∞ ohm

Teacher's Signature :

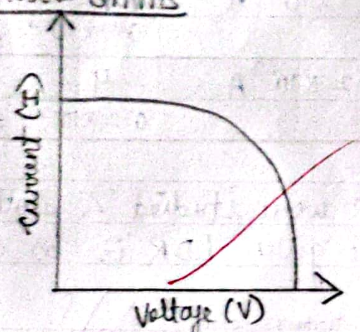
★ Schematic Representation and Circuit of Solar cell



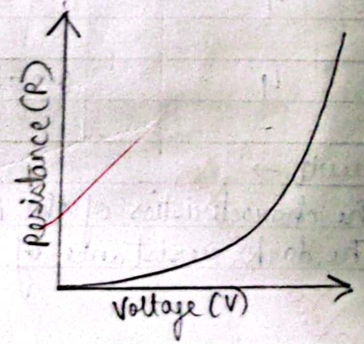
★ OBSERVATION TABLE

S.NO	Intensity	Resistance [R (ohm)]	Reading of Voltmeter [V (volts)]	Reading of Ammeter [I (A)]
1	10	SC	0.02	11.5×10^{-3}
2	10	10	0.13	11×10^{-3}
3	10	22	0.24	10×10^{-3}
4	10	33	0.29	8.5×10^{-3}
5	10	47	0.34	7×10^{-3}
6	10	82	0.38	4.5×10^{-3}
7	10	100	0.40	3.5×10^{-3}
8	10	150	0.41	2.5×10^{-3}
9	10	220	0.42	1.5×10^{-3}
10	10	1000	0.44	0.5×10^{-3}

★ MODEL GRAPHS



V-I characteristics



V-R characteristics

Date 23/01/2023

Expt. No. 2 Page No. 3

Experiment-2

Study of V-I and V-R characteristics of a Solar cell

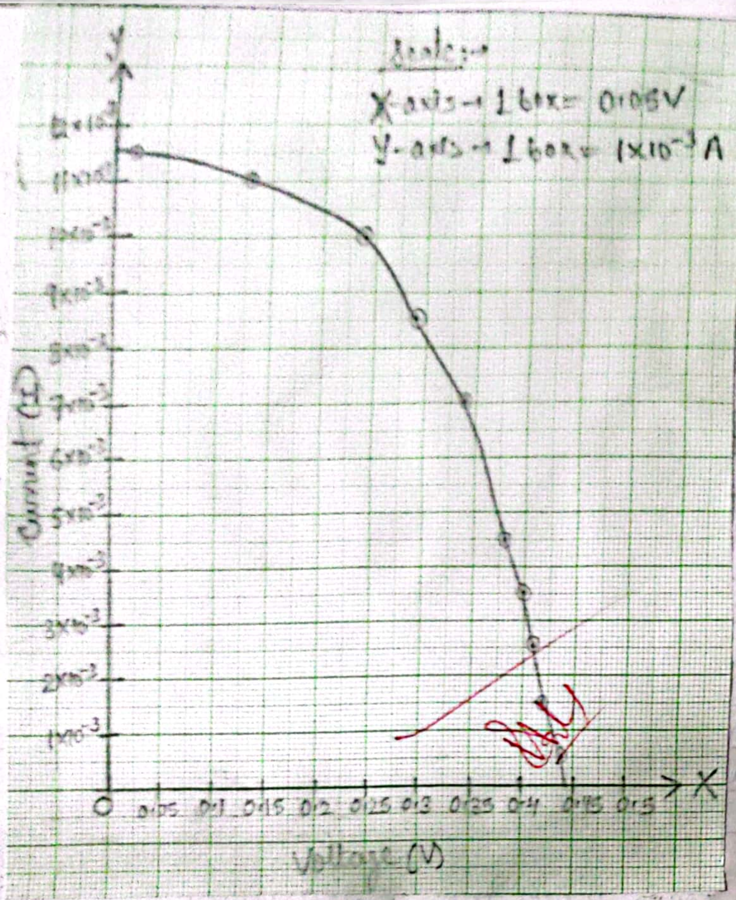
★ **Aim** → To study the V-I and V-R characteristics of a solar cell.

★ **Apparatus Required** → Solar cell, voltmeter, miliammeter, a dial-type resistance box, keys, illuminating lamps, connecting wires, etc.

★ **Principle** →
A solar cell (photovoltaic cell) essentially consists of a p-n junction diode, in which electrons & holes are generated by the incident photons. When an external circuit is connected through the p-n junction device, a current passes through the circuit. Therefore, the device generates power when the electromagnetic radiation is incident on it.

★ **Formula** →
By ohm's law, $V = IR \Rightarrow R = \left(\frac{V}{I}\right)$ ohm

Teacher's Signature :



★ Calculations

⊙ $V_1 = 0.13\,V$; $I_1 = 11\times10^{-3}A$; $R_1 = \frac{V_1}{I_1} = \frac{0.13}{11\times10^{-3}} = 11.8\,\Omega \approx 10\,\Omega$

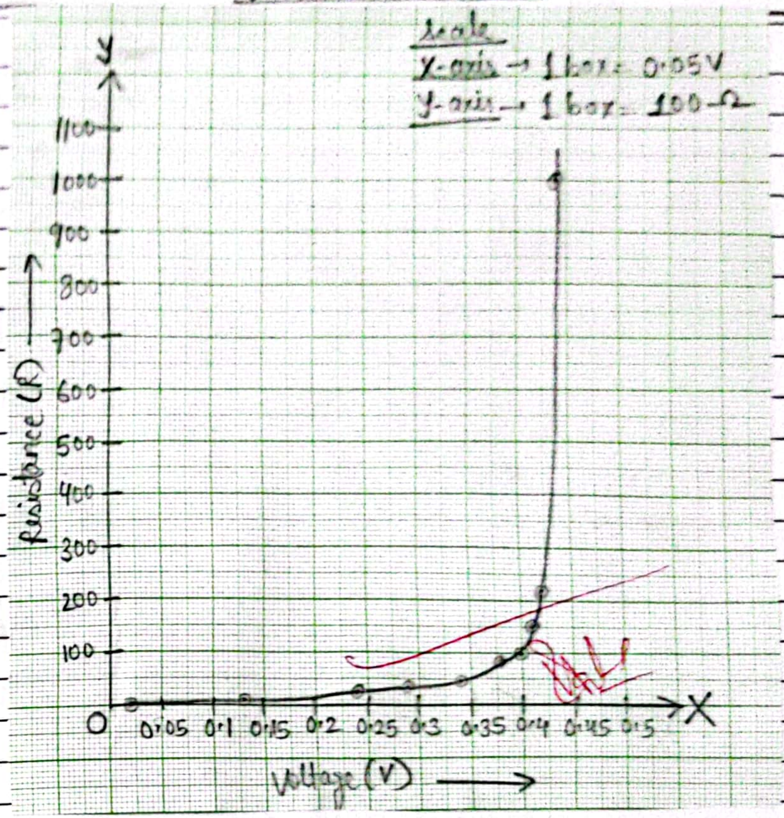
⊙ $V_2 = 0.24\,V$; $I_2 = 10\times10^{-3}A$; $R_2 = \frac{V_2}{I_2} = \frac{0.122}{10\times10^{-3}} = 24\,\Omega \approx 22\,\Omega$

⊙ $V_3 = 0.29\,V$; $I_3 = 8.5\times10^{-3}A$; $R_3 = \frac{V_3}{I_3} = \frac{0.129}{8.5\times10^{-3}} = 34.1\,\Omega \approx 33\,\Omega$

⊙ $V_4 = 0.34\,V$; $I_4 = 7\times10^{-3}A$; $R_4 = \frac{V_4}{I_4} = \frac{0.34}{7\times10^{-3}} = 48.6\,\Omega \approx 47\,\Omega$

Date ....

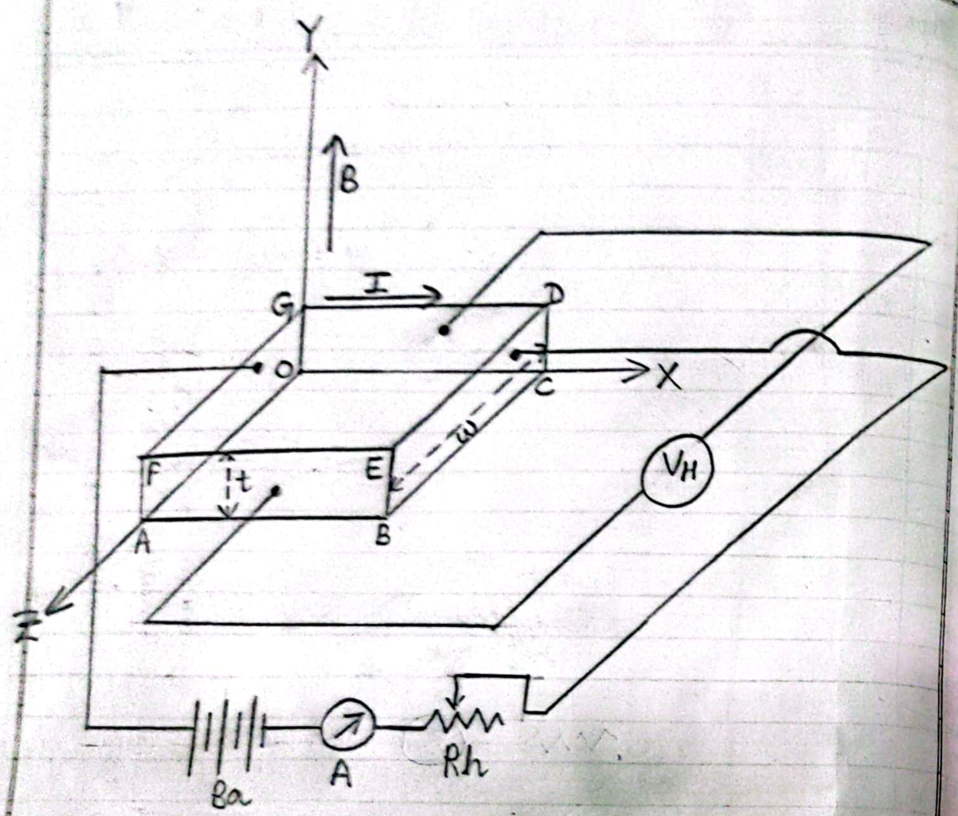
Expt. No. .... V-R characteristics Page No. 4



★ Result →

The V-I and V-R characteristics of the solar cell are plotted.

Teacher's Signature :



Hall Effect setup

Experiment-3

Determination of Hall Coefficient and carrier type for a semi-conducting material

Aim : To determine the hall coefficient of the given n-type or p-type semiconductor.

Apparatus Required : Hall probe (n-type or p-type), Hall effect setup, Electromagnet, constant current power supply, gauss meter, etc.

Formulae :

(i) Hall coefficient $(R_H) = \frac{V_H \cdot t}{I H} \times 10^8 \ cm^3 C^{-1}$

where, V_H = Hall Voltage (volt)
t = thickness of the sample (cm)
I = Current (Ampere)
H = Magnetic field (Gauss)

(ii) Carrier Density $(n) = \frac{1}{R_H q} \ cm^{-3}$

where, R_H = Hall coefficient $(cm^3 C^{-1})$
q = charge of the $e^{\ominus}$ or hole (C)

(iii) Carrier Mobility $(\mu) = R_H \sigma \ cm^2 V^{-1} s^{-1}$

where, R_H = Hall coefficient $(cm^3 C^{-1})$
σ = conductivity $(C V^{-1} s^{-1} cm^{-1})$

Observation Table →

Current in the constant current power supply (A)	Magnetic field (H) (gauss)	Hall voltage (V_H) (Volts)	Hall Coefficient (R_H) $cm^3 C^{-1}$
1.0	2.28	0.026	7.9×10^4
1.5	3.76	0.033	4.1×10^4
2.0	5.15	0.041	2.8×10^4
2.5	6.44	0.043	1.9×10^4
3.0	8.24	0.044	1.2×10^4

Calculations →

★ $\text{Avg. } R_H = \dfrac{(7.9\times10^4 + 4.1\times10^4 + 2.8\times10^4 + 1.9\times10^4 + 1.2\times10^4)}{5}$

$\Rightarrow \text{Avg. } R_H = \dfrac{(7.9 + 4.1 + 2.8 + 1.9 + 1.2)\times10^4}{5}$

$\Rightarrow \boxed{\text{Avg. } R_H = 3.58 \times 10^4 \, cm^3 C^{-1}}$

★ Carrier density $= n = \dfrac{1}{R_H q} = \dfrac{1}{3.58\times10^4 \times 1.6\times10^{-19}}$

$= 1.75 \times 10^{14} \, cm^{-3}$

★ Carrier mobility $= \mu = R_H \sigma$

$= 3.58 \times 10^4 \times \dfrac{1}{8}$

$= 4.475 \times 10^3 \, cm^2 V^{-1} s^{-1}$

Date ______

Expt. No. ______ Page No. 6

Principle :

★ Hall Effect : When a current-carrying conductor is placed in a transverse magnetic field, a potential difference is developed across the conductor in a direction perpendicular to both the current & the magnetic field.

Observations :

(i) Thickness of the sample (t) = 0.07 cm

(ii) Resistivity of the sample (ρ) = $8 \, V C^{-1} s \, cm$

(iii) Conductivity of the sample (σ) = $\dfrac{1}{8} \, C V^{-1} s^{-1} cm^{-1}$

(iv) Hall Coefficient of the sample = $R_H = \dfrac{V_H t}{I H} \times 10^8 \, cm^3 C^{-1}$

$= 3.58 \times 10^4 \, cm^3 C^{-1}$

(v) Carrier Density of the sample = $n = \dfrac{1}{R_H q} \, cm^{-3}$

$= 1.75 \times 10^{14} \, cm^{-3}$

(vi) Carrier mobility = $\mu = R_H \sigma \, cm^2 V^{-1} s^{-1}$

$= 4.475 \times 10^3 \, cm^2 V^{-1} s^{-1}$

Result :

(i) Hall coefficient of the given semi-conducting material = $R_H = 3.58 \times 10^4 \, cm^3 C^{-1}$

(ii) The carrier density = $n = 1.75 \times 10^{14} \, cm^{-3}$

(iii) The carrier mobility = $\mu = 4.475 \times 10^3 \, cm^2 V^{-1} s^{-1}$

Teacher's Signature 02/02/23

Date 30/01/2023

Expt. No. 4 Page No. 7

Experiment - 4

Aim: Determination of electron & hole mobility v/s doping concentration using GNU Octave.

Materials Required: Computer, GNU Octave software, Readings.

Formulae:

(i) Hall Coefficient $(R_H) = \frac{V_H \cdot t}{IH} \times 10^8 \ cm^3 C^{-1}$ — (1)

where, V_H = Hall Voltage (volt)
t = thickness of the sample (cm)
I = Current (Ampere)
H = Magnetic Field (Gauss)

(ii) Carrier Density $(n) = \frac{1}{R_H q} \ cm^{-3}$ — (2)

where, R_H = Hall coefficient $(cm^3 C^{-1})$
q = charge of the $e^{\ominus}$ or hole (C)

(iii) Carrier Mobility $(\mu) = R_H \sigma \ cm^2 V^{-1} s^{-1}$ — (3)

where, R_H = Hall Coefficient $(cm^3 C^{-1})$
σ = Conductivity $(C V^{-1} s^{-1} cm^{-1})$

Principle:

* Hall Effect: When a current-carrying conductor is placed in a transverse magnetic field, a potential difference is developed across the conductor in a direction perpendicular to both the current & the magnetic field.

Teacher's Signature:

Observation Table

SNO	Hall Coefficient(R_H) $[cm^3 C^{-1}]$	Carrier Density (n) $[cm^{-3}]$ / Doping	Carrier Mobility (μ) $[cm^2 V^{-1} s^{-1}]$
1	7.9×10^4	7.91×10^{13}	9.88×10^3
2	4.1×10^4	15.24×10^{13}	5.13×10^3
3	2.8×10^4	22.32×10^{13}	3.5×10^3
4	1.9×10^4	32.89×10^{13}	2.38×10^3
5	1.2×10^4	52.08×10^{13}	1.5×10^3

→ Using eq^n (1) we can determine the 5 values of Hall Coefficient & using these 5 values of Hall Coefficient in eq^n (2) and eq^n (3), we can determine the 5 values of doping concentration & mobility respectively.

→ Finally the value of mobility & concentration will be insuded into the program to obtain the graph.

Date ______

Expt. No. ______ Page No. 8

Calculations :

1) $R_{H_1} = 7.9 \times 10^4 \ cm^3 C^{-1}$

$$n_1 = \frac{1}{R_{H_1} q} = \frac{1}{7.9 \times 10^4 \times 1.6 \times 10^{-19}} = 7.91 \times 10^{13} \ cm^{-3}$$

$$\mu_1 = R_{H_1} \sigma = 7.9 \times 10^4 \times \frac{1}{8} = 9.88 \times 10^3 \ cm^2 V^{-1} s^{-1}$$

2) $R_{H_2} = 4.1 \times 10^4 \ cm^3 C^{-1}$

$$n_2 = \frac{1}{R_{H_2} q} = \frac{1}{4.1 \times 10^4 \times 1.6 \times 10^{-19}} = 15.24 \times 10^{13} \ cm^{-3}$$

$$\mu_2 = R_{H_2} \sigma = 4.1 \times 10^4 \times \frac{1}{8} = 5.13 \times 10^3 \ cm^2 V^{-1} s^{-1}$$

3) $R_{H_3} = 2.8 \times 10^4 \ cm^3 C^{-1}$

$$n_3 = \frac{1}{R_{H_3} \cdot q} = \frac{1}{2.8 \times 10^4 \times 1.6 \times 10^{-19}} = 22.32 \times 10^{13} \ cm^{-3}$$

$$\mu_3 = R_{H_3} \cdot \sigma = 2.8 \times 10^4 \times \frac{1}{8} = 3.5 \times 10^3 \ cm^2 V^{-1} s^{-1}$$

4) $R_{H_4} = 1.9 \times 10^4 \ cm^3 C^{-1}$

$$n_4 = \frac{1}{R_{H_4} \cdot q} = \frac{1}{1.9 \times 10^4 \times 1.6 \times 10^{-19}} = 32.89 \times 10^{13} \ cm^{-3}$$

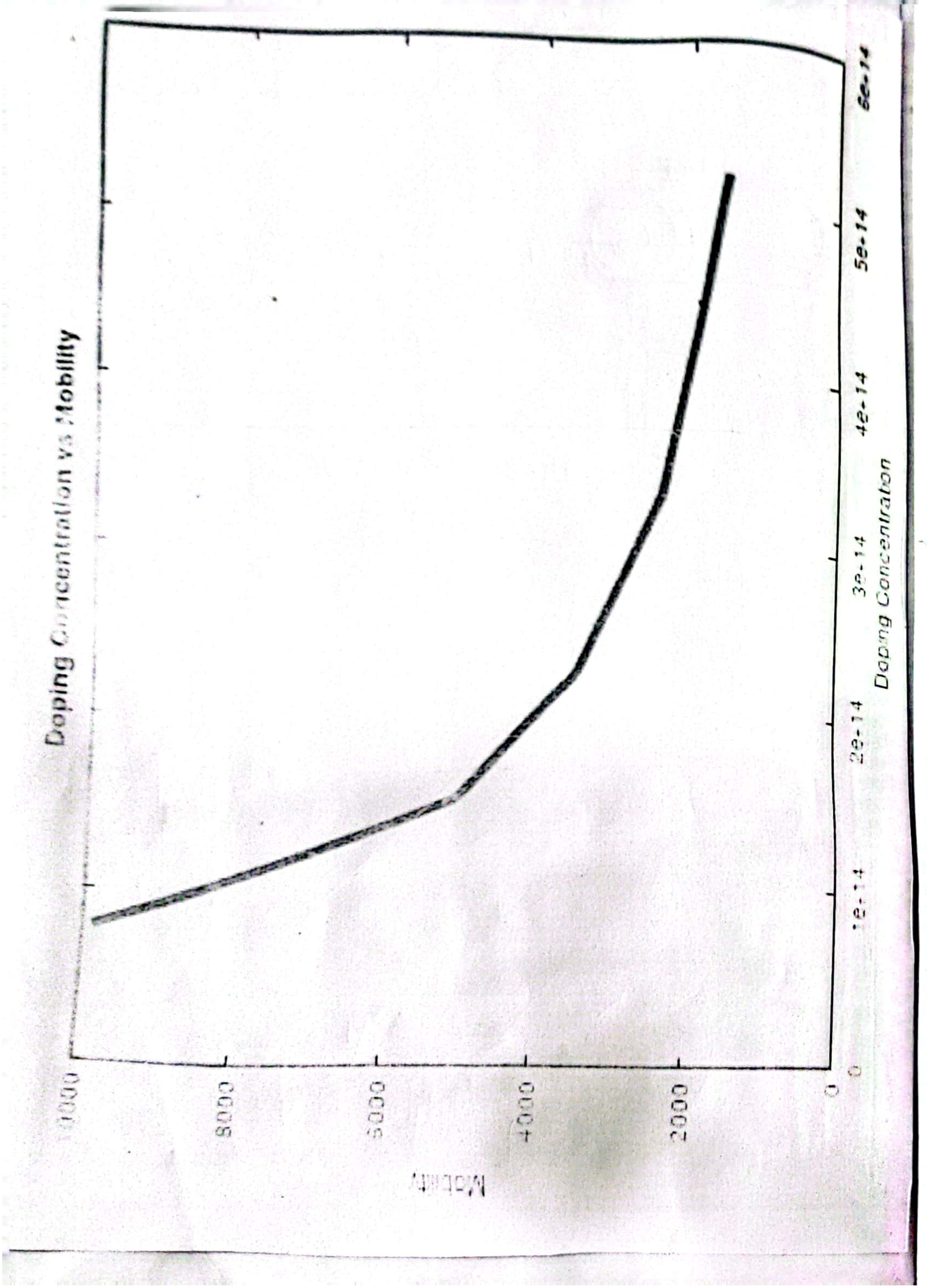
$$\mu_4 = R_{H_4} \cdot \sigma = 1.9 \times 10^4 \times \frac{1}{8} = 2.38 \times 10^3 \ cm^2 V^{-1} s^{-1}$$

5) $R_{H_5} = 1.2 \times 10^4 \ cm^3 C^{-1}$

$$n_5 = \frac{1}{R_{H_5} \cdot q} = \frac{1}{1.2 \times 10^4 \times 1.6 \times 10^{-19}} = 52.08 \times 10^{13} \ cm^{-3}$$

$$\mu_5 = R_{H_5} \cdot \sigma = 1.2 \times 10^4 \times \frac{1}{8} = 1.5 \times 10^3 \ cm^2 V^{-1} s^{-1}$$

Teacher's Signature : ______



Date ______

Expt. No. ______ Page No. 9

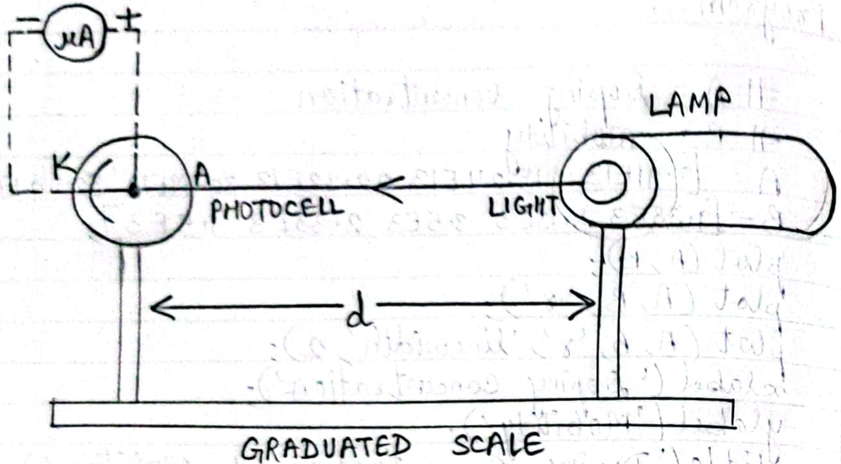
Program →

```
# A = Doping Concentration
# B = Mobility
A = [7.91E13 15.24E13 22.32E13 32.89E13 52.08E13];
B = [9.88E3 5.13E3 3.5E3 2.38E3 1.5E3];
plot(A,B);
plot(A,B,'r');
plot(A,B,'r','linewidth',2);
xlabel('Doping Concentration').
ylabel('Mobility').
title('Doping Concentration v/s Mobility');
```

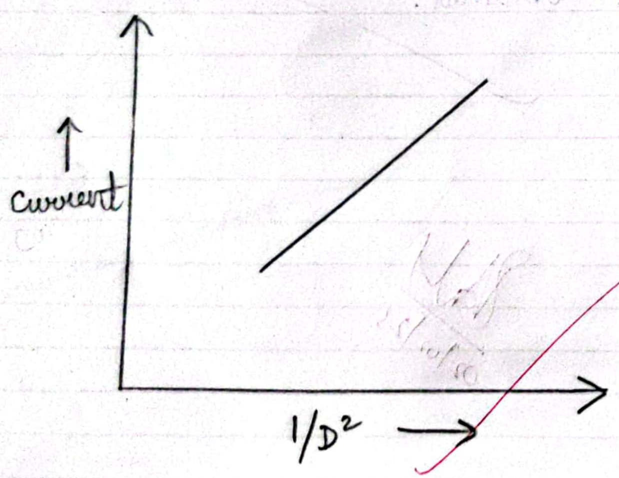
Result → The graph for Doping concentration v/s Mobility through GNU Octave Software is obtained.

02/02/23

Teacher's Signature : ______



Photocell



Model Graph

Date 6/2/2023

Expt. No. 5 Page No. 10

Experiment- 5

Aim:
To verify inverse square law of radiations using a photo-electric cell.

Apparatus Required:
Photo cell (selenium) mounted in the metal box with connections brought out at terminals, lamp holder with 60W bulb, Two moving coil analog meters (1000μA and 500mV) mounted on the front panel & connections brought out at terminals. Two single point & two multi points patch cords.

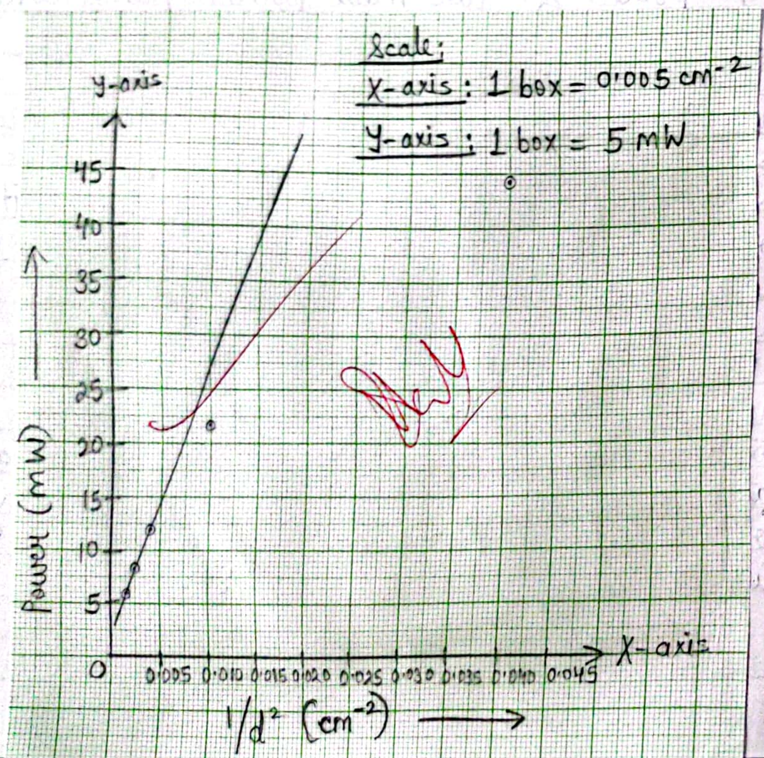
Principle:
Photocell is a device in which light energy is used to create a potential difference which is directly proportional to frequency and intensity of the incident light.

The inverse square law is a principle that express the way radiant energy propogates through space. The rule states that the power intensity per unit area from a point source, if the rays strike the surface at a right angle, varies inversely according to the square of the distance from the surface.

Teacher's Signature :

OBSERVATION TABLE

S.NO	d (cm)	d^2 (cm^2)	$1/d^2$ (cm^{-2})	Voltage (V) (volts)	Current (I) (mA)	Power (P = VI) (mW)	Intensity ($E = I/d^2$) ($mA\ cm^{-2}$)
1	5	25	0.0400	6	7.4	44.4	0.2960
2	10	100	0.0100	6	3.6	21.6	0.0360
3	15	225	0.0040	6	2.0	12.0	0.0089
4	20	400	0.0025	6	1.4	8.4	0.0035
5	25	625	0.0016	6	1.0	6.0	0.0016



Actual graph

Calculations:

1) $d_1 = 5cm$

$d_1^2 = (5)^2 cm^2 = 25cm^2$

$1/d_1^2 = (1/25) cm^{-2} = 0.0400 cm^{-2}$

$P_1 = V_1 I_1 = (6)(7.4) mW = 44.4 mW$

$E_1 = I_1/d_1^2 = (7.4/25) mA\ cm^{-2} = 0.2960 mA\ cm^{-2}$

2) $d_2 = 10 cm$

$d_2^2 = (10)^2 cm^2 = 100 cm^2$

$1/d_2^2 = (1/100) cm^{-2} = 0.0100 cm^{-2}$

$P_2 = V_2 I_2 = (6)(3.6) mW = 21.6 mW$

$E_2 = I_2/d_2^2 = (3.6/100) mA\ cm^{-2} = 0.0360 mA\ cm^{-2}$

3) $d_3 = 15cm$

$d_3^2 = (15)^2 cm^2 = 225cm^2$

$1/d_3^2 = (1/225) cm^{-2} = 0.0040 cm^{-2}$

$P_3 = V_3 I_3 = (6)(2.0) mW = 12.0 mW$

$E_3 = I_3/d_3^2 = (2.0/225) mA\ cm^{-2} = 0.0089 mA\ cm^{-2}$

4) $d_4 = 20cm$

$d_4^2 = (20)^2 cm^2 = 400cm^2$

$1/d_4^2 = (1/400) cm^{-2} = 0.0025 cm^{-2}$

$P_4 = V_4 I_4 = (6)(1.4) mW = 8.4 mW$

$E_4 = I_4/d_4^2 = (1.4/400) mA\ cm^{-2} = 0.0035 mA\ cm^{-2}$

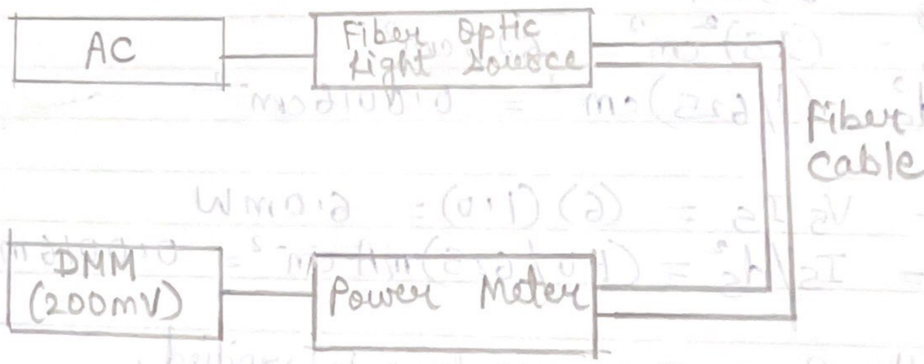
Teacher's Signature : ______

5) $d_5 = 25 cm$
$d_5^2 = (25)^2 cm^2 = 625 cm^2$
$1/d_5^2 = (1/625) cm^{-2} = 0.0016 cm^{-2}$

$P_5 = V_5 I_5 = (6)(1.0) = 6.0 mW$
$E_5 = I_5/d_5^2 = (1.0/625) mA\ cm^{-2} = 0.0016 mA\ cm^{-2}$

Result: Inverse square law is verified.

8/2/23



Setup for Loss Measurement

Experiment-6

Study of Attenuation and Propogation Characteristics of Optical fiber Cable

Aim:

(i) To determine the attenuation for the given optical fiber.

(ii) To measure the numerical aperture & hence, the acceptance angle of the given fiber cables.

Apparatus Required: Fiber optic light source, optic power meter & fiber cables (1m and 5m), Numerical aperture measurement JIG, optical fibre cable with source, screen.

(I) Attenuation in Fibres

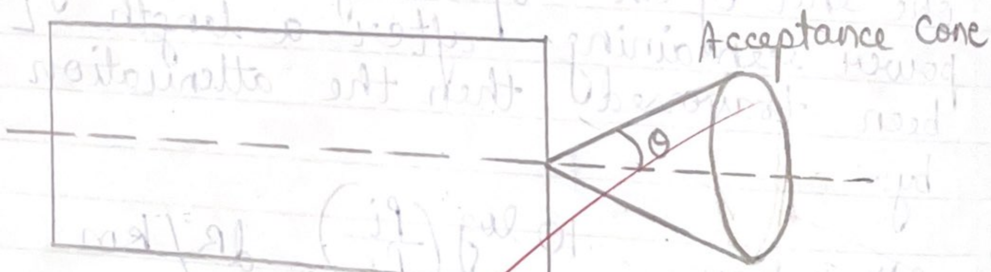
Principle: The propogation of light down dielectric waveguides bears some similarity to the propogation of microwaves down metal waveguides. If a beam of power P_i is launched into one end of an optical fiber and if P_f is the power remaining after a length L km has been traversed, then the attenuation is given by:-

$$\text{Attenuation} = \frac{10 \log\left(\frac{P_i}{P_f}\right)}{L} \text{ dB/km}$$

OBSERVATION TABLE

Determination of Attenuation for optical fiber cables ($L = 4m = 4 \times 10^{-3}$ km)

S.NO	Power output for 1m cable (P_i) [dB]	Power output for 5m cable (P_f) [dB]	Attenuation $= \frac{10 \log\left(\frac{P_i}{P_f}\right)}{L}$ dB/km
1	−90.5	−84.2	78.341219



Numerical Aperture

Formula:

$$\text{Attenuation (dB/km)} = \frac{10 \log\left(\frac{P_i}{P_f}\right)}{L}$$

Calculation:

$$\text{Attenuation} = \frac{10 \log\left(\frac{P_i}{P_f}\right)}{L} \text{ dB/km}$$

$$= \frac{10 \log\left(\frac{-90.5}{-84.2}\right)}{4 \times 10^{-3}} \text{ dB/km}$$

$$= \left(\frac{1}{4} \times 10^4 \times 0.0313364877\right) \text{ dB/km}$$

$$= 78.341219 \text{ dB/km}$$

(II) Numerical Aperture

Principle: Numerical Aperture refers to the maximum angle at which the light incident on the fibre end is totally internally reflected & transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber.

Observation Table

[Measurement of Numerical Aperture]

S.NO	distance b/w source & screen (L) (mm)	Diameter of spot (W) (mm)	$NA = \frac{W}{\sqrt{4L^2+W^2}}$	θ (in degree)
1	8	10	0.529	31.9°
2	12	15	0.530	32.0°
3	20	20	0.447	26.6°
4	36	25	0.328	19.1°
5	50	30	0.287	16.7°

Formula →

Numerical Aperture (NA) $= \dfrac{W}{\sqrt{4L^2+W^2}} = \sin\theta_{max}$

Acceptance angle $= 2\theta_{max}$ (in degree)

L = distance of screen from fiber end (in metre)
W = diameter of the spot (in metre)

Calculations

(1) $L_1 = 8mm$
$W_1 = 10mm$

$$NA_1 = \frac{W}{\sqrt{4L^2+W^2}} = \frac{10}{\sqrt{4(8)^2+(10)^2}}$$

$$\Rightarrow \boxed{NA_1 = 0.529}$$

$$\theta_1 = \sin^{-1}(NA_1) = \sin^{-1}(0.529)$$

$$\Rightarrow \boxed{\theta_1 = 31.9^\circ}$$

(2) $L_2 = 12mm$
$W_2 = 15mm$

$$NA_2 = \frac{W}{\sqrt{4L^2+W^2}} = \frac{15}{\sqrt{4(12)^2+(15)^2}}$$

$$\Rightarrow \boxed{NA_2 = 0.530}$$

$$\theta_2 = \sin^{-1}(NA_2) = \sin^{-1}(0.530)$$

$$\Rightarrow \boxed{\theta_2 = 32.0^\circ}$$

Teacher's Signature :

(3) $L_3 = 20\,mm$
$W_3 = 20\,mm$

$$NA_3 = \frac{W}{\sqrt{4L^2+W^2}} = \frac{20}{\sqrt{4(20)^2+(20)^2}}$$

$\Rightarrow \boxed{NA_3 = 0.447}$

$\theta_3 = \sin^{-1}(NA_3) \Rightarrow \theta_3 = \sin^{-1}(0.447)$
$\Rightarrow \boxed{\theta_3 = 26.6^{0}}$

(4) $L_4 = 36\,mm$
$W_4 = 25\,mm$

$$NA_4 = \frac{W}{\sqrt{4L^2+W^2}} = \frac{25}{\sqrt{4(36)^2+(25)^2}}$$

$\Rightarrow \boxed{NA_4 = 0.328}$

$\theta_4 = \sin^{-1}(NA_4) \Rightarrow \theta = \sin^{-1}(0.328)$
$\Rightarrow \boxed{\theta_4 = 19.1^{0}}$

(5) $L_5 = 50\,mm$
$W_5 = 30\,mm$

$$NA_5 = \frac{W}{\sqrt{4L^2+W^2}} = \frac{30}{\sqrt{4(50)^2+(30)^2}}$$

$\Rightarrow \boxed{NA_5 = 0.287}$

$\theta_5 = \sin^{-1}(NA_5) \Rightarrow \theta_5 = \sin^{-1}(0.287)$
$\Rightarrow \boxed{\theta_5 = 16.7^{0}}$

Teacher's Signature : ______

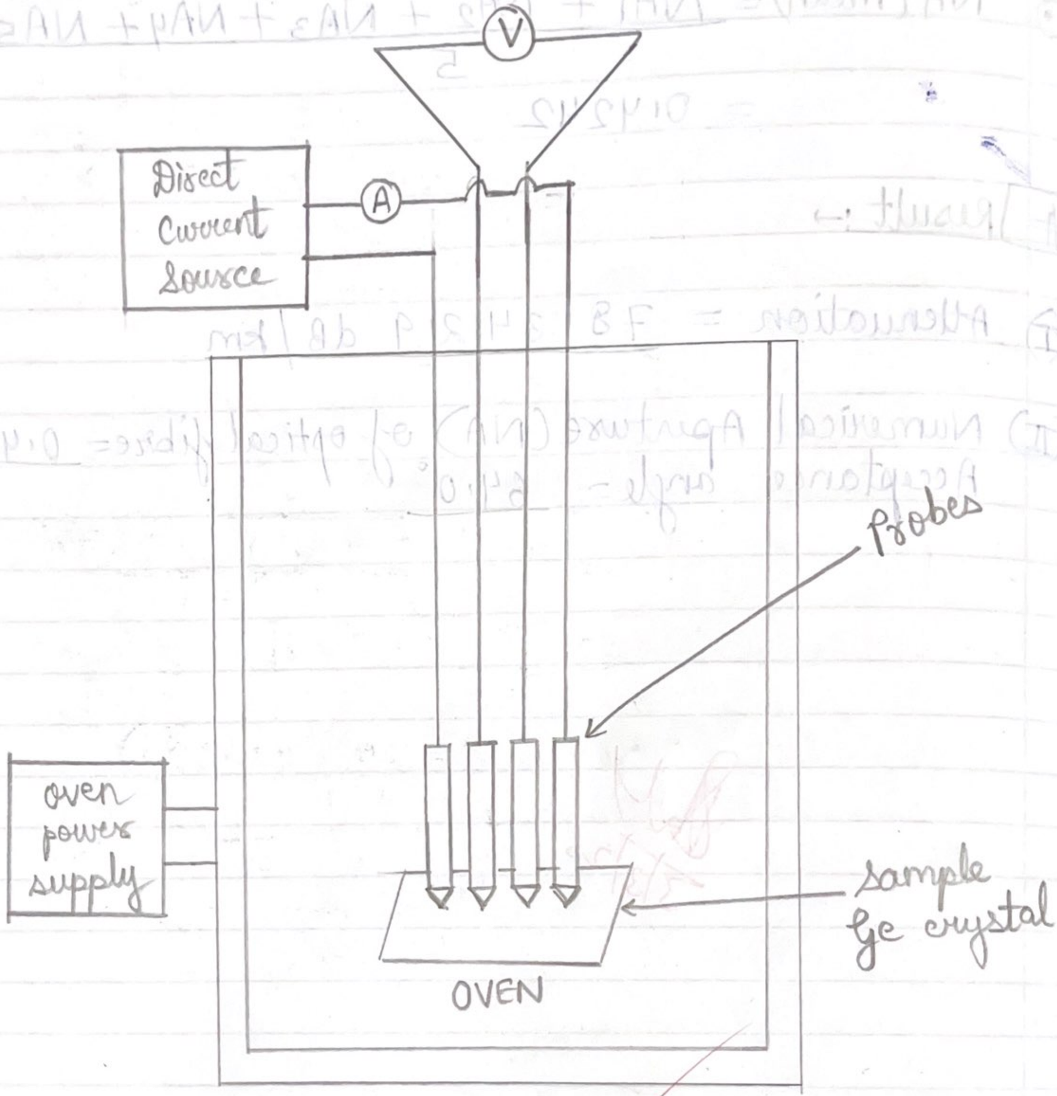
- $\theta_{max} = 32.0'$
- Acceptance angle $= 2\theta_{max}$
  $= 2(32.0^\circ)$
  $= 64.0^\circ$
- $NA\,(mean) = \frac{NA_1 + NA_2 + NA_3 + NA_4 + NA_5}{5}$
  $= 0.4242$

Result :→

(I) Attenuation = 78.341219 dB/km

(II) Numerical Aperture (NA) of optical fibre = 0.4242
Acceptance angle = 64.0°

3/3/23



Four Probe Setup

Experiment-7

Aim: To determine the energy gap of a semiconductor (germanium) using four probe method.

Apparatus Required:

Probes arrangement (it should have four probes, coated with zinc at the tips). The probes should be equally spaced & must be in a good electrical contact with the sample. (Germanium or silicon crystal chip with non-conducting base).

Oven (for the variation of temperature of the crystal from room temp. to about 200°C). A constant current generator (open circuit voltage about 20V, current range 0 to 10mA), milivoltmeter (range from 100mV to 3V), power supply from oven thermometer.

Formula:

The Energy band gap, E_g of semiconductor is given by →

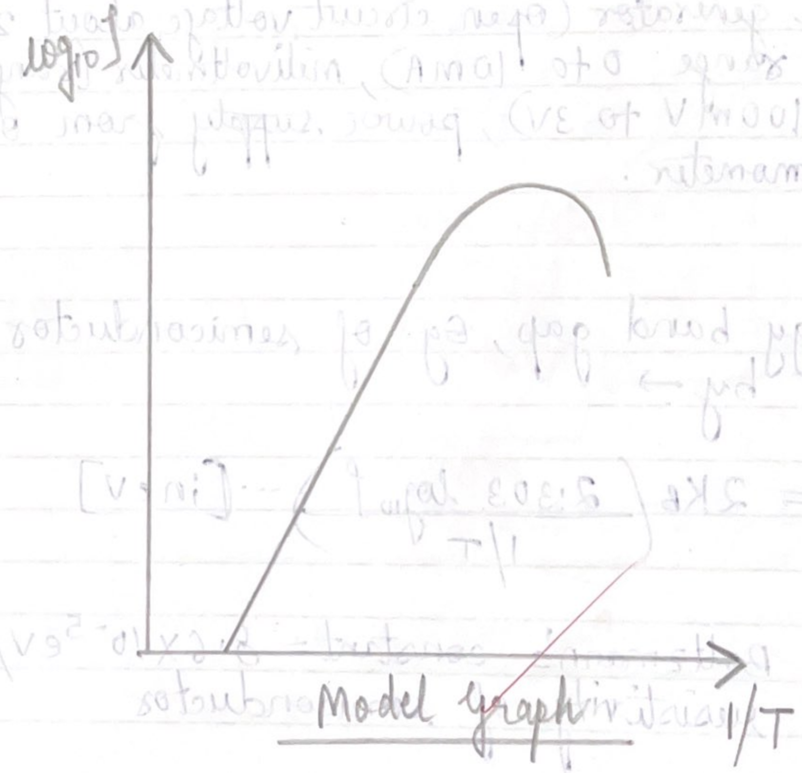
$$E_g = 2K_B\left(\frac{2.303 \log_{10} \rho}{1/T}\right) \cdots [\text{in eV}]$$

Here, K_B = Boltzmann's constant = 8.6×10^{-5} eV/K

and ρ = resistivity of semiconductor

Observation Table

S.NO	Temperature		Voltage(V) (volts)	Resistivity(ρ) (ohm-cm)	$10^3/T$ (K^{-1})	$\log_{10}\rho$
	°C	K				
1	35°C	303K	237V	25.2405	3.24	1.402
2	40°C	313K	232V	24.708	3.19	1.392
3	45°C	318K	224V	23.356	3.14	1.377
4	50°C	323K	213V	23.217	3.09	1.365
5	55°C	328K	210V	22.365	3.04	1.349
6	60°C	333K	200V	21.300	3.00	1.323



Model Graph

$$\rho = \frac{\rho_0}{f(W/s)} \quad \text{where } \rho_0 = \frac{V}{I} \times 2\pi s$$

$$\Rightarrow \rho = \frac{V}{I}(0.213)$$

where, $s \rightarrow$ distance b/w probes
$W \rightarrow$ thickness of semi-conducting material (crystal)
V and I are voltage & current across & through the crystal chip.

graph: Plot a graph in $\left(\frac{10^3}{T}\right)$ and $\log_{10} \rho$

Slope of curve $(AB/BC) = \log_{10}\rho / (10^3/T)$

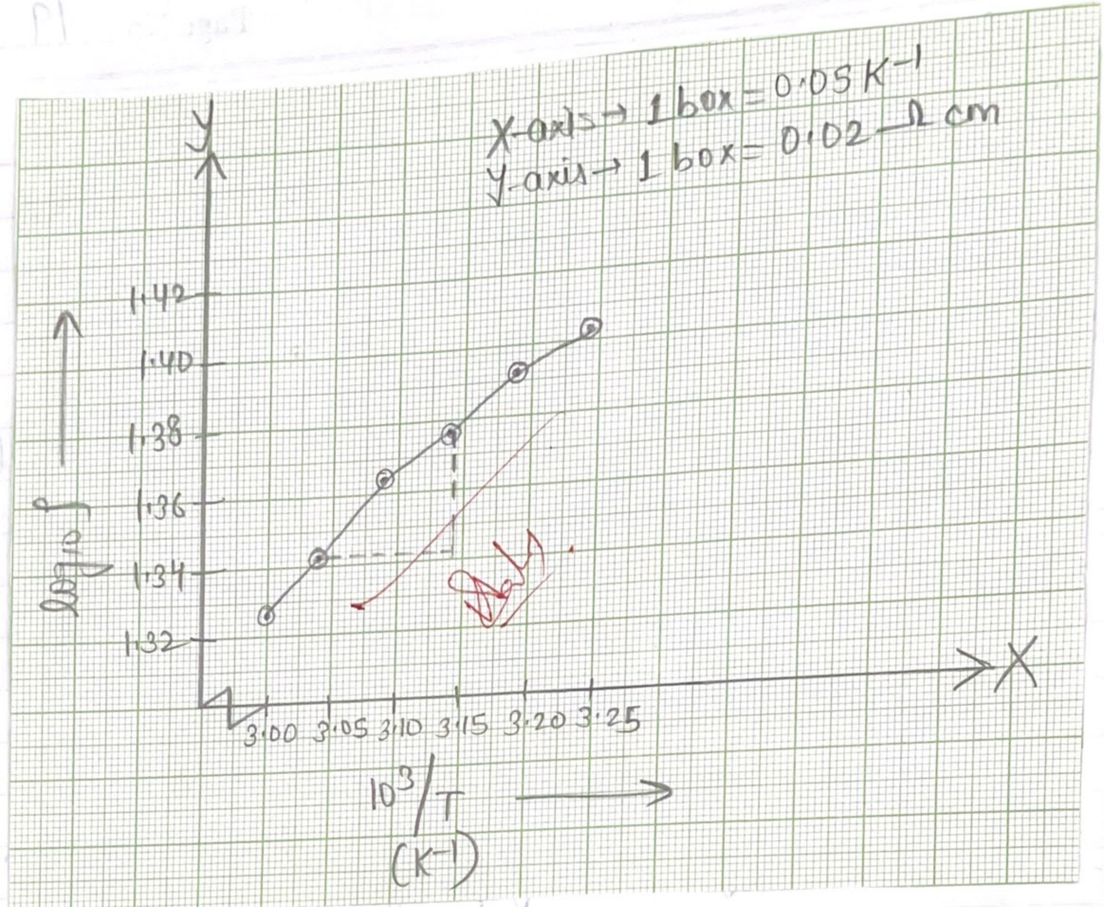
So, the energy band gap of semiconductor is –

$$E_g = \frac{2K \times 2.303 \log_{10}\rho}{(1/T)}$$

$$E_g = 2K \times 2.303 \times \frac{AB}{CD} \times 1000$$

$$\Rightarrow E_g = \left[2 \times 8.6 \times 10^{-5} \times 2.303 \times 1000 \left(\frac{AB}{CD}\right)\right] eV$$

$$\Rightarrow E_g = \left(0.396 \times \frac{AB}{CD}\right) eV$$



Actual graph

Calculations:

⊛ Values of ρ (Resistivity) → $\left[\rho = 0.213 \times \frac{V}{I}\right]$

1) 308K ; $\rho = 0.213 \times \frac{237}{2} = 25.2405\ \Omega\,cm$.

2) 313K ; $\rho = 0.213 \times \frac{232}{2} = 24.703\ \Omega\,cm$

3) 318K ; $\rho = 0.213 \times \frac{224}{2} = 23.856\ \Omega\,cm$

4) 323K ; $\rho = 0.213 \times \frac{213}{2} = 23.217\ \Omega\,cm$

5) 328K ; $\rho = 0.213 \times \frac{210}{2} = 22.365\ \Omega\,cm$

6) 333K ; $\rho = 0.213 \times \frac{200}{2} = 21.300\ \Omega\,cm$.

⊛ Values of $\log_{10}\rho$

1) $\rho = 25.2405\ \Omega\,cm$; $\log_{10}\rho = \log_{10}(25.2405) = 1.402\ \Omega\,cm$

2) $\rho = 24.708\ \Omega\,cm$; $\log_{10}\rho = \log_{10}(24.708) = 1.392\ \Omega\,cm$

3) $\rho = 23.856\ \Omega\,cm$; $\log_{10}\rho = \log_{10}(23.856) = 1.377\ \Omega\,cm$

4) $\rho = 23.217\ \Omega\,cm$; $\log_{10}\rho = \log_{10}(23.217) = 1.365\ \Omega\,cm$

5) $\rho = 22.365\ \Omega\,cm$; $\log_{10}\rho = \log_{10}(22.365) = 1.349\ \Omega\,cm$.

Teacher's Signature : ____________

6) $\rho = 21.3\ \Omega\,cm$; $\log_{10}\rho = \log_{10}(21.3) = 1.328\ \Omega\,cm$

* Values of $E_g = \frac{2K \times 2.303 \log_{10}\rho \times 10^3}{1/T \times 10^3}$

$\Rightarrow E_g = \frac{2 \times 8.6 \times 10^{-5} \times 2.303 \log_{10}\rho \times 1000}{10^3/T}$

$\Rightarrow E_g = \boxed{0.396 \times \frac{\log_{10}\rho}{10^3/T}}\ eV$

1) $E_{g1} = 0.396 \times \frac{1.402}{3.24} = 0.1713\ eV$

2) $E_{g2} = 0.396 \times \frac{1.392}{3.19} = 0.1728\ eV$

3) $E_{g3} = 0.396 \times \frac{1.377}{3.14} = 0.1736\ eV$

4) $E_{g4} = 0.396 \times \frac{1.365}{3.09} = 0.1749\ eV$

5) $E_{g5} = 0.396 \times \frac{1.349}{3.04} = 0.1757\ eV$

6) $E_{g6} = 0.396 \times \frac{1.328}{3.00} = 0.1752\ eV$

Observations:

Distance b/w probes (S) = 2mm

Thickness of crystal chip (W) = 0.47mm

Current (I) = 2mA

Result:

Energy Band gap for semiconductor (germanium) is $E_g = 0.1739\ eV$.

Teacher's Signature : 21/3/23

Observation Table

S.No	2θ	$\sin^2\theta$	$1 \times \frac{\sin^2\theta}{(\sin^2\theta)_{min}}$	$2 \times \frac{\sin^2\theta}{(\sin^2\theta)_{min}}$	$3 \times \frac{\sin^2\theta}{(\sin^2\theta)_{min}}$	$h^2+k^2+l^2$	h k l	a (Å)	d (Å)
1	38.43	0.108	1.00	2.00	3.00	3	1 1 1	4.16	2.40
2	44.67	0.144	1.33	2.66	3.99	4	2 0 0	4.16	2.08
3	65.02	0.288	2.66	5.32	7.98	8	2 2 0	4.11	1.45
4	78.13	0.397	3.67	7.34	11.01	11	3 1 1	4.05	1.22
5	82.33	0.433	4.00	8.00	12.00	12	2 2 2	4.10	1.18
6	93.93	0.577	5.34	10.68	16.02	16	4 0 0	4.10	1.02
7	111.83	0.685	6.34	12.68	19.02	19	3 3 1	4.10	0.94
8	116.36	0.722	6.68	13.36	20.04	20	4 2 0	4.05	0.90

Values of $h^2+k^2+l^2$ for different planes

h k l	$h^2+k^2+l^2$	h k l	$h^2+k^2+l^2$
1 0 0	1	3 0 0	9
1 1 0	2	3 1 0	10
1 1 1	3	3 1 1	11
2 0 0	4	2 2 2	12
2 1 0	5	3 2 0	13
2 1 1	6	3 2 1	14
2 2 0	8	4 1 0	17

Experiment-8

Aim: To calculate the lattice cell parameters from the powder X-ray diffraction data.

Apparatus Reqd: Powder X-ray diffraction diagram.

Formula:

For a cubic crystal $= \frac{1}{\alpha^2} = \frac{(h^2+k^2+l^2)}{a^2}$

For tetragonal crystal $= \frac{1}{\alpha^2} = \left[\frac{h^2+k^2}{a^2} + \frac{l^2}{c^2}\right]$

For an orthogonal crystal $= \frac{1}{\alpha^2} = \left(\frac{h^2}{a^2}\right) + \left(\frac{k^2}{b^2}\right) + \left(\frac{l^2}{c^2}\right)$

The lattice parameters & interplanar distance are given for a cubic crystal as,

$$a = \frac{\lambda}{2\sin\theta}\sqrt{h^2+k^2+l^2} \ \mathring{A}$$

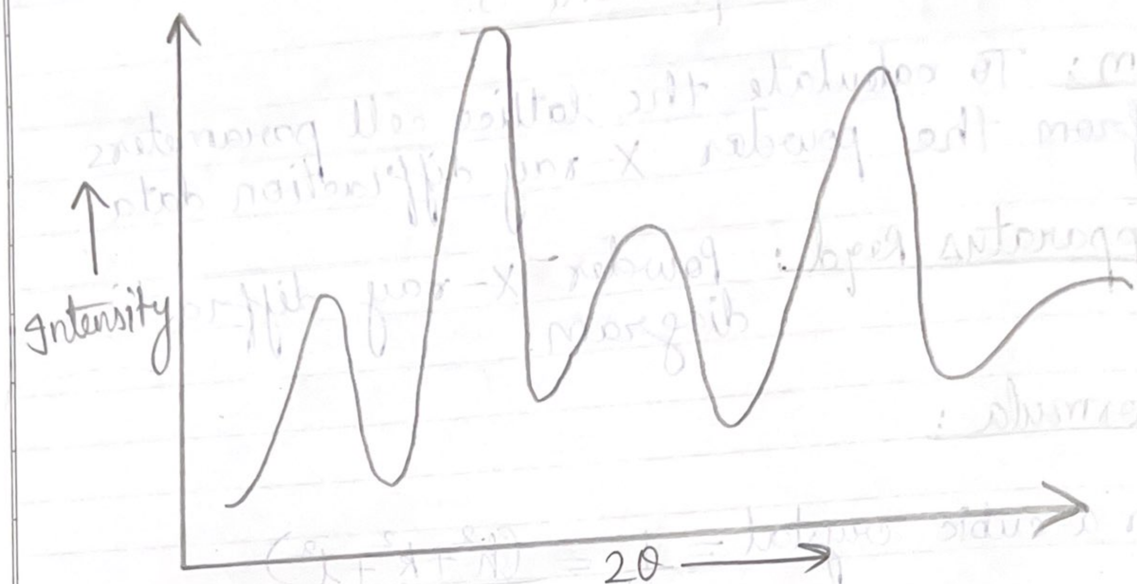
$$\alpha = \frac{a}{\sqrt{h^2+k^2+l^2}} \ \mathring{A}$$

where, a = lattice parameters ; λ = wavelength of CuKα radiation (1.5405)

α = Interplanar distance

h, k, l = Miller indices

Teacher's Signature :



XRD Pattern

Lattice type	$h^2+k^2+l^2$
Primitive lattice	1, 2, 3, 4, 5, 6, 8, ...
Body-centered	2, 4, 6, 8, 10, 12, ...
Face-Centered	3, 4, 8, 11, 12, 16, 19, 20, ...
Diamond Cubic	3, 8, 11, 16, 19, 24, ...

Lattice Determination

Principle: Bragg's law is the theoretical basis for X-ray diffraction.

$$(\sin^2\theta)_{hkl} = \frac{\lambda^2}{4a^2}(h^2+k^2+l^2)$$

Each of the miller indices can take values 0, 1, 2, 3, ...
Thus, the factor $(h^2+k^2+l^2)$ takes the values given in table.
The problem of indexing lies in fixing the correct value of a by inspection of the $\sin^2\theta$ values.

Calculation:

$a_1 = \frac{1.54 \times \sqrt{3}}{2 \times 0.32} = 4.16\ A^\circ$; $d_1 = \frac{4.16}{\sqrt{3}} = 2.40\ A^\circ$

$a_2 = \frac{1.54 \times \sqrt{4}}{2 \times 0.37} = 4.16\ A^\circ$; $d_2 = \frac{4.16}{\sqrt{4}} = 2.08\ A^\circ$

$a_3 = \frac{1.54 \times \sqrt{8}}{2 \times 0.53} = 4.11\ A^\circ$; $d_3 = \frac{4.11}{\sqrt{8}} = 1.45\ A^\circ$

$a_4 = \frac{1.54 \times \sqrt{11}}{2 \times 0.63} = 4.05\ A^\circ$; $d_4 = \frac{4.05}{\sqrt{11}} = 1.22\ A^\circ$

$a_5 = \frac{1.54 \times \sqrt{12}}{2 \times 0.65} = 4.10\ A^\circ$; $d_5 = \frac{4.10}{\sqrt{12}} = 1.18\ A^\circ$

$a_6 = \frac{1.54}{2 \times 0.75} \times \sqrt{16} = 4.10 A^\circ$; $d_6 = \frac{4.10}{\sqrt{16}} = 1.02 A^\circ$

$a_7 = \frac{1.54}{2 \times 0.82} \times \sqrt{19} = 4.10 A^\circ$; $d_7 = \frac{4.10}{\sqrt{19}} = 0.94 A^\circ$

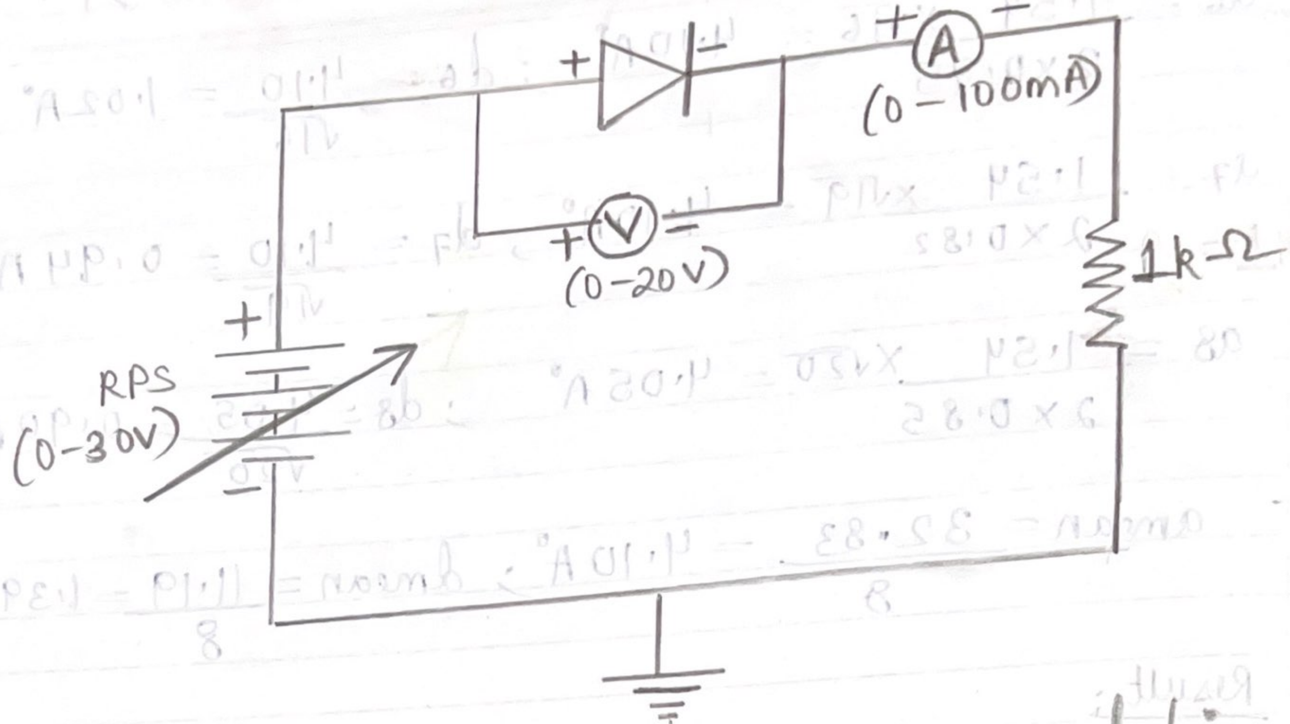
$a_8 = \frac{1.54}{2 \times 0.85} \times \sqrt{20} = 4.05 A^\circ$; $d_8 = \frac{4.05}{\sqrt{20}} = 0.90 A^\circ$

$a_{mean} = \frac{32.83}{8} = 4.10 A^\circ$; $d_{mean} = \frac{11.19}{8} = 1.39 A^\circ$

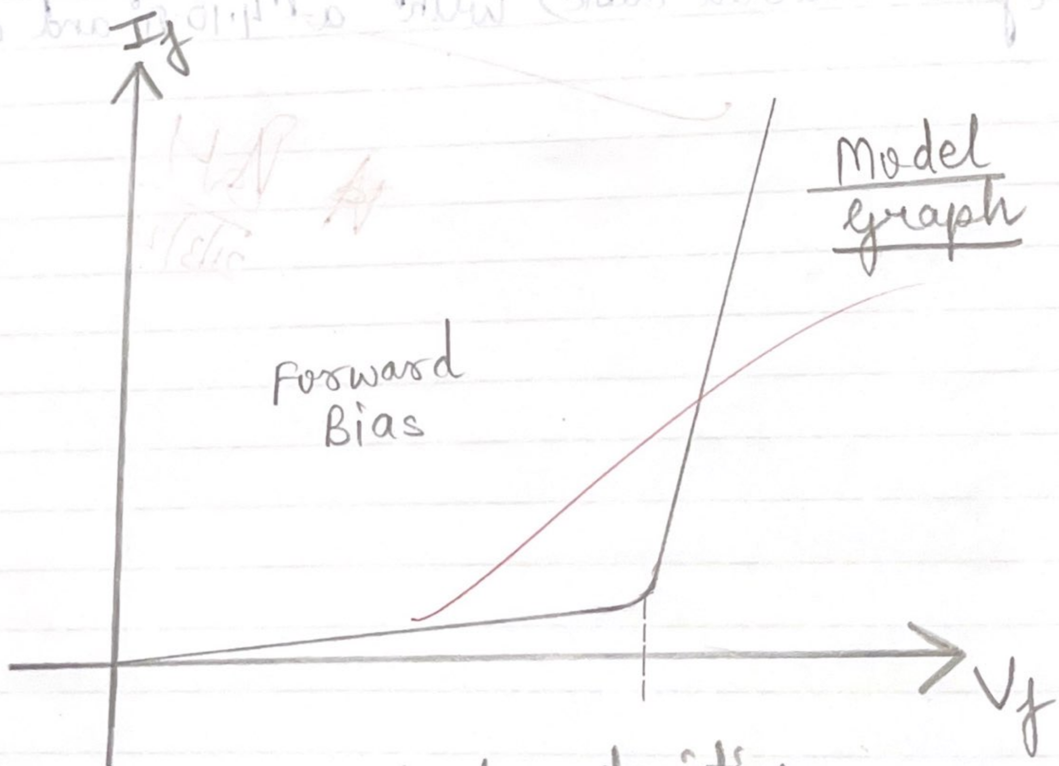
Result :

The lattice parameters are calculated theoretically from the powder X-ray diffraction pattern (face-centered cubic) with $a = 4.10 A^\circ$ and $d = 1.39 A^\circ$

A
21/3/23



P-N junction diode in forward bias



I-V characteristics

Experiment - 9 - (A)

Aim: To plot the characteristics curve of P-N junction diode in forward bias.

Apparatus Required: A diode, DC voltage supplies, breadboard, 100 Ω resistor, 2 multimeter for measuring current & voltage, connecting wires.

Principle: For the forward-bias of P-N junction diode, P-type is connected to +ve terminal & N-type is connected to -ve terminal of the battery. The potential of the diode can be varied with the help of potential divider. At some forward voltage (0.3V for Ge and 0.7V for Si) the potential barrier is all-together eliminated & current starts flowing due to majority-charge carriers. This voltage is known as threshold voltage (V_{th}) or knee voltage. It is practically same as barrier voltage V_e. For $V < V_e$, the current is negligible. As forward applied voltage increases beyond V_{th}, the forward current rises exponentially. In forward bias, the width of depletion layer decreases.

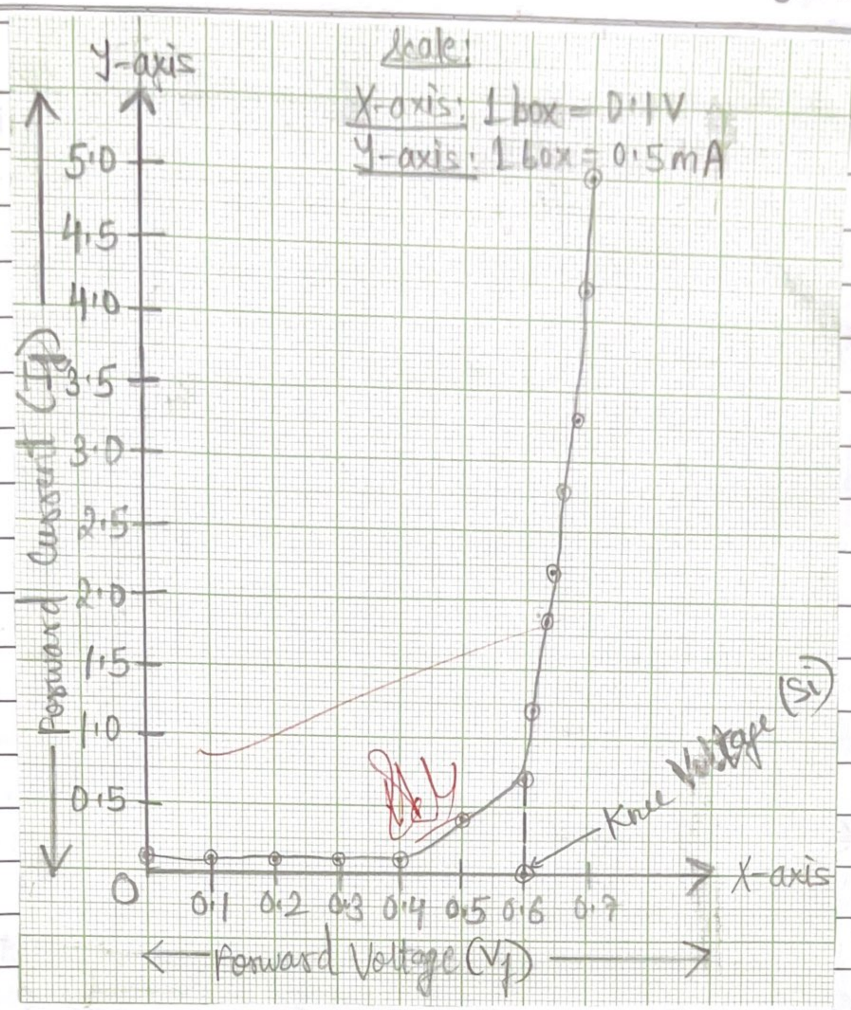
P.T.O.

Teacher's Signature :

OBSERVATION TABLE

S.NO	Forward Voltage (V)	Forward Current (mA)
1	0.00	0.1
2	0.10	0.1
3	0.20	0.1
4	0.30	0.1
5	0.40	0.1
6	0.50	0.4
7	0.60	0.7
8	0.61	1.2
9	0.63	1.9
10	0.64	2.2
11	0.66	2.8
12	0.68	3.3
13	0.69	4.2
14	0.70	5.0

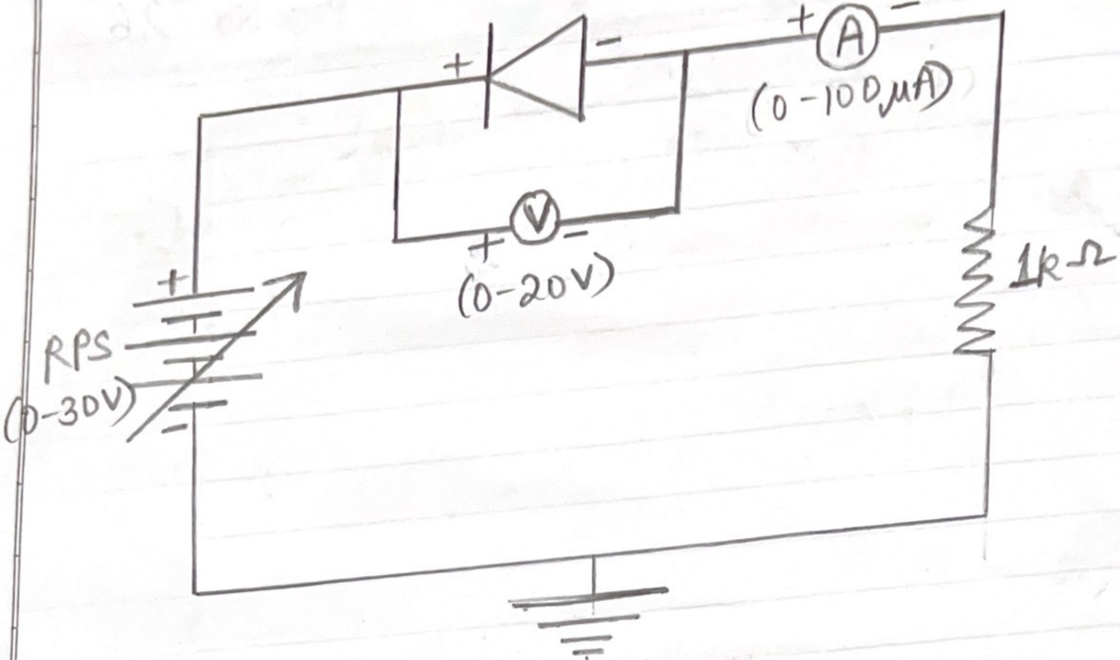
Graph:



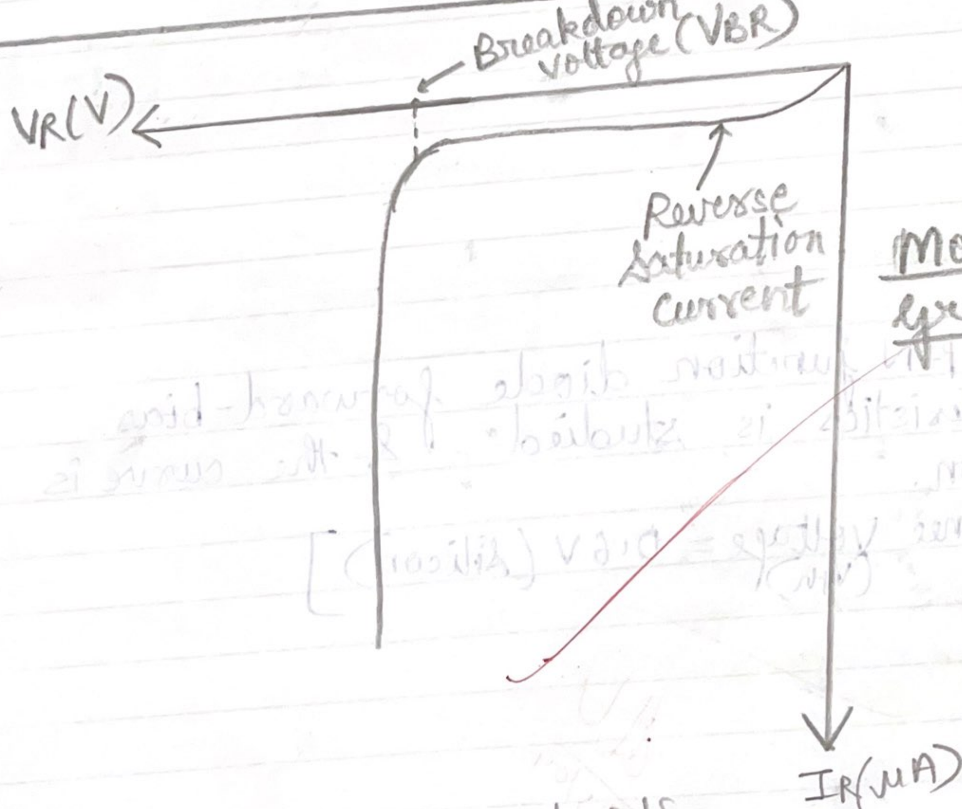
Result: p-N junction diode forward-bias characteristics is studied & the curve is drawn.

[Knee voltage (V_{th}) = 0·6 V (Silicon)]

05/04



Circuit Diagram



Model graph

I-V characteristics

Experiment-9~~0~~-(B)

Aim: To plot the characteristics curve of P-N junction diode in reverse bias.

Apparatus Required: A diode, DC voltage suppliers, breadboard, 100 Ω resistor, 2 multimeters for measuring current & voltage and connecting wires.

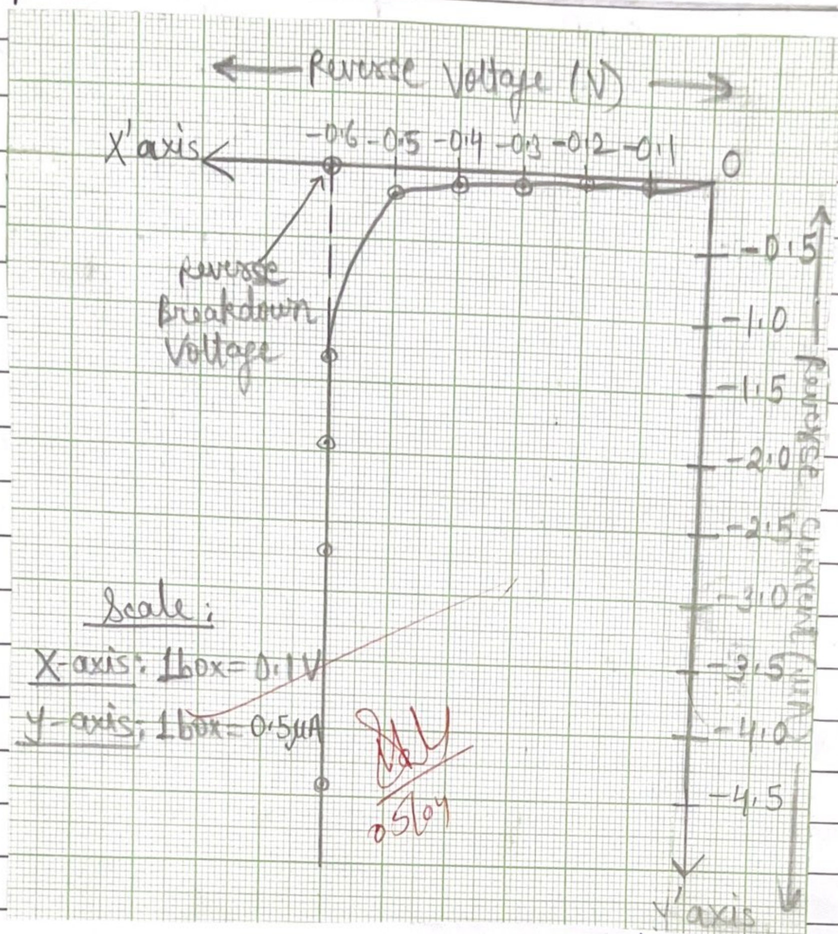
Principle: For the reverse bias of P-N junction diode, P-type is connected to -ve terminal and N-type is connected to +ve terminal of the battery. Under normal reverse voltage, a very little current flows through P-N junction diode by minority charge carriers. But when reverse voltage is increased, a point is reached when the junction breakdowns with sudden rise in reverse current. This critical value of voltage is called breakdown voltage (V_{BR}). In reverse bias, the width of depletion layer increases.

P.T.O.

OBSERVATION TABLE

S.NO	Reverse Voltage(V)	Reverse Current(μA)
1	-0.1	-0.07
2	-0.2	-0.07
3	-0.3	-0.07
4	-0.4	-0.10
5	-0.5	-0.17
6	-0.6	-1.33
7	-0.6	-1.92
8	-0.6	-2.74
9	-0.6	-4.42

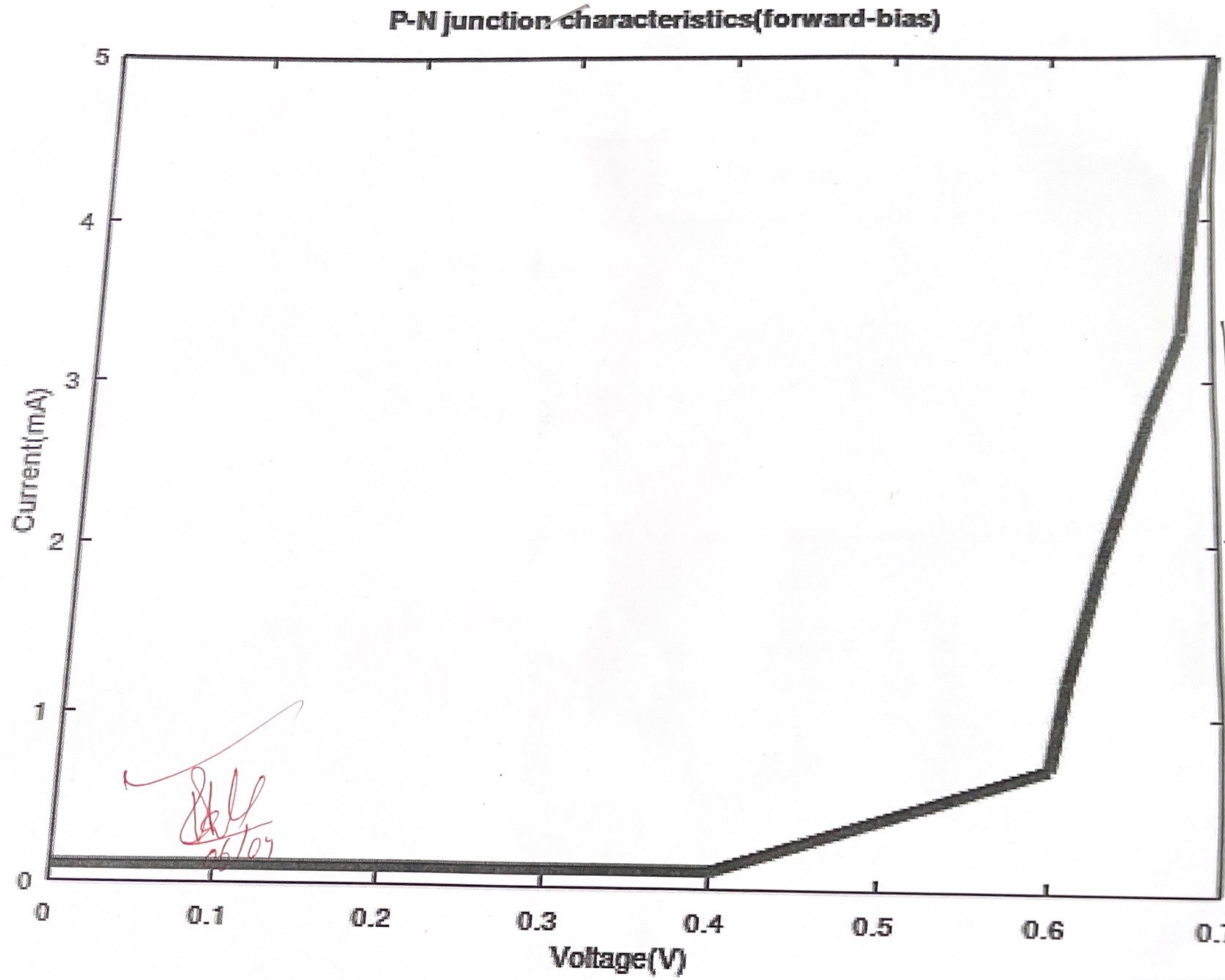
Graph:



Result: P-N junction diode reverse-bias characteristics is studied & the curve is drawn.

[Reverse Breakdown Voltage (V_{BR}) = 0.6 V (Si)]

Teacher's Signature : ______



(P.L.O.) — [Phase Lift Over]

GNU Octave graph [Forward-Bias]

Date 13/3/20

Expt. No. 10 Page No. 29

Experiment-10

Aim: To plot & interpret I-V characteristics of P-N junction diode using GNU Octave.

Materials Required: Computer, GNU Octave Software, Readings (Forward & Reverse Bias).

Program:→ ** FORWARD - BIAS **

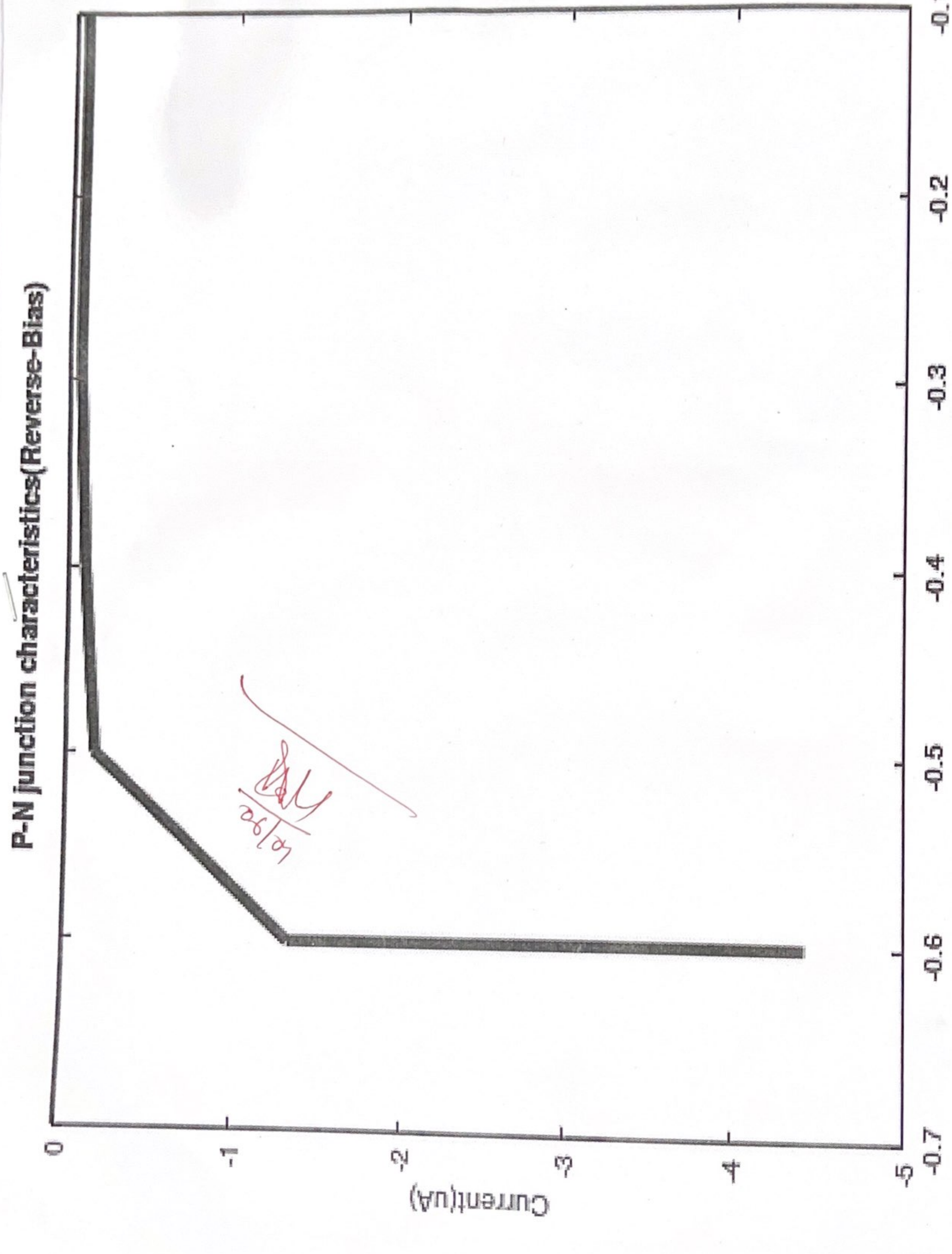
```
#A = Voltage
# B = Current
A= [0.00  0.10  0.20  0.30  0.40  0.50  0.60  0.61
    0.63  0.64  0.66  0.68  0.69  0.70 ];
B = [0.1 0.1 0.1 0.1 0.1 0.4 0.7 1.2 1.9 2.2
     2.8  3.3  4.2  5.0];
plot (A, B);
plot (A, B, 'r');
plot (A, B, 'r', 'linewidth', 2);
xlabel ('voltage (V)');
ylabel ('Current (mA)');
title ('PN Junction Characteristics (Forward-Bias)');
```

P.T.O.

Teacher's Signature :

(P.L.O.) (Please Lift Over)

GNU Octave graph (Reverse-Bias)

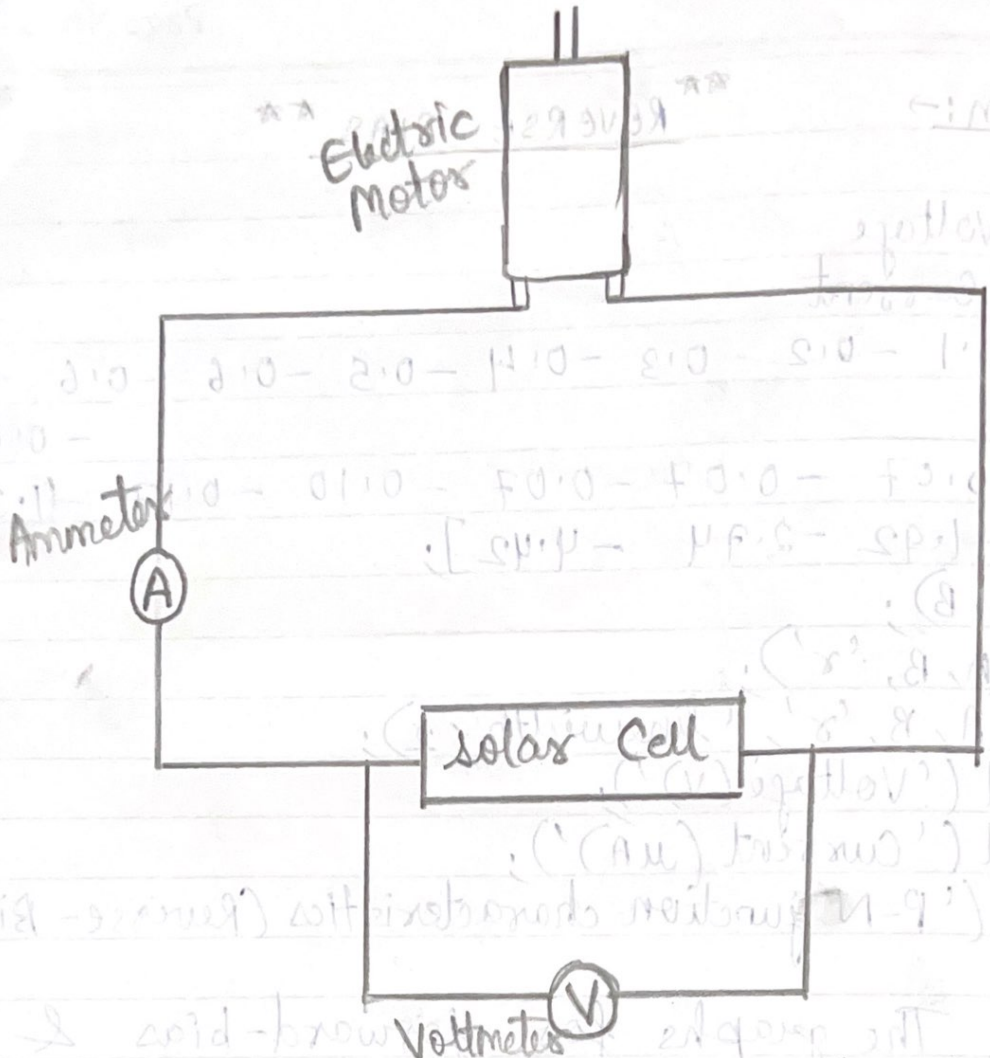


Program:→ **REVERSE-BIAS**

```
#A = Voltage
# B = Current
A=[-0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.6 -0.6
   -0.6];
B=[-0.07 -0.07 -0.07 -0.10 -0.17 -1.33
   -1.92 -2.74 -4.42];
plot(A, B);
plot (A, B, 'r');
plot (A, B, 'r', 'linewidth', 2);
xlabel ('Voltage(V)');
ylabel ('Current (µA)');
title ('P-N junction characteristics (Reverse-Bias)');
```

Result: The graphs for forward-bias & reverse-bias characteristics of P-N junction diode are obtained.

06/04



Solar Cell Efficiency Test Circuit Diagram

Observation Table

S.No	Trial(d)	Voltage (V)	Current(A)	Power (W)
1	14 cm	1.0	0.00400	0.004000
2	15 cm	0.9	0.000375	0.003375
3	16 cm	0.8	0.000325	0.002600

Experiment-12-(B)

Aim: To explore solar cells as renewable energy sources & test their efficiency in converting solar radiation to electrical power.

Apparatus Required: Solar cell, Variable Resistor, Digital Multimeter (DMM), Electric Motor, Desk Lamp, Protractor, Vernier Calliper.

Formula:

$$\boxed{\eta = \frac{P}{E \times A} \times 100}$$

$P \rightarrow$ Input Power
$E \rightarrow$ Applied Input Voltage
$A \rightarrow$ Area of Solar cell.

calculations:

Applied Input Voltage = 350mW
l (length) = 3.5 cm
b (breadth) = 1.7 cm

Area(A) = $l \times b = (3.5 \times 1.7)\,cm^2 = 5.95\,cm^2$
$= 0.000595\,m^2$

Least count (Ammeter) = 0.5 mA
Least count (Voltmeter) = 10 V

(i) $d = 14\,cm$

$V = 100\,mV = (0.1 \times 10)\,V = 1\,V$; $A = 8\,mA = (0.008 \times 0.5)\,A = 0.004\,A$; $P = V \times I = 0.004\,W$

(ii) $d = 15\,cm$

$V = 90\,mV = (0.09 \times 10)\,V = 0.9\,V$; $A = 7.5\,mA = (0.0075 \times 0.5)\,A = 0.00375\,A$; $P = V \times I$ ~~0.00226 W~~ $= 0.003375\,W$

(iii) $d = 16\,cm$

$V = 80\,mV = (0.08 \times 10)\,V = 0.8\,V$; $A = 6.5\,mA = (0.0065 \times 0.5)\,V = 0.00325\,A$; $P = V \times I = 0.0026\,W$

$$P_{avg} = \frac{0.004 + 0.003375 + 0.0026}{3} = \frac{0.009975}{3} = 0.003325\,W$$

$$\eta = \frac{P}{E \times A} \times 100$$

$$\Rightarrow \eta = \frac{0.003325 \times 10^6}{350 \times 0.000595 \times 10^6} \times 100$$

$$\Rightarrow \eta = 1.596\%$$

06/04

Result: Efficiency ($\eta = 1.596\%$) is calculated.

Experiment - 11

Aim: Determination of fermi function for different temperatures using GNU Octave.

Materials Required: Computer, GNU Octave Software, Readings.

Problem: Plot Fermi - Dirac Distribution function using the following equation & given parameters

$$f(E) = \frac{1}{1 + \exp((E - E_f)/K_B T)}$$

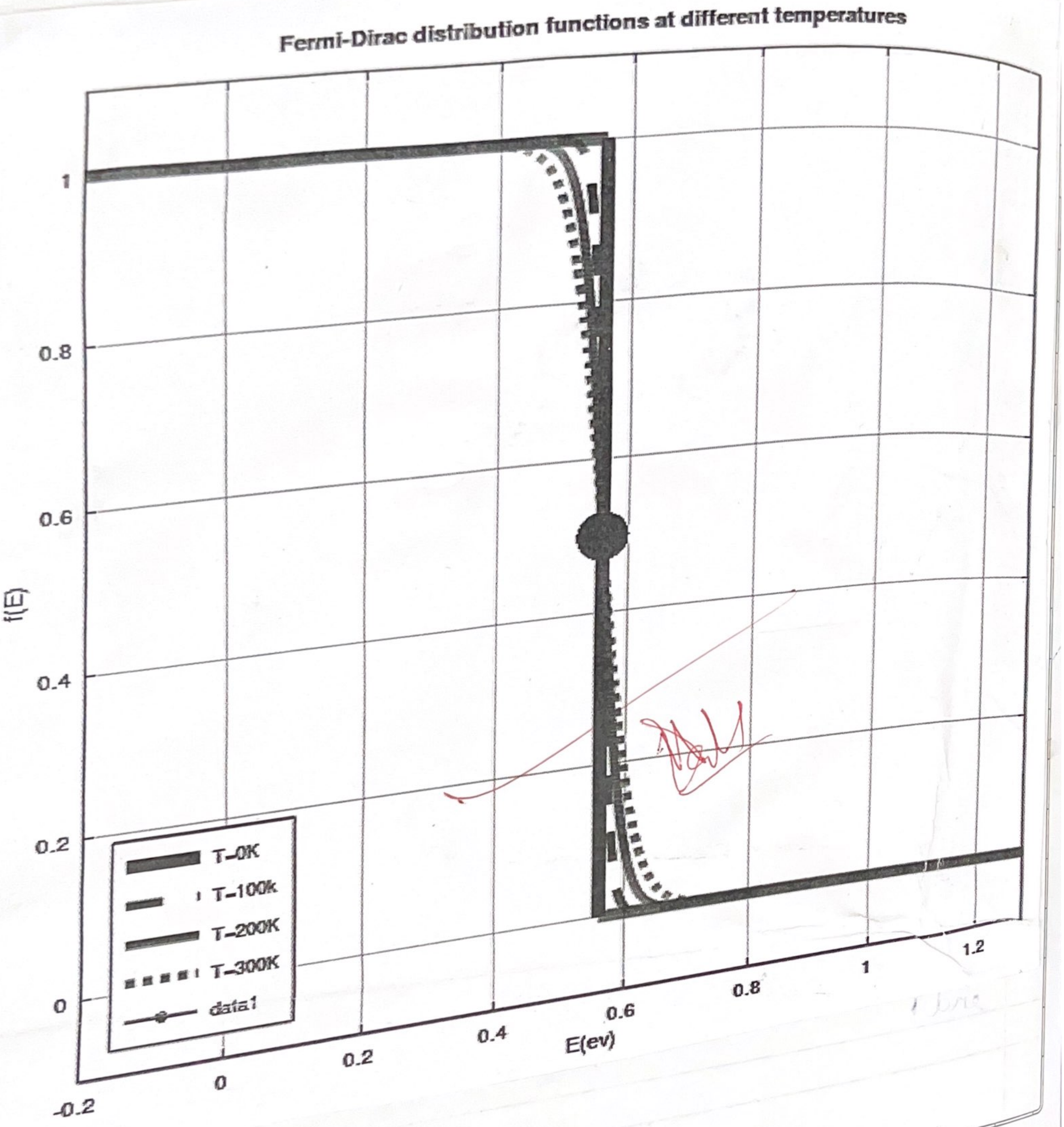
$K_B = 8.617E-5$; % in eV/K.
$E_F = 0.56$; % Fermi level in eV
$E = -0.2eV$ to $1.4eV$; % Energy range

Program:

```
Ef = 0.56;
E = -0.2 : 0.0005 : 1.4;
fT0 = zeros(size(E));
for k=1 : length(E);
if E(k) < Ef fT0(k) = 1;
elseif E(k) == Ef fT0(k) = 0.5; end
end
```

P.T.O

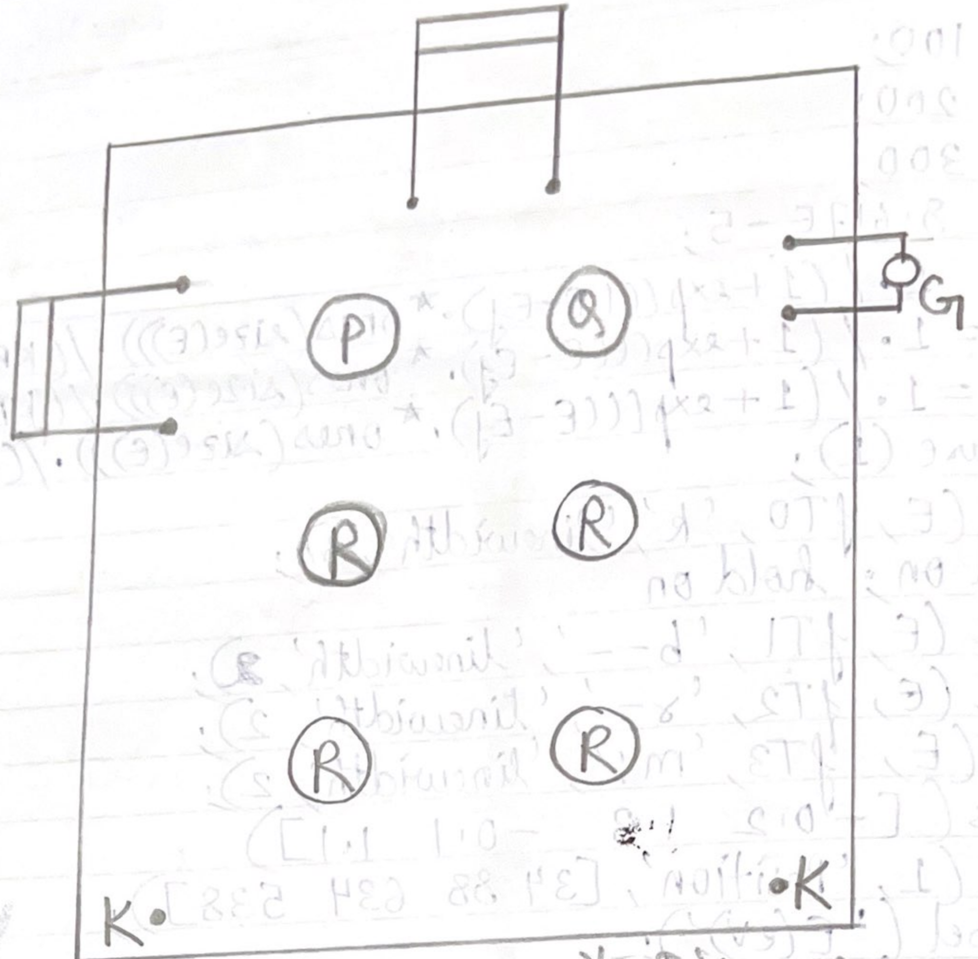
GNU octave graph



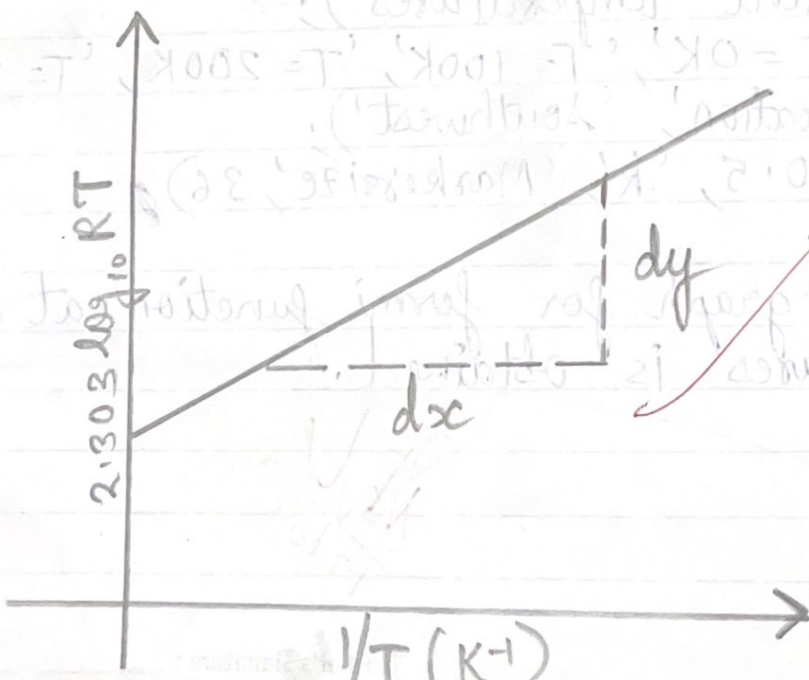
```
T1 = 100;
T2 = 200;
T3 = 300;
KB = 8.617E-5;
fT1 = 1./(1+exp(((E-Ef).*ones(size(E)))./(KB.*T1)));
fT2 = 1./(1+exp(((E-Ef).*ones(size(E)))./(KB.*T2)));
fT3 = 1./(1+exp(((E-Ef).*ones(size(E)))./(KB.*T3)));
figure(1);
plot(E, fT0, 'k', 'linewidth', 3);
grid on; hold on
plot (E, fT1, 'b--', 'linewidth', 2);
plot (E, fT2, 'r-', 'linewidth', 2);
plot(E, fT3, 'm:', 'linewidth', 2);
axis([-0.2 1.3 -0.1 1.1])
set(1, 'Position', [34 88 634 538]);
xlabel('E(eV)');
ylabel('f(E)');
title('Fermi-Dirac distribution functions at
      different temperatures');
legend('T=0K', 'T=100K', 'T=200K', 'T=300K',
       'Location', 'southwest');
plot(Ef, 0.5, 'k', 'Markersize', 36)
```

Result: The graph for fermi function at different temperatures is obtained.

12/04



Post office Box – Circuit Diagram



Model Graph

Experiment-12

Aim: To find the band gap of the material of the given thermistor using post-office box.

Apparatus Required: Thermistor, thermometer, post-office box, power supply, galvanometer, insulating coil & glass beakers.

Principle & Formulae:

(1) Wheatstone's principle for balancing a network

$$\left(\frac{P}{Q} = \frac{R}{S}\right)$$

Of the 4 resistances, if 3 resistances are known and 1 is unknown, the unknown resistance can be calculated.

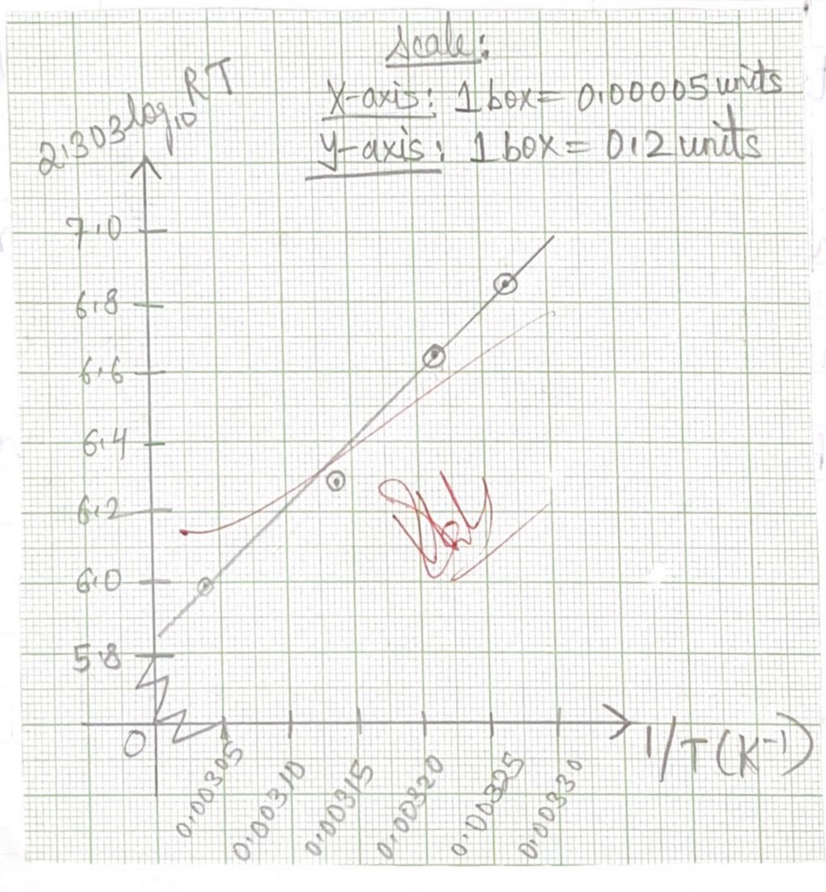
(2) The band gap for semiconductor is given by -

$$E_g = 2K\left(\frac{2.303 \log_e R_T}{1/T}\right)$$

where K = Boltzmann constant = 1.38×10^{-23} J/K
R_T = Resistance at T Kelvin

Observation Table

S.NO	Temp. of thermistor $T = t+273$ (K)	$1/T$ (K^{-1})	Resistance in P (ohm)	Resistance in Q (ohm)	Resistance in R (ohm)	Resistance of thermistor $R_T = \frac{P}{Q} \times R$ (ohm)	$2.303 \times \log_{10} R_T$ (ohm)
1	305	0.00327	10	10	946	946	6.853
2	310	0.00322	10	10	740	740	6.607
3	318	0.00314	10	10	528	528	6.270
4	328	0.00304	10	10	400	400	5.992



Calculations :→

* Value of $1/T$

(1) $T = 305\,K$; $1/T = 0.00327\,K^{-1}$
(2) $T = 310\,K$; $1/T = 0.00322\,K^{-1}$
(3) $T = 318\,K$; $1/T = 0.00314\,K^{-1}$
(4) $T = 328\,K$; $1/T = 0.00304\,K^{-1}$

* Value of $2.303 \log_{10} R_T$

(1) $R_T = 946\,\Omega \Rightarrow (2.303)\log_{10}(946) = 6.853\,\Omega$
(2) $R_T = 740\,\Omega \Rightarrow (2.303)\log_{10}(740) = 6.607\,\Omega$
(3) $R_T = 528\,\Omega \Rightarrow (2.303)\log_{10}(528) = 6.207\,\Omega$
(4) $R_T = 400\,\Omega \Rightarrow (2.303)\log_{10}(400) = 5.992\,\Omega$

$$(2.303 \log_{10} R_T)_{mean} = \left[\frac{6.853 + 6.607 + 6.207 + 5.992}{4}\right]\Omega$$
$$= 6.414\,\Omega$$

$$(1/T)_{mean} = \left[\frac{(0.00327) + (0.00322) + (0.00314) + (0.00304)}{4}\right]K^{-1}$$
$$= 0.00316\,K^{-1}$$

$$E_g \text{ (band gap)} = 2K \times \frac{2.303 \log_{10} R_T}{1/T}$$

$$E_g = 2 \times 1.38 \times 10^{-23} \times \frac{6.414}{0.00316} = \frac{17.702}{0.00316} \times 10^{-23}$$
$$= 5601.89 \times 10^{-23}$$
$$= 5.601 \times 10^{-20}\,J$$

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$$= \frac{0.5601}{1.6}\,\cancel{e}V = 0.3500\,eV$$

from graph → $\frac{dy}{dx} = \frac{6.853 - 5.992}{0.00327 - 0.00304} = \frac{0.861}{0.00023}$

$= 3743.47 \Omega K$

Band gap :→ $E_g = 2K\left(\frac{dy}{dx}\right) = 2 \times 1.38 \times 10^{-23} \times 3743.47$

$= \frac{10331.9 \times 10^{-23}}{1.6 \times 10^{-19}} eV$

$= 0.6457 eV$

Observation:

from graph: $\frac{dy}{dx}$ = (slope) $= 3743.47 \Omega K$

★ graph:

→ A graph is drawn b/w $1/T$ in x-axis & $2.303 \log_{10} R_T$ in Y-axis where T is the temperature in K & R_T is the resistance of thermistor at T Kelvin.

Band gap = $E_g = 2K \times$ slope of graph

$\Rightarrow E_g = 2 \times 1.38 \times 10^{-3} \times \left(\frac{dy}{dx}\right)$

$\Rightarrow E_g = 0.6457 eV$

(where K → Boltzmann's constant)

12/04

Result →

The band gap of material of thermistor = 0.6457eV (acc. to graph)

from formula, band gap = 0.35 eV

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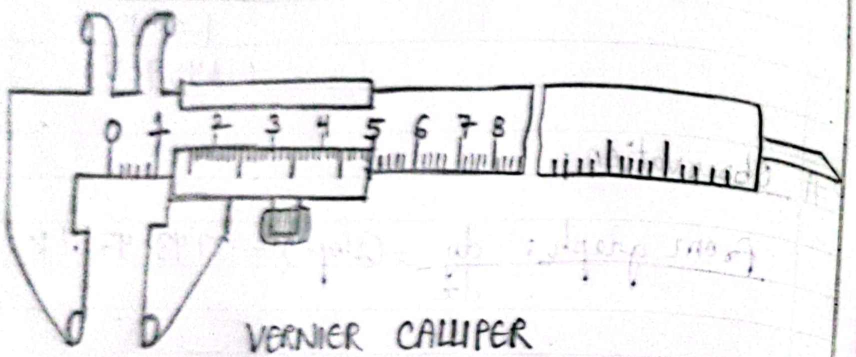


VERNIER CALLIPER

Date 24/9/2

Expt. No. 13-(A)

Experiment - 13 (A)

Aim: To determine the diameter of given pen using Vernier Callipers.

Apparatus used: Vernier Caliper, Pen.

Formula:

1) Least Count = $\dfrac{\text{Value of one main scale division}}{\text{Total no of division on vernier scale}}$

2) Zero Error = (No. of divisions b/w zero of vernier scale & main scale [when the jaws are touched]) × least count

3) Total Reading = Main Scale Reading (M.S.R.) + Vernier Scale Reading (V.S.R.) − (± Zero Error)

Observations:

(i) Least Count = $\dfrac{1}{50}$ = 0.02 unit

(ii) Zero Error = 0 [No Zero Error]

Teacher's Signature : ____________

★ OBSERVATION TABLE

S.NO	M.S.R (mm)	V.S.R (mm)	Reading (MSR + VSR) [mm]	Total Reading (mm)
1.	9	1 × 0.02 = 0.02	9.02	9.02
2.	11.1	17 × 0.02 = 0.34	11.44	11.44
3.	9	1 × 0.02 = 0.02	9.02	9.02

Date

Expt. No.

Calculations:

Main Scale Division = 1

Total no. of Vernier Scale Division = 50

Least count = $\frac{1}{50}$ = 0.02

CALCULATION TABLE

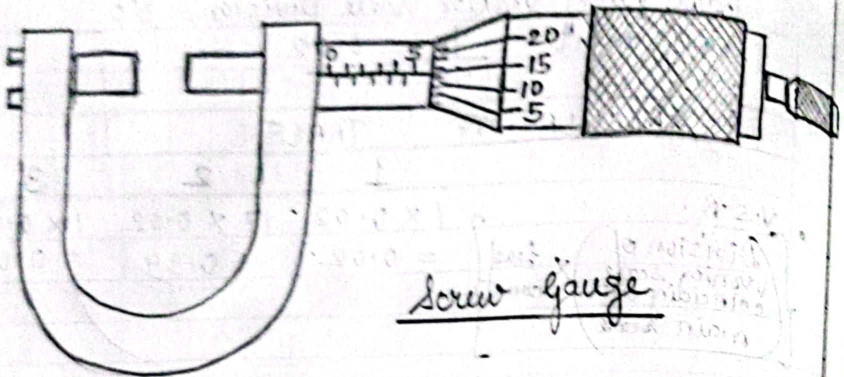
	1	2	3
• V.S.R. [(Division of vernier scale coinciding with main scale) × least count]	1 × 0.02 = 0.02	17 × 0.02 = 0.34	1 × 0.02 = 0.02
• Reading {MSR + VSR}	9 + 0.02 = 9.02	11.1 + 0.34 = 11.44	9 + 0.02 = 9.02
• Total Reading [MSR + VSR − (± Zero Error)]	9 + 0.02 − 0 = 9.02	11.1 + 0.34 − 0 = 11.44	9 + 0.02 − 0 = 9.02

Mean Diameter = (9.02 + 11.44 + 9.02)/3 = 9.82 mm

Result: The diameter of the given pen is 9.82 mm

26/04

Teacher's Signature :



Screw Gauge

Date 24/4/23

Expt. No. 13-(B) Page No. 40

Experiment - 13 (B)

Aim: To determine the diameter of given pen using screw gauge.

Apparatus Used: Screw gauge, pen.

Formula:

1) Least Count = $\dfrac{\text{Value of 1 main scale division}}{\text{No. of divisions on circular scale}}$

2) Zero Error = (No. of divisions b/w the zero mark on circular scale & zero mark on the base line of main scale) X least count

3) Total Reading = Main Scale Reading (M.S.R.) + Circular Scale Reading (C.S.R.) − (± Zero Error)

Observations:

(i) Least Count = $\dfrac{0.5}{50}$ = 0.01 unit

(ii) Zero Error = −0.11 {Negative Zero Error}

Teacher's Signature :

★ Observation Table

S.NO	M.S.R. (mm)	C.S.R. (mm)	Reading (M.S.R.+C.S.R.)	Total Reading
1	17×0.5=8.5	14×0.01=0.14	8.64	8.75
2	21×0.5=10.5	10×0.01=0.1	10.6	10.71
3	17×0.5=8.5	14×0.01=0.14	8.64	8.75

Calculations:

Zero Error = −(11 × 0.01) = −0.11

CALCULATION TABLE

	1.	2.	3.
• M.S.R. {No. of division × 1 Main Scale Division}	17 × 0.5 = 8.5	21 × 0.5 = 10.5	17 × 0.5 = 8.5
• C.S.R. {(50 − division of circular scale coinciding with base line) × least count}	14 × 0.01 = 0.14	10 × 0.01 = 0.1	14 × 0.01 = 0.14
• Reading (M.S.R + C.S.R.)	8.5 + 0.14 = 8.64	10.5 + 0.1 = 10.6	8.5 + 0.14 = 8.64
• Total Reading (M.S.R + C.S.R − Zero Error)	8.5 + 0.14 − (−0.11) = 8.75	10.5 + 0.1 − (−0.11) = 10.71	8.5 + 0.14 − (−0.11) = 8.75

Mean diameter = $\frac{(8.75 + 10.71 + 8.75)\,mm}{3}$ = 5.8 mm

Result: The diameter of given pen is 5.8 mm

26/09

Teacher's Signature : ______