Observation Table

S. No	Voltage in (Volt)	Current in (mA)	Current in (A)	$R_t = V/I$ (Ω)	R_t/R_0	t in (°C)	T in (K)	Radiated Power E = VI (mW)	ln T (K)	ln E
1	2	58	58×10^{-3}	34	4.38	598.6	871.6	116	6.77	4.75
2	2.5	66	66×10^{-3}	38	4.90	683.5	956.5	165	6.86	5.10
3	3	72	72×10^{-3}	42	5.41	765	1038	216	6.94	5.37
4	3.5	80	8×10^{-2}	44	5.67	805.7	1078.7	280	6.98	5.63
5	4	86	86×10^{-3}	47	6.06	866.8	1139.8	344	7.03	5.84
6	4.5	92	92×10^{-3}	49	6.32	907	1180	414	7.07	6.02
7	5	96	96×10^{-3}	52	6.70	964.7	1237.7	480	7.12	6.17

$V_g = 1.5$ volt

and $I_g = 49$ mA

$\therefore R_g = \frac{V_g}{I_g} = 30.612\,\Omega$

and $R_0 = \frac{R_g}{3.95}$

$\boxed{R_0 = 7.75\,\Omega}$

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Experiment – 1

AIM – To verify Stefan's Law of thermal radiation by electrical method.

APPARATUS – Experimental Set up of Stefan's law, Voltage Source, DC Voltmeter, Variable resistance and connecting Wires.

Theory:– The Stefan's law states that the energy radiated by a black body per second per unit surface area is given by $P_{(rad)} = \sigma T^4 \ (W/m^2)$

where T is the absolute temprature of the body and σ is Stefan's Constant.

If the body is not perfectly black then

$$P_{(rad)} = \sigma \varepsilon T^4 \ (W/m^2)$$

ε is emmisivity of the body $(\varepsilon < 1)$.

Let T is the temprature of bulb's filament and T_s is the surrounding temperature. Then the net rate of heat loss by the filament in environment

$$E = A\sigma\varepsilon[T^4 - T_s^4]$$

iff $T_s << T \Rightarrow E = \underbrace{A\sigma\varepsilon}_{C} T^4 = CT^4 = CT^4$

The above energy loss by the filament due to radiation can be equated with the power dissipated by the electrical source in the filament resistance under some circumstances.

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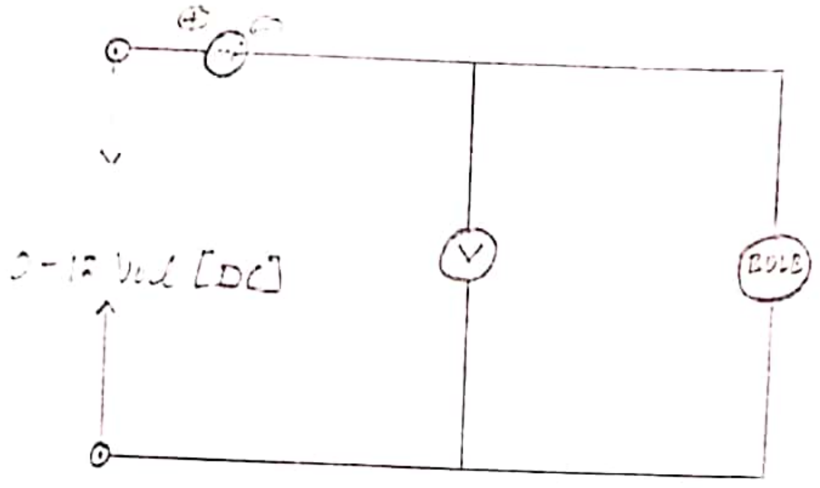
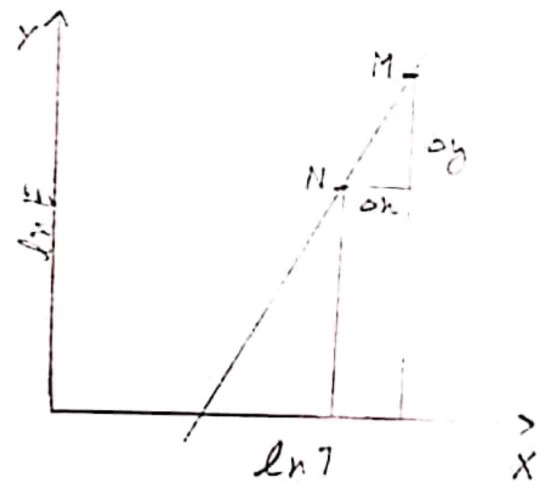


Circuit Diagram



Slope = $\frac{\Delta y}{\Delta x}$

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* No loss of Heat by Convection
* The heat lost by Conduction is small.

Conduction heat linearly depends upon the fourth power of the temprature. Therefore

Thermal Radiations (E) = Electrical Power Dissipiated (P)

$$E = P = VI$$

Also resistance of filament changes when temperature goes increases, as follow

$$R_t = R_0\left[1 + \alpha t + \beta t^2\right]$$

R_t and R_0 are the resistance at temprature $t°C$ and $0°C$ respectively.

$$\alpha = 5.21 \times 10^{-3}\,°C^{-1} \qquad \beta = 7.2 \times 10^{-7}\,°C^{-2}$$

The temprature of a tungeston Filament when it just starts glowing is $t_g \sim 527°C$ and R_g be the corresponding resistance.

$$R_0 = \frac{R_g}{3.95}$$

R_g is determined by noting the Voltage V_g and the Current I_g at the glowing point $R_g = V_g/I_g$.

After calculating the ratio of R_t/R_0 we can get

$$t = \frac{-\alpha + \sqrt{\alpha^2 - 4\beta(1 - R_t/R_0)}}{2\beta}$$

The corresponding absolute temprature is readily obtained by $T = t + 273\,°K$

Taking $\ln$ of equation $E = CT^{\gamma}$

$$\ln E = \gamma \ln T + C' \quad \text{as } [\ln C = C']$$

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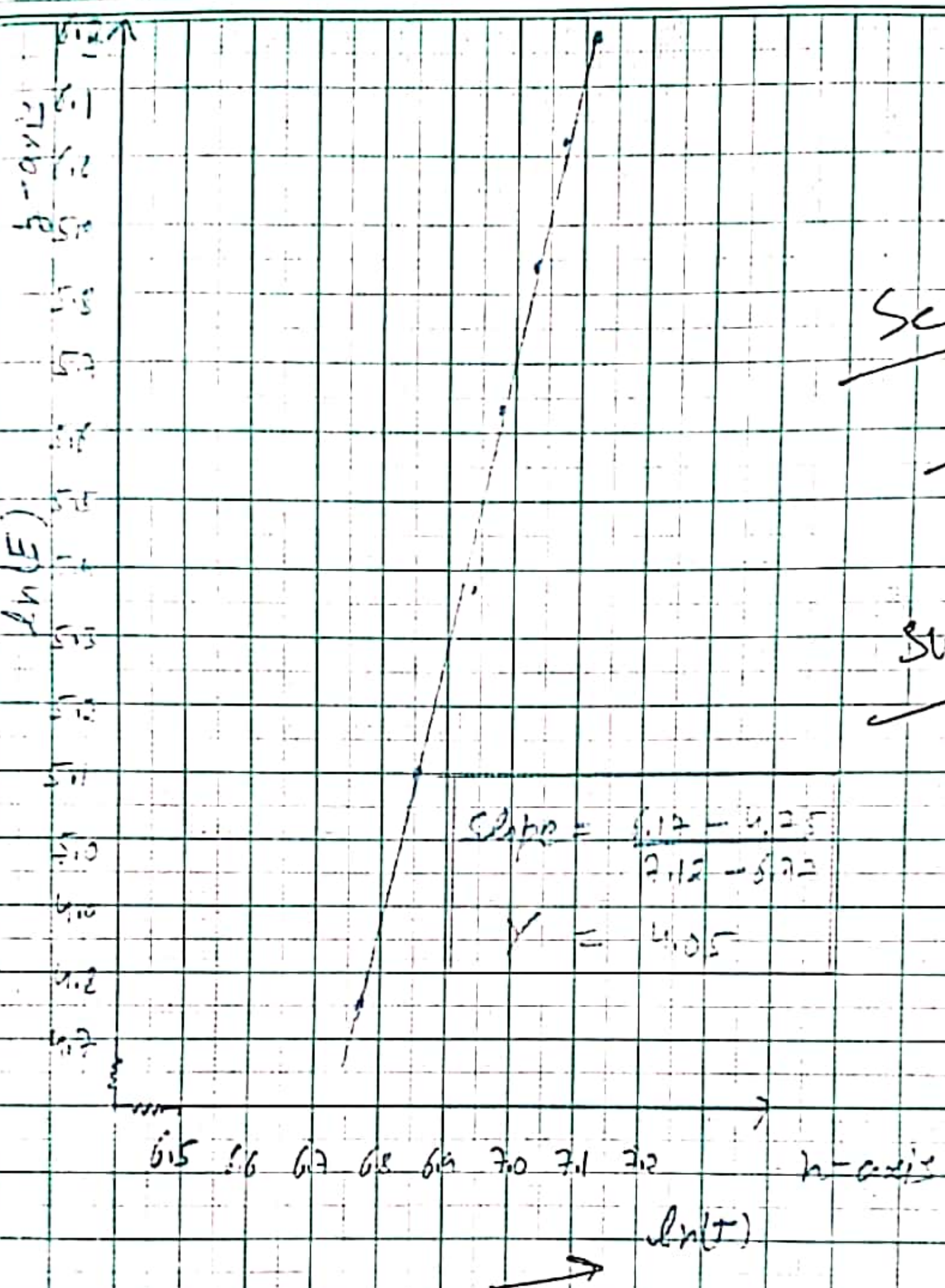

Scale ?

Slope ?

$$\text{Slope} = \frac{5.17 - 4.25}{7.12 - 6.72}$$

$$Y = 4.05$$

Scale Used

2cm = 0.1 units on both axis

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Result

① The plot between lnT vs lnE is a straight line. Thus Stephan's law $E = CT^{\gamma}$ is verified.

② The slope of the line $\gamma = 4$. This verifies the fourth power law.

4.05

Precautions

① Bulb used should have tungsten filament.

② Voltage reading should be carefully noted after every change in current.

③ Current should be increased in steps.

Sources Of Error

① Connections must be tight.

② Variable resistance of appropriate range should be chosen.

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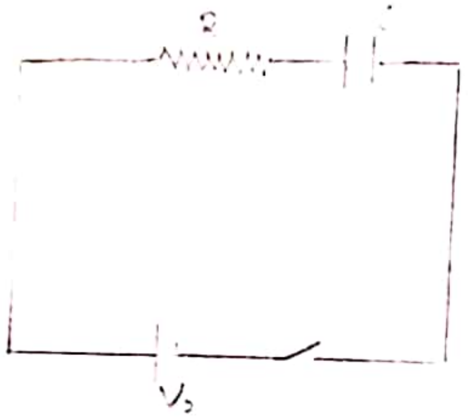
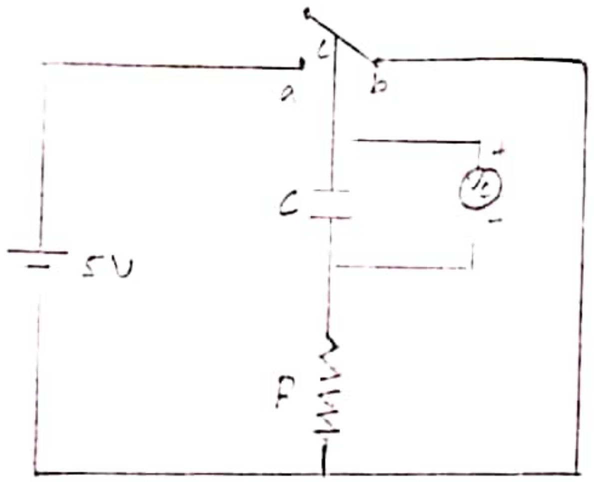
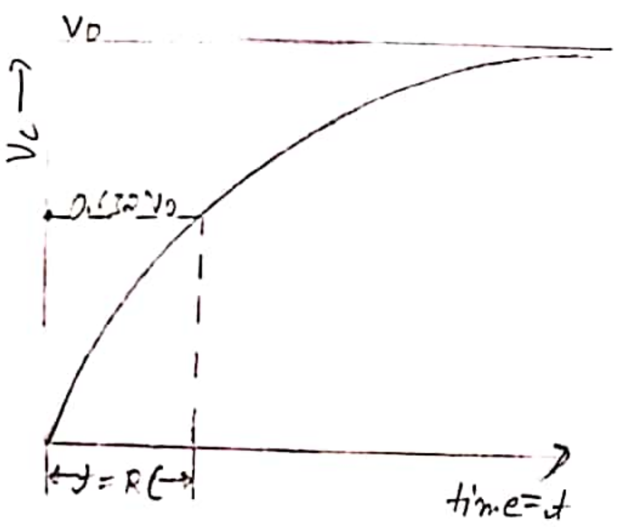
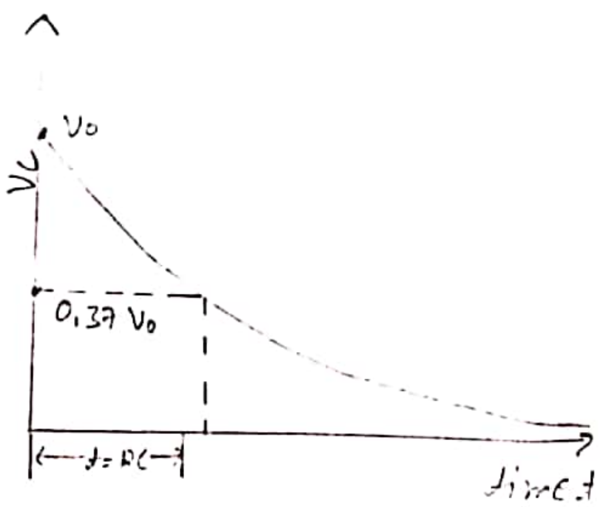


Charging of Capacitor



Discharging of Capacitor





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Experiment - 2

AIM :- To study the charging and discharging of a capacitor and find out the time constant. [Using Voltmeter]

APPARATUS: A resistance, a capacitor, a 5V battery, a Voltmeter, a key, a stop watch and connecting wires.

Theory We shall consider the charging and discharging of a capacitor C in series with resistance R.

(a) Charging of a Capacitor:

Let us consider a series RC-circuit with a DC voltage source. When the key is closed, the charge Q on the capacitor starts building up increasing the voltage V_c across it.

At any instant t, the e.m.f equation for the circuit is $V_0 = V_c + iR$

and the voltage V_c across the capacitor is given by $V_c = V_0(1 - e^{-t/RC})$

this equation gives the rise in voltage across the capacitor with time, as shown in diagram

When $t = RC$

$$V_c = V_0\left(1 - \frac{1}{e}\right) = 0.632\, V_0$$

Here, the time $t = RC$ is called the time constant of the series RC circuit.

Observations

Least count of the voltmeter = 0.25 V
Resistance of the Circuit = 10 kΩ
Capacitance of the Circuit = 4700 μF

	CHARGING		DISCHARGING	
S.No	Time (sec)	Voltage	Time (sec)	Voltage
1	10	2.5	0 10	15 15 → 13.75
2	10	4.75	10	12
3	10	6.75	10	10.25
4	10	7.75	10	8.5
5	10	9.25	10	6.25
6	10	10.25	10	5.5
7	10	12.00	10	4.25
8	10	13.00	10	3.5
9	10	14.25	10	3.00
10	10	14.75	10	2.5
11	10	14.75	10	2.25
12	10	14.75	10	2.00
13	10	15	10	1.5
14	10	15	10	1.25
15			10	1
16			10	0.75
17			10	0.50
18			10	0.50
19			10	0.25

Time Constant = RC = 47 sec

Thus the time constant of an RC circuit is defined as the charging time of the capacitor C in which the charge (or the voltage) across it becomes 0.632 times the final maximum charge (or the voltage).

(b) Discharging of a Capacitor:
Let us consider the discharging of a capacitor C through a resistor R after charging it fully. At any instant t, if i the current in the circuit and V_c is the voltage across the capacitor, we have

$$iR + V_c = 0$$

where V_c is given as $V_c = V_0 e^{-t/RC}$
the equation represents the discharging of a capacitor through a resistance.

When $t = RC$

$$V_c = \frac{V_0}{e} = 0.368\, V_0$$

Thus, the time constant of an RC circuit can also be defined as the discharging time of the capacitor through a resistor in which the charge (or the voltage) across the capacitor become 0.37 times the initial charge (or the voltage) across it.

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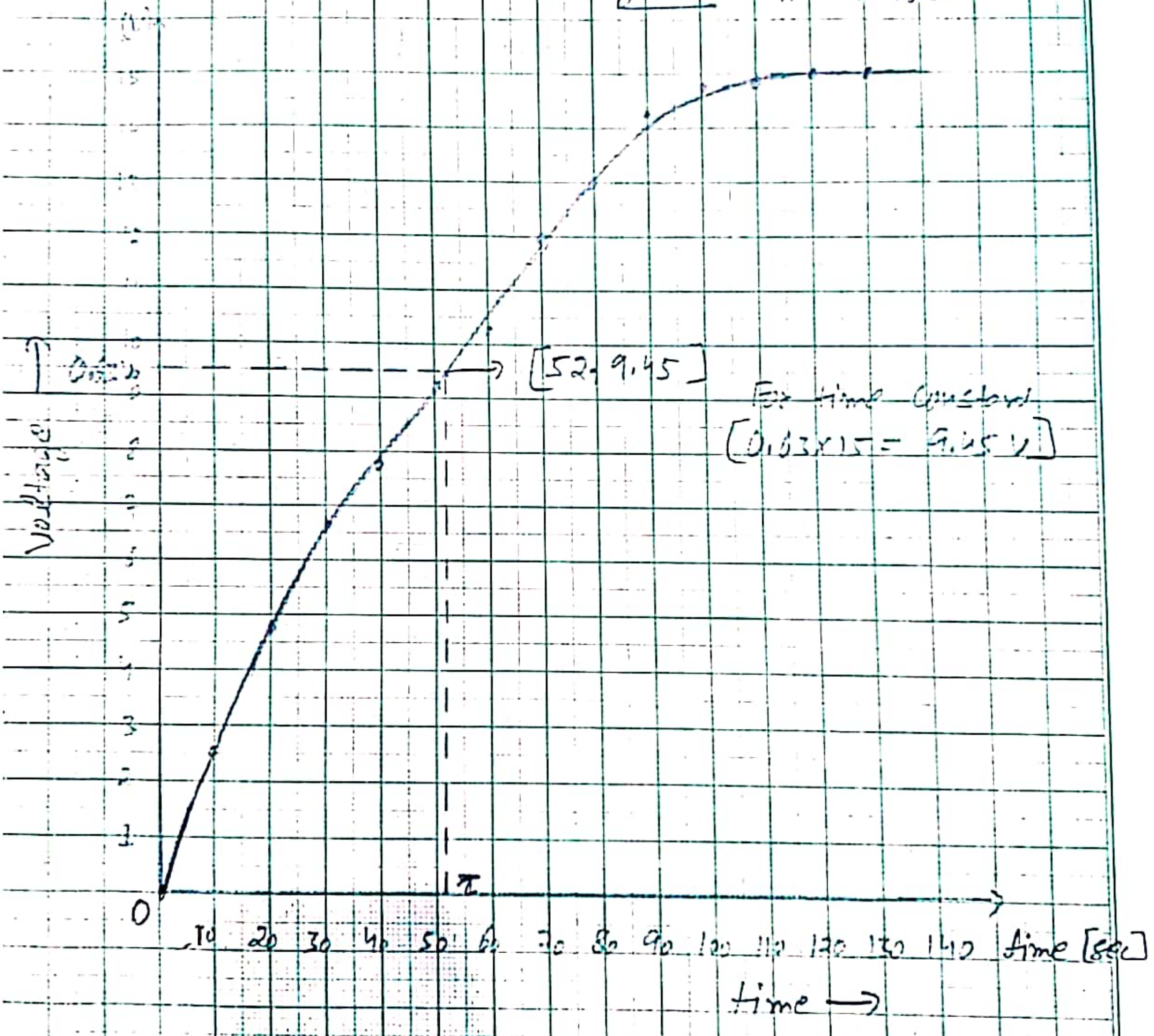
Scale Used

x-axis 1cm = 10 sec
y-axis 1cm = 1 volt



Charging Of Capacitor

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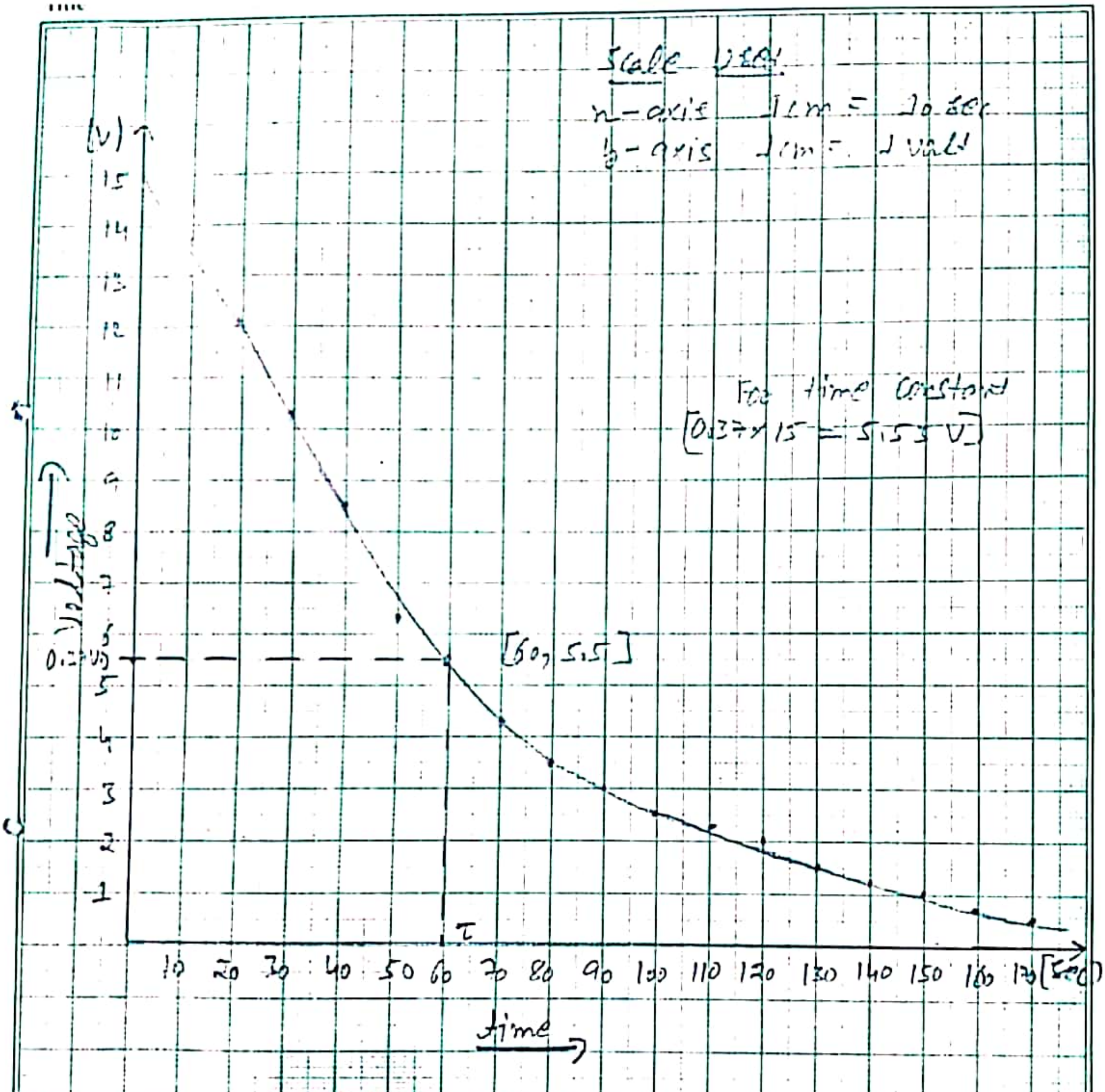

Discharging of Capacitor

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Result

Time constant of the RC circuit as determined by charging and discharging of the capacitor is $(52+60)\div 2 = 56$

Theoritical value $= 47$

$\%$ Error $= \left|\frac{56-47}{47}\right| \times 100 = 19.14\%$

Precautions

① Connections should be tight

② The time t and the corresponding voltage across the capacitor should be noted very carefully.

③ The values of capacitor C and Resistance R should be chosen so as to keep the time constant RC large.

Sources of Error

① The capacitor should not be leaky.

② Watch the readings after the exact time interval so that % of Error will minimise.

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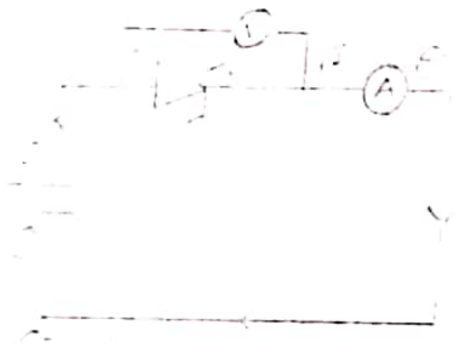
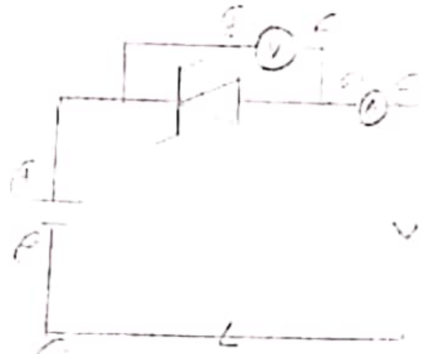
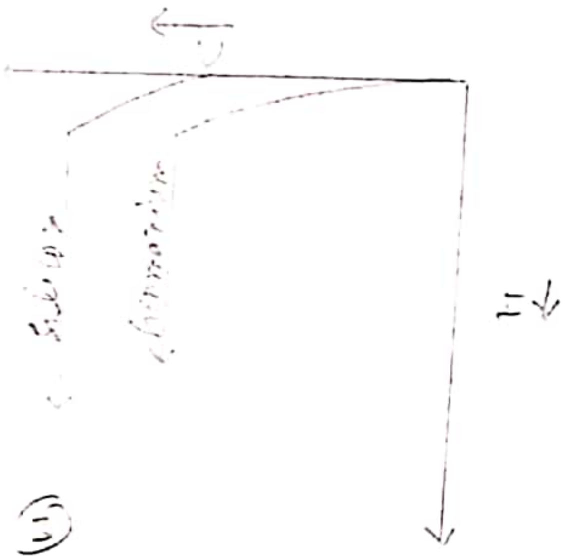


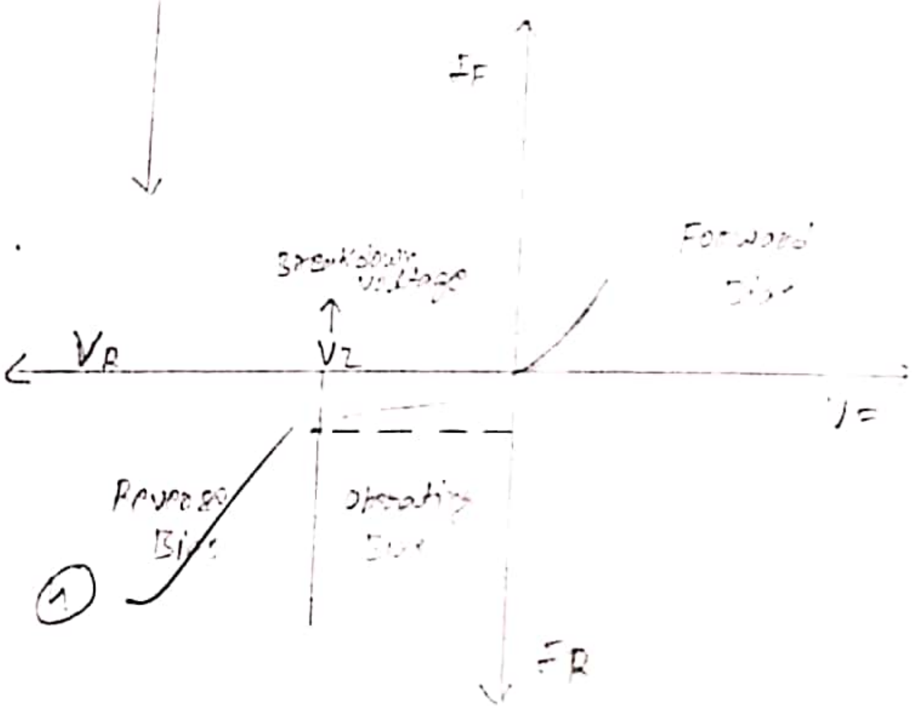
(1) Forward Bias



(2) Reverse Bias



(iii)



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Experiment - 3

AIM: To study the I-V characteristics of Zener Diode

APPARATUS:- A Zener diode, A variable power supply, voltmeter, milliammeter and microammeter.

Theory:- Zener Diode: A zener diode is a highly doped pn diode. Due to heavy doping on both p and n side, the junction is relatively narrow as compared to the normal diode.

As seen in pn diode, when a reverse bias is applied to zener diode, a very small current flows through it due to the minority charge carriers. However, at some reverse voltage, the reverse current in the junction increases rapidly. The current through the device increases while the voltage remains essentially constant, i.e. the reverse resistance decreases. In this condition, the diode is said to have reached breakdown.

There are two possible mechanism for such a break down. The first of the type occurring in zener diode is called zener breakdown. Here due to heavy doping, the depletion layer is very thin and hence the electric field becomes large even for a small reverse bias voltage. A very sharp increase in current is observed causing the breakdown of the

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Observations

Least count of Voltmeter = 0.2V

Least count of Ammeter = 0.2 mA

[Backward / Reverse Bias]

S.No	Voltage (V)	Current (mA)
1	1	0
2	1.5	0
3	2	0
4	3	0
5	4	0
6	6	0
7	6.7	1
8	6.7	6
9	6.7	8
10	6.7	10

[Forward Bias]

S.No	Voltage (V)	Current (mA)
1	0.10	0
2	0.16	0
3	0.23	0
4	0.30	0
5	0.50	0
6	0.70	0.4
7	0.80	6.5
8	0.90	8
9	0.90	9
10	0.90	10

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junction. The value of the reverse voltage at which breakdown occurs is called the breakdown/Zener [illegible] [illegible].
Another mechanism responsible for the breakdown of a [illegible] is a case of avalanche multiplication. It occurs when a large reverse voltage applied causes a large electric field and a number of [illegible] [illegible] [illegible] with [illegible] increase in [illegible]. The rapidly accelerated [illegible] collide with the [illegible] and release many more [illegible] charges and the process of multiplication [illegible] in an avalanche [illegible]. This type of junction breakdown is called avalanche breakdown.

Result

As the reverse voltage V_R is increased, the reverse current remains small, as the effect of V_R [illegible]

Precautions

(i) In both forward-bias and reverse-bias, the sliding contact of the rheostat should be kept so as to give minimum voltage before switching on the power supply.

(ii) The reverse-bias voltage should be kept below

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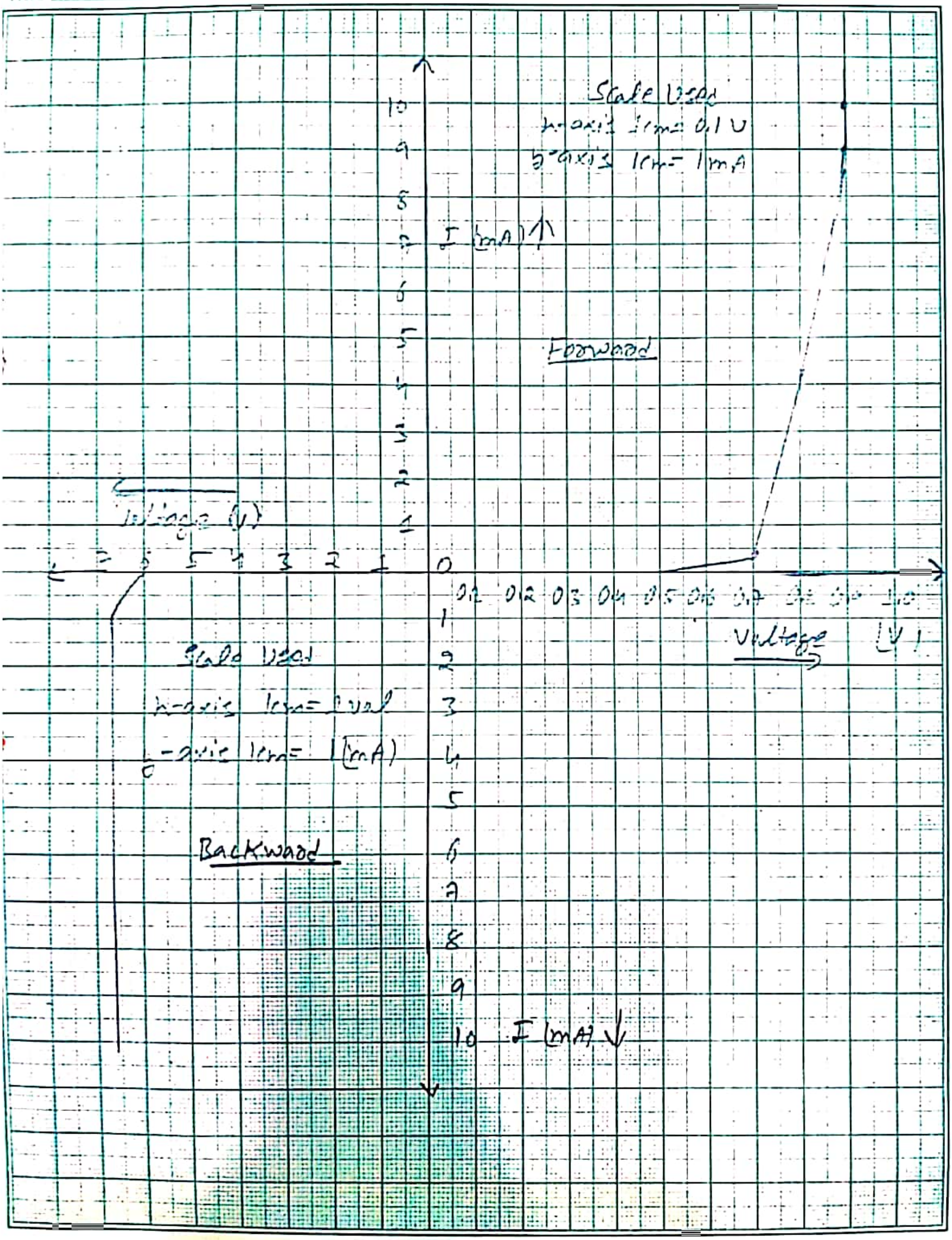

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the breakdown voltage of the diode.

(3) In forward Bias & Reverse Bias must be
Increase in voltage (0.1V) | Use of milliammeter
Increase in voltage (1V) | Use of microammeter

Source of Error

(1) Instrumental Error.
(2) Increment in voltage can be gradual so that individual will face an error.

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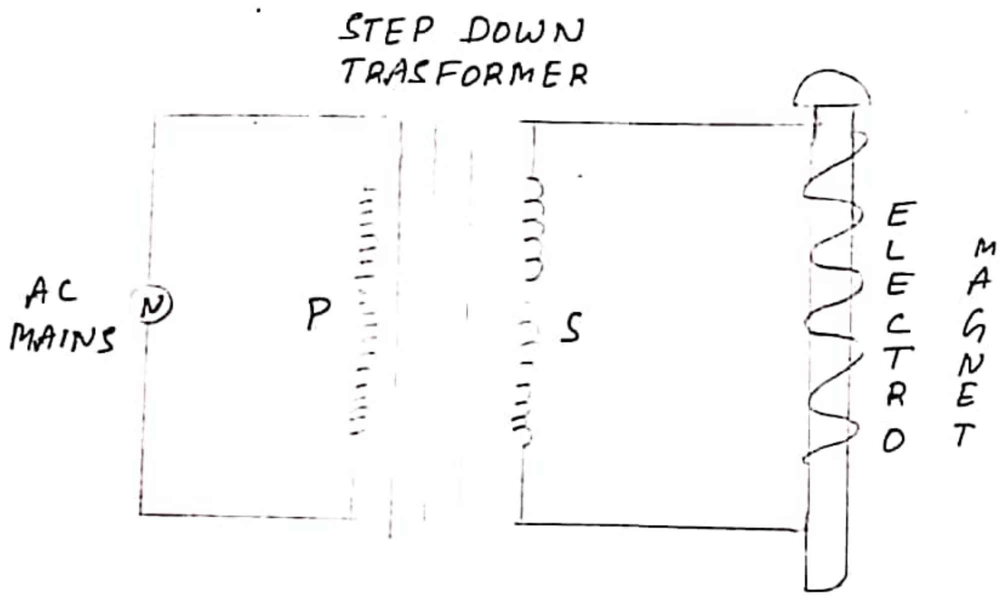

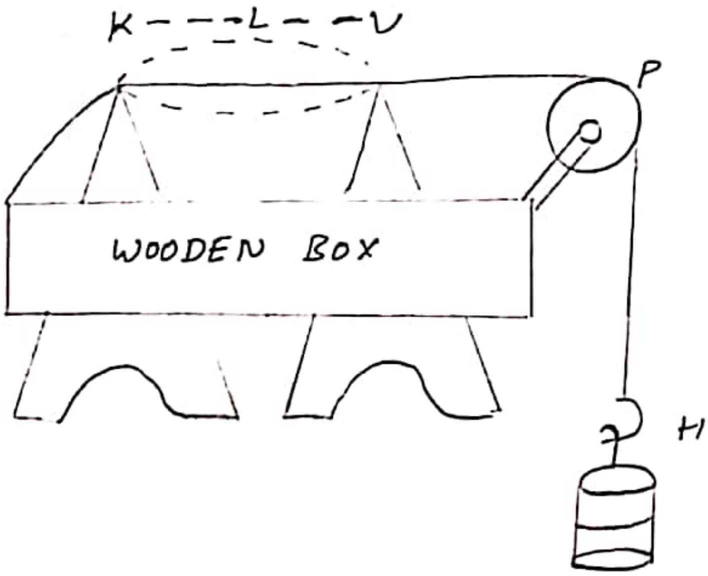

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EXPERIMENT - 4
SONOMETER

AIM: To determine the frequency of the AC mains using sonometer and an electromagnet.

APPARATUS REQUIRED:- A sonometer with soft iron core wire, an electromagnet, a step down transformer, hanger with slotted weights, a clamp stand, meter scale, screw guage, a sensitive balance, connecting wires.

THEORY:-

If a wire of length l and mass per unit length m is stretched over two bridges with a Tension T and plucked it vibrates with a frequency

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2l}\sqrt{\frac{Mg}{m}}$$

In this experiment, the length of the wire and tension are so adjusted that the natural frequency of the wire is equal to the frequency of the electromagnet.
The electromagnet has a soft iron cylindrical core on which enameled copper wire is wrapped. Current through the AC mains is stepped down by a step down transformer and then passed through the copper wire of the electromagnet. The current magnitisies the cylindrical core twice during each cycle - first

Observation Table

S.No	LOAD M (gm)	Length for Outward (cm)	Resonance Inward (cm)	Mean L (cm)	Frequency (Hz)
1	500	20	22	21	44.22
2	1000	26	26.5	26.25	50.039
3	1500	30.5	31.5	31	51.89
4	2000	34	35	34.5	53.84

CALCULATION

$m = 0.0355 \text{ gm/cm}$

$$f_1 = \frac{1}{4(21)} \sqrt{\frac{500(980)}{0.0355}} = 44.22 \text{ Hz}$$

$$f_2 = \frac{1}{4(26.25)} \left(\frac{1000(980)}{0.0355}\right)^{1/2} = 50.039 \text{ Hz}$$

$$f_3 = \frac{1}{4(31)} \sqrt{\frac{1500(980)}{0.0355}} = 51.89 \text{ Hz}$$

$$f_4 = \frac{1}{4(34.5)} \left(\frac{2000(980)}{0.0355}\right)^{1/2} = 53.84 \text{ Hz}$$

$$\% \text{ error} = \frac{49.99}{50} \times 100 = 0.99\%$$

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with one polarity when the current flows in one direction and then with the opposite polarity when current flows in opposite direction. When the tip of this cylindrical core is kept very close to the stretched soft iron wire of the sonometer, the wire will be pulled towards the tip twice during each cycle.

Eg:- If frequency of AC mains is 50 Hz then it will be 100 times per second.

So the natural frequency n of the sonometer wire is double the frequency f of the AC mains

$$f = \frac{n}{2} = \frac{1}{4l}\sqrt{\frac{Mg}{m}}$$

The value of mass per unit length m can be determined either by weighing length of the wire or by measuring the radius r and taking the density ρ of the material of the wire [ρ = 7.8 gm/cc].

Then mass per unit length of the wire is given by the formula $m = \pi r^2 \rho$.

RESULT

The frequency of the AC mains = 50.9 Hz

Standard value = 50 Hz

% Error = 0.99%

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PRECAUTIONS

① The string should be uniform, inextensible and kink free.
② For the determination of m [mass per unit length] determine the diameter of wire via using screw guage.

SOURCES OF ERROR

① The weight M in the formula should include the weight of hanger.
② Sonometer wire should be of magnetic material so that it can attract by electromagnet.

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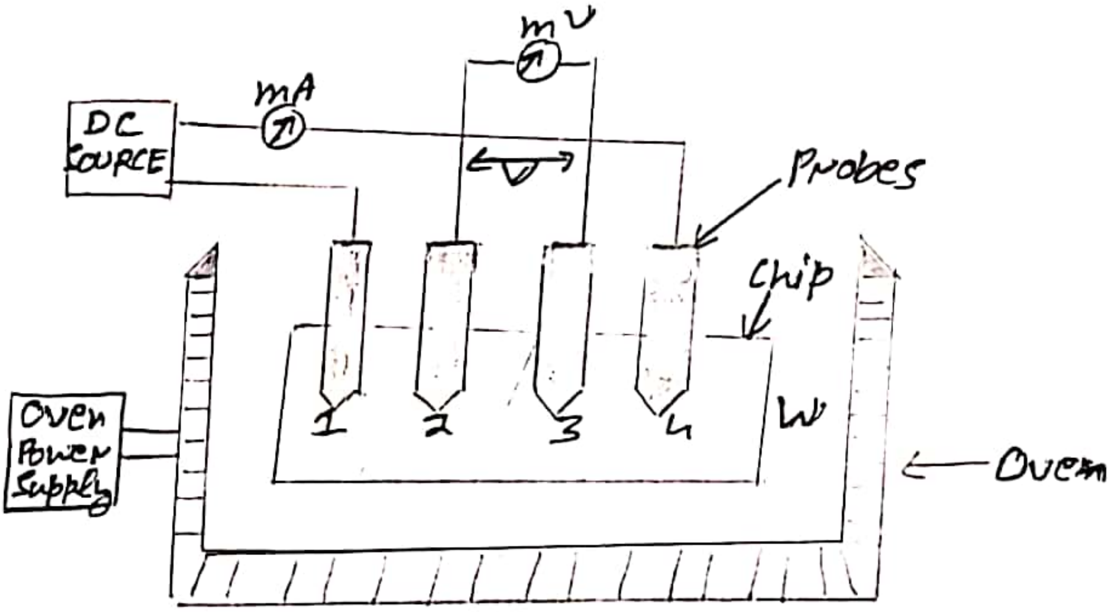

Four Probe Experiment Setup

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EXPERIMENT - 5

Four Probe Method

AIM: To determine the energy band gap of a semiconductor by Four Probe method.

APPARATUS REQUIRED:- A thin semiconductor sample, a four probe arrangement, a digital multivoltmeter, a constant current source (0 to 10mA) an oven with power supply and a thermometer (0-200°C).

THEORY:- By Ohm's law, the electric field intensity, E at a point in a material is proportional to the current density, J that it induces at that point.

$$E \propto J$$

$$E = \rho J \quad [\rho = \text{Proportionality constant}]$$

In the four probe method, four pointed collinear equally spaced probe are placed in pressure constant with the plane into the sample through the outer two probes (1 and 4). The resulting electric potential distribution is measured via the two linear probes (2 and 3)

$$V = \frac{I \rho \ln 2}{\pi d}$$

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Observations

$f(d/s) = 5.5$

Thickness of the sample = 0.05 cm

Distance between poles [s] = 0.2 cm

Value of Boltzman's Constant = 8.6×10^{-15} eV/K

Value of current I = 4mA (Const)

SNo	Temperature ln θ°c	ln K	Valtage (V)	ρ_0 [ohm cm]	ρ (Ω cm)	$-\log_{10}(\rho)$	$10^3/T$
1	37	310	0.300	94.2	17.16	1.23	3.22
2	42	315	0.287	90.16	16.39	1.21	3.17
3	47	320	0.286	89.84	16.33	1.21	3.12
4	52	325	0.269	84.50	15.36	1.86	3.07
5	57	330	0.248	77.91	14.16	1.15	3.03
6	62	335	0.224	70.31	12.79	1.10	2.98
7	67	340	0.198	62.30	11.30	1.05	2.94
8	72	345	0.173	54.34	9.88	0.99	2.89
9	82	350	0.148	46.49	8.45	0.92	2.85
10	87	355	0.127	39.89	7.25	0.86	2.81
11	87	355	0.180	33.92	6.16	0.78	2.77
12	92	360	0.920	28.90	5.25	0.72	2.73

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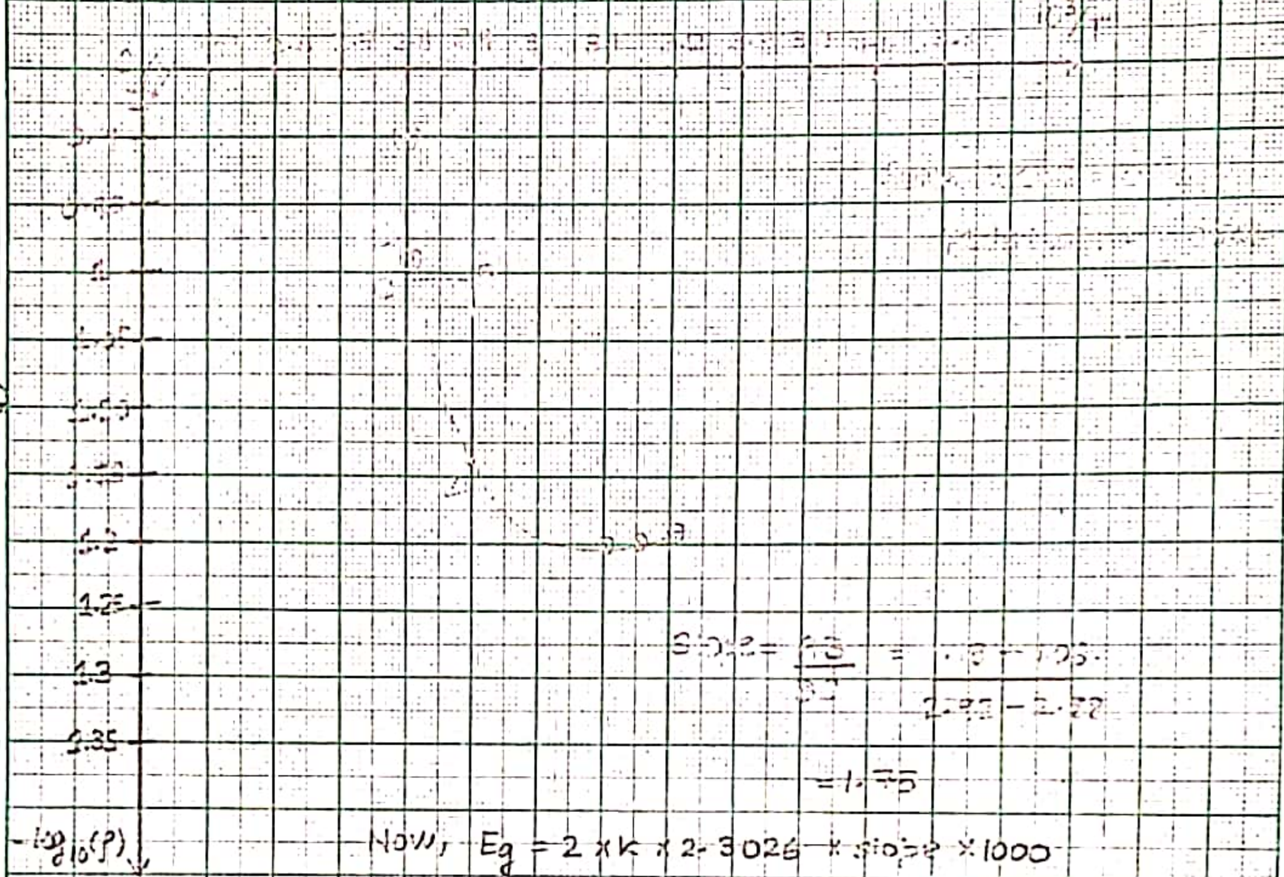

Slope = $\frac{\Delta y}{\Delta x}$ = [illegible]

= 1.75

Now, $E_g = 2 \times k \times 2.3026 \times \text{slope} \times 1000$

$= 2 \times 8.6 \times 2.3026 \times 1.75 \times 10^{-2}$ eV

= 0.69 eV

% error = $\frac{0.7 - 0.69}{0.7} \times 100$

= 1.4 %

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ρ is the resistivity or semiconducting sample. The Temprature variation of resistivity.

$$\rho = \rho_0 \exp\left(\frac{E_g}{KT}\right)$$

E_g is band gap
K is boltzman's constant

$$E_g = (2K \times 2.303 \times \ln \rho)T \text{ eV}$$

$$K = 8.6 \times 10^{-5} \text{ eV/deg}$$

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

$f(d/s)$ refer to the take data given in calculation, s is the distance between probes and d/s is the thickness of semiconducting crystals. V and I are the voltage and current across and through the crystals.

RESULT

Energy band gap for semiconductor is 0.69V and % error is 1.4%

PRECAUTIONS

(1) Resistivity of the material should be uniform throughout the conductor.

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② Current in the sample should be kept constant.

SOURCES OF ERROR

① Temperature can vary. So need to perform under similar / constant physical conditions.
② The tip of the thermometer should be will inside the hole.

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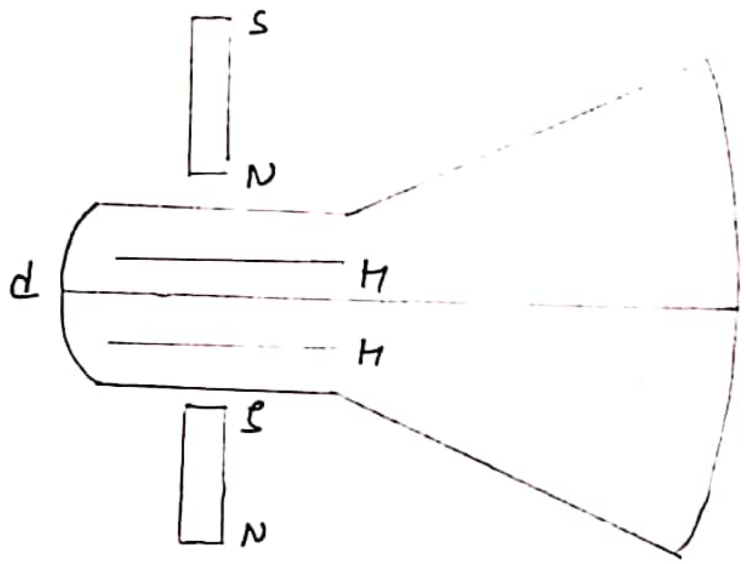

Deflection of $e^{\ominus}$ beam in CRT by Magnatic Field

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EXPERIMENT - 6

e/m Method

AIM: To determine the e/m ratio of an electron by J.J Thomson method using bar magnets.

APPARATUS:- Cathode ray tube, wooden stand with two arms perpendicular to the axis of the tube having scale on both arms, Power Supply, magnetic Compass, a pair of bar magnets, voltmeter [0-100V range]

Formula Used

$$\frac{e}{m} = \frac{VY \times 10^8}{He^2 \tan^2\theta (L + l/2) l \times d}$$

Where

l = length of horizontal pair of plates
L = distance of screen from edges
V = Voltage applied to plates
Y = total deflection of spot on screen
H = Intensity of applied field
d = Separation between plates

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Observations

Length of deflecting plates (l) = 6.5 cm
Distance of screen from plates (L) = 6 cm

Distance plates (d) = 1.5 cm
Horizontal component of Earth's magnetic field = B_H = 3.5×10^{-5} wb/m²

S.No	Applied Voltage	Direct Field y(cm)	θ_1	θ_2	Indirect Field y(cm)	θ_1	θ_2	Mean $y(cm)_m$	θ_m
1	5	0.005	76	79	0.002	40	40	0.35	51.2
2	7	0.006	71	80	0.004	49	45	0.5	60
3	9	0.009	75	86	0.008	46	46	0.35	63.2

Calculations

$$\frac{e}{m} = \frac{Vy}{(B_H)^2 \tan^2\theta \cdot e\,(l/2 + L)\,d} \qquad \theta_{av} = 63.25^\circ$$

$$\frac{e}{m} = \frac{9 \times 0.0085 \times 0.67 \times 10^6}{(0.35 \times 10^{-4}) \tan^2(63.25) \times 6.5 \times \left(\frac{6.5}{2} + 6\right)}$$

$$e/m = 1.765 \times 10^{11}\ C/Kg$$

% Error = 0.284 %

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Cathode Ray Tube is made of three components

(1) Electron Gun :- It's function is to produce, accelerate and focus the emitted electron into a narrow beam.

(2) Deflecting System : It's function is to deflect the electron beam either electrically or magnetically.

(3) Fluroscent Screen :- Beam of electron impringes on a plate to produce a visible spot.

In the cathode ~~ray~~ tube [CRT], the cathode ~~rays~~ can be deflected both electrostatically as well as ~~mg~~ magnetically. In the absence of any deflecting field the undeflected ray strikes the fluroscent screen S at O and produces a bright spot.
Let E be intensity of electric field applied between horizontal plates HH. This cause a force $F = eE$ to act on $e^{\ominus}$ of charge e. This force is perpendicular to direction of flow of $e^{\ominus}$.
If m is mass of $e^{\ominus}$ and v is its velocity along x-axis the value of e/m can be calculated by

$$e/m = \frac{V^2 Y}{E l (L + l/2)}$$

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When Electric field force = Magnetic field force

$$eE = Bev \Rightarrow [v = E/B]$$

and

$$\frac{e}{m} = \frac{V y}{B^2 l(l/2+L)d}$$

Magnetic field B is measured by removing CRT and placing compass both between magnets. If the deflection of needle is θ then $B = B_H \tan\theta$ is horizontal component of earth's magnetic field.
Formula is written intially.

RESULT

The value of e/m of $e^{\ominus}$ = 1.765×10^{11} C/Kg
Standard Value = 1.758×10^{11} C/Kg
% Error = 0.284%

PRECAUTION

1. The CRT must be handled carefully.
2. The axis of the CRT should be in the north-soth direction.

SOURCES OF ERROR

1. Direction of the spot should be noted both for direct field and reverse field.
2. While measuring B, reading should be taken for both ends of the pointer.

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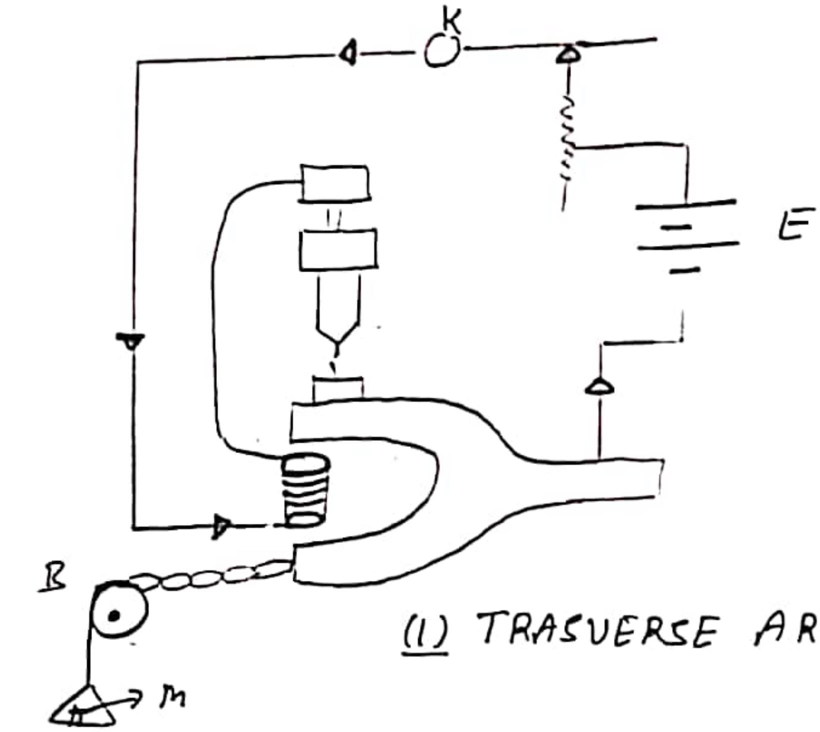
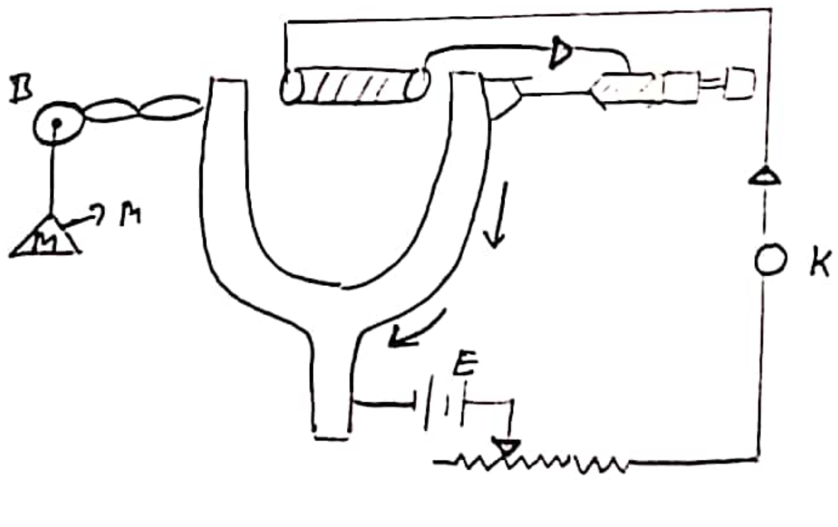


(1) TRASVERSE ARRANGEMENT



(2) LONGITUDNAL ARRANGEMENT

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EXPERIMENT - 7
Tunning Fork

Aim: To determine frequency of an electrically maintain-ed tunning fork by Melde's method by transverse and longitudinal arrangement.

APPARATUS REQUIRED

Pully stand, Weight box, Weight pan, meter Scale, thin string, Battery Eliminator.

THEORY

A string can be set into vibration in number of well defined loops. they are due to superposition of direct and reflected waves. They are due to superposition where it is fixed to prong stationary oscillations midway b/w them lie antinodes where displacement is maximum. this metal piece is in contact with screwed spring, long flexible thread is attached to end of prong and thread is placed over frictionless pulley. If thread is perpendicular to length of prongs longitudinal waves will be set up in thread

Formula Used

The frequency 'n' for stretched string is given by :-

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Observation Table

Mass of pan (M_p) = 22 g = 0.022 Kg
Mass per unit length of thread (cm) = 0.0011 Kg/m
Acceleration due to gravity = 9.8 m/s²

MODES OF Vibration	S.No	Length of thread b/w loops	Length of one loop ($l = L/p$)	Load M (Kg)	Tension T $(N+N_p)g$	Frequency (Hz)
Trans-verse	1	2.38	0.17	0.05	0.705	74.4
	2	2.38	0.21	0.10	1.95	78.5
	3	2.38	0.26	0.15	1.69	75.2
Longitu-dnal	1	2.50	0.31	0.05	0.705	81.6
	2	2.50	0.415	0.10	1.195	79.2
	3	2.50	0.50	0.15	1.665	78.3

Calulation

For transverse transformation

$$n_1 = \frac{1}{2l_1}\sqrt{\frac{T}{m}} = \frac{1}{2(0.17)}\sqrt{\frac{0.70}{0.01}} = 74.4\,Hz$$

Mean transverse $f_1 = (74.4 + 78.5 + 75.2)/3 = 76.03\,Hz$

Mean long. frequency $f_2 = 74.7\,Hz$

mean frequency $= f = (f_1 + f_2)/2 = 77.83\,Hz$

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$$n = \left(\frac{p}{2l}\right)\sqrt{\frac{T}{m}}$$

where, m = mass per unit length of string in gm/cm
p = no. of loops
l = length of string in cm
T = Tension in string
M = mass in ion w.r.t mass of pan.

RESULT

The calculated value for frequency of electrically maintained tuning fork is 97.825 vib/sec.

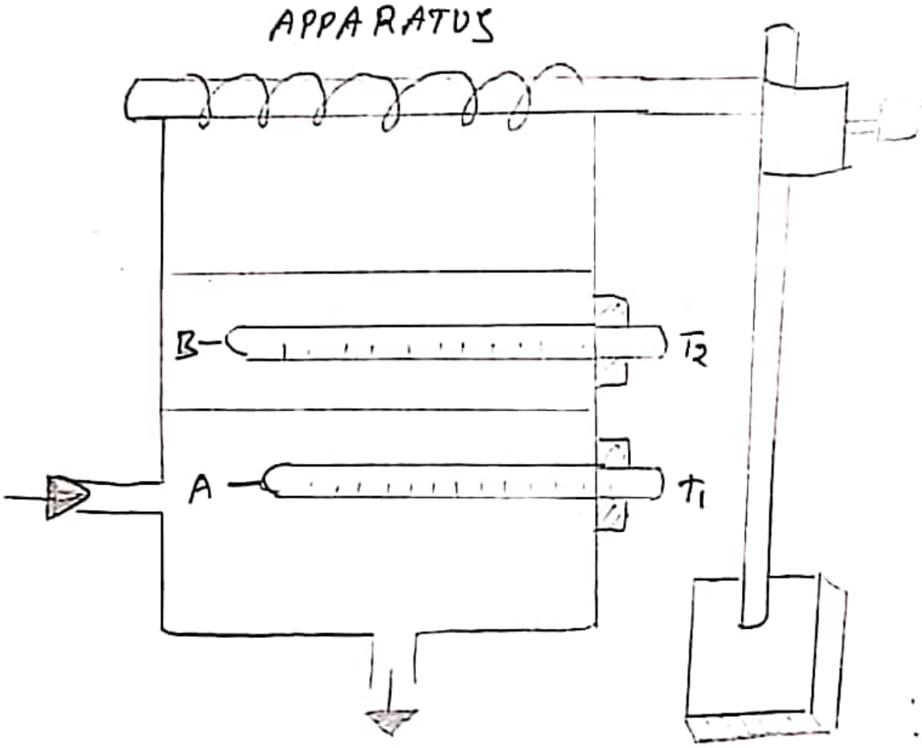
PRECAUTION

1. Scale pan should be light and weight added small.
2. String should be uniform, inextensible.

SOURCES OF ERROR

1. Thread should be thin and uniform in diameter
2. Minimise the amount of friction of the pulley.

APPARATUS



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EXPERIMENT - 8
Lee's Disc

AIM: To find the thermal conductivity of poor conductor by lee's Disc method.

APPARATUS REQUIRED: Lee's apparatus with circular Disc of a poor conductor, two sensitive thermometer, steam generator, stand and threads, stopwatch, screw guage and vernier calliper

THEORY

The coefficient of thermal conductivity K is given by formula

$$K = \frac{m s d}{\pi r^2 (\theta_1 - \theta_2)} \left(\frac{d\theta}{dt}\right)_{\theta=\theta_2}$$

$m \rightarrow$ mass of disc placed over slab
$s \rightarrow$ specific heat of material of Disc
$d \rightarrow$ thickness of experimental Disc
$r \rightarrow$ radius of experimental Disc
$\theta_1, \theta_2 \rightarrow$ Steady temprature of two surfaces of the experimental disc
$\frac{d\theta}{dt} \rightarrow$ rate of radiation of two surface of disc.

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Observations

Radius of experimental disc (r) = 5.56×10^{-2} m
Thickness of experimental disc (d) = 0.27×10^{-2} m
Mass of glass disc (m) = 0.76 Kg
Specific heat of glass (s) = 377 J/Kg k

S.No	TIME (sec)	Reading in Therm(T_2) C°
1	20	93.5
2	40	91.9
3	60	90.5
4	80	89.2
5	100	87.6
6	120	86.3
7	140	84.3
8	160	83.8
9	180	82.1
10	200	80.7
11	220	79.5
12	240	78.4
13	260	77.4
14	280	76.3
15	300	75.2

Calculations

Steady state Temperature

$\theta_1 = 100°C$ $\theta_2 = 85°C$

From Graph $\left.\frac{d\theta}{dt}\right|_{\theta_2} = 0.067$

$$K = \frac{m s d}{\pi r^2 (\theta_1 - \theta_2)} \times \left.\frac{d\theta}{dt}\right|_{\theta_2} = 0.357$$

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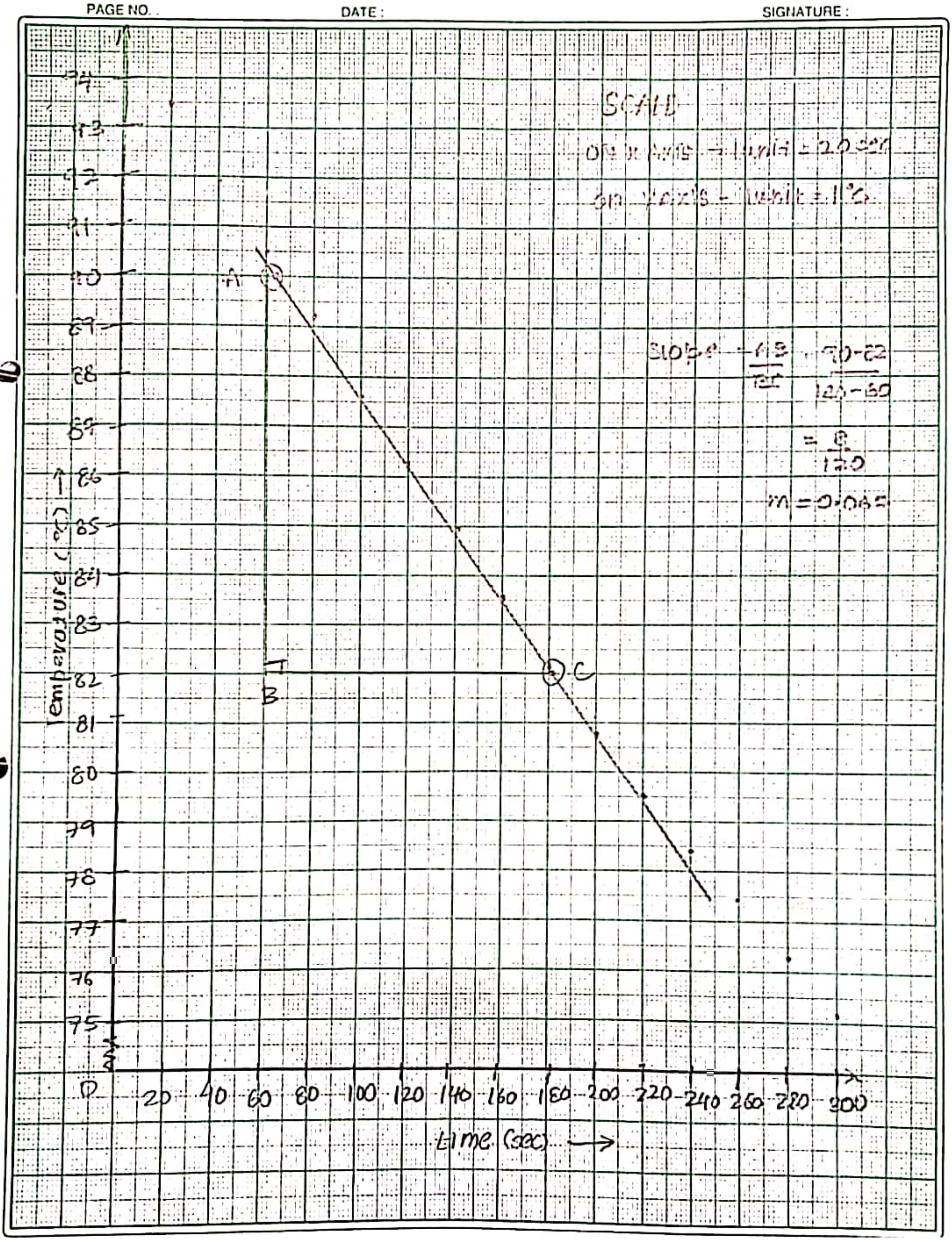

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RESULT

The cofficient of thermal cofficient of the given non-metallic solid (glass Disc) is K

$K = 0.356 \ J/mc^{\circ}sec$

PRECAUTIONS

① The steady state should be obtained very accurately.

② observations of d and x of the experimental disc should be taken before starting the experiment.

SOURCES OF ERROR

① Experimental disc may be thick, it should be thin.

② The value of $\frac{d\theta}{dt}$ from graph should be obtained at temprature θ_2.

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INNOVATIVE EXPERIMENT - I

AIM :-
A comparative study of different diodes

1 Zener diode
The operation of zener diode is same as that of ordinary in diode under forward biased condition whereas under reverse bias condition, Breakdown of the junction occurs. The breakdown voltage depends upon the amount of doping. If the diode the heavily doped. Depletion layer will we then and consequently breakdown occurs at lower reverse voltage whereas a lightly doped diode has a higher breakdown voltage. Thus the breakdown voltage can be selected with the amount of doping.
The sharp increasing current under breakdown conditions are due to the following two mechanisms :-

(1) Avalanche breakdown
(2) Zener breakdown

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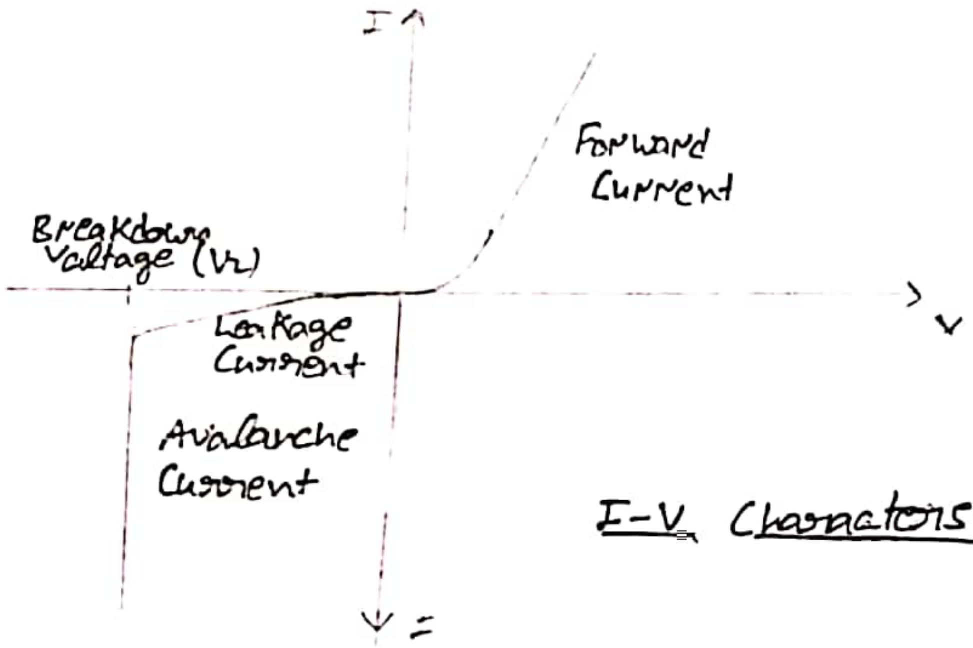
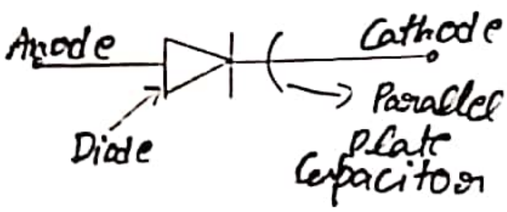
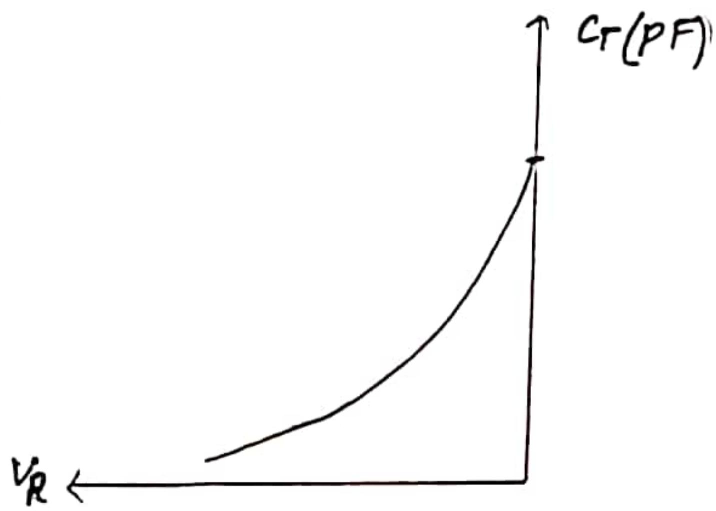
Zener Diode



I-V Characteristics



VARACTOR DIODE



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2. Varactor Diode

The varactor diode also called a varicap tuning of voltage capacitor diode is a junction diode with a small impurity dose as its junction, which has the useful property that its junction or transition capacitance is easily varied electronically when diode is reverse biased, a depletion region is formed. The larger the reverse bias applied accross the diode. The width of the depletion layer "w" becomes wider conversely the depletion region width "w" becomes narrower.

As the capacitance is universly proportional to the distance between the plates $\left(C_T \propto \frac{1}{W}\right)$ the transition capacitance C_T varies universly with the reverse voltage.

The varactor diode are used in Radio and TV recievers. AC circuits, self adjusting bridge circuits and adjustable bandpass filters.

3. POINT - CONTACT - DIODE

It consists of N-type germinium or silicon wafer about 1.25 mm square by 0.5mm thicks, one face of which is soldered to a metallic base, by radio frequency heating.

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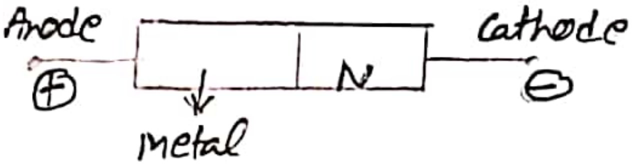
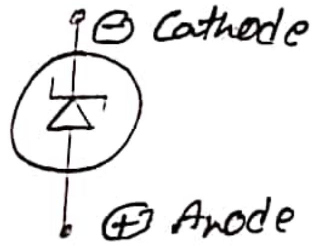
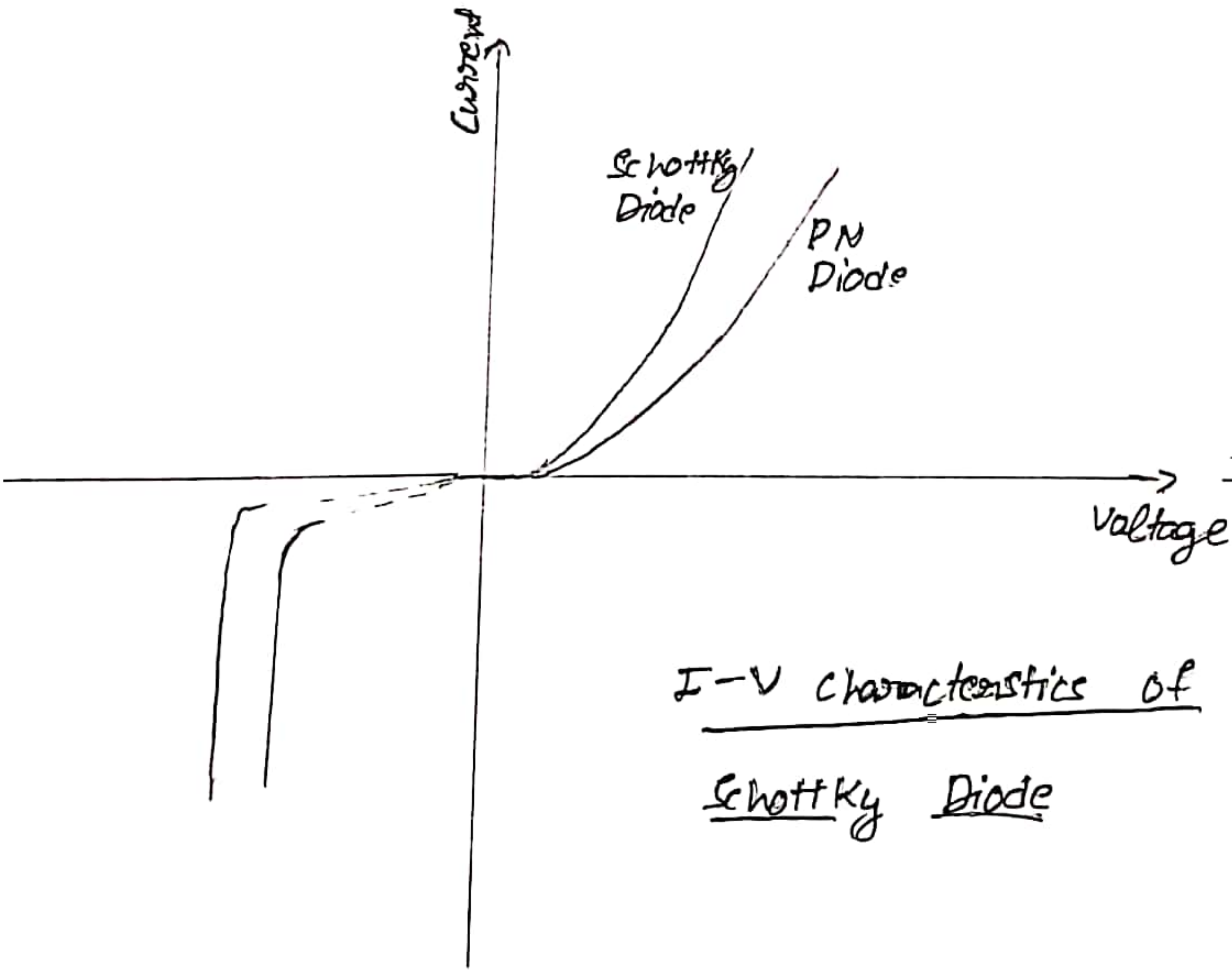
Symbol







I-V characteristics of Schottky Diode

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So that an external ohmic contact can be made. The front contast is made simply by pressing a tungesten or phospher bronze were of a few micro meter diameter, called cat's whisker against. The exposed surface of the crystal. The contact area may be smaller than the area of the wire. After the whisker is in place the whole assembly in encapsulated in a ceramic or glass envelope to give it a mechanical strength. The S-shaped bend in the whisker gives it mechanical stability and also spring like property for maintaining good electrical contact.

4. Schottky Diode

Schottky diode is an extension of the oldest semiconductor device that is the point contact diode. Here the metal semi-conductors interface is a surface, the schottky diode rather than a point contact.

The schottky diode is formed when a metal such as Aluminium, is brought into a contact with a moderately doped N-type semiconductor. It is a unipolar device because it has high electrons as majority carriers on both sides of junctions. Hence no formation of

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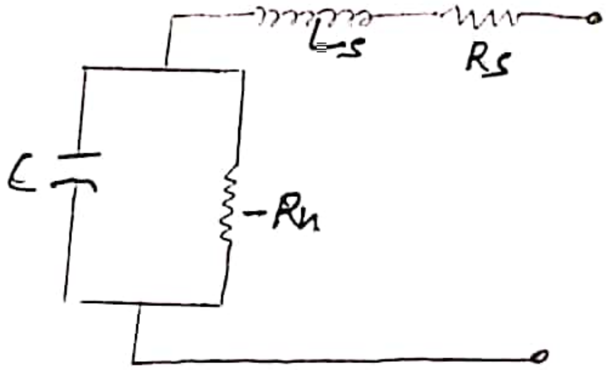

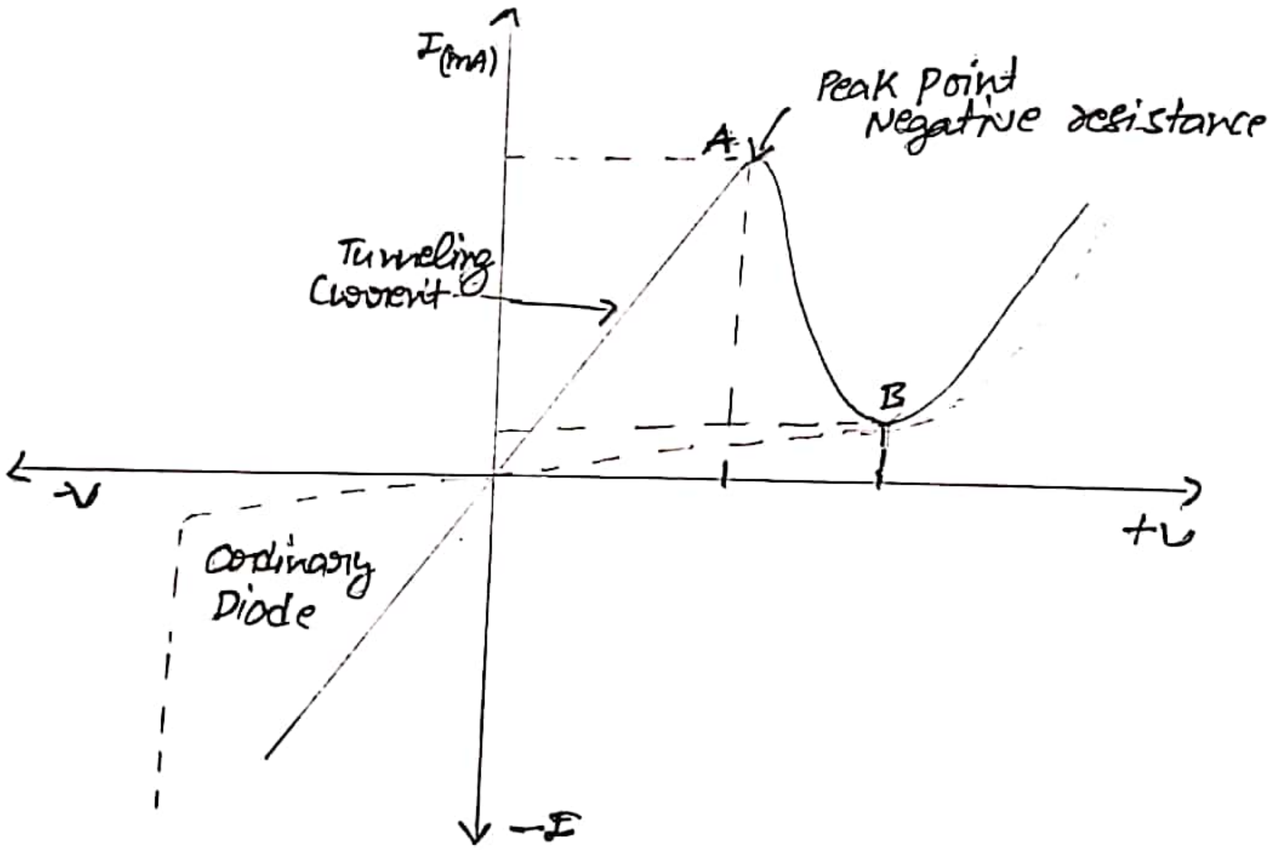

TUNNEL DIODE

depletion layer. The V-I characteastice of a schotky diode and a PN-Junation diode is controlled by the diffusion of minority carrier whereas the current in the schottky diode results from the flow of majority charge carriers over the potential barriers at the metal semiconductor junction.

5 Tunnel Diode

It is a thin junction diode which exhibits negative resistance under low forward bias conditions. The width of the junction barrier varies inversely as the square root of impurity concentration and ∴ is reduced from 5 microns to less than 100A (10^{-8}m). This thickness is only about (1/50)th time of the (λ) of visible light. For such thin potential energy barriers, the $e^{\ominus}$ will penetrate through the junction barrier.

It is seen that at first forward current rises sharply as applied voltage is increased where it would have risen slowly for an PN Junction Diode. The reverse current is much larger for comparison of back bias than in other diodes due to the thickness of junction.

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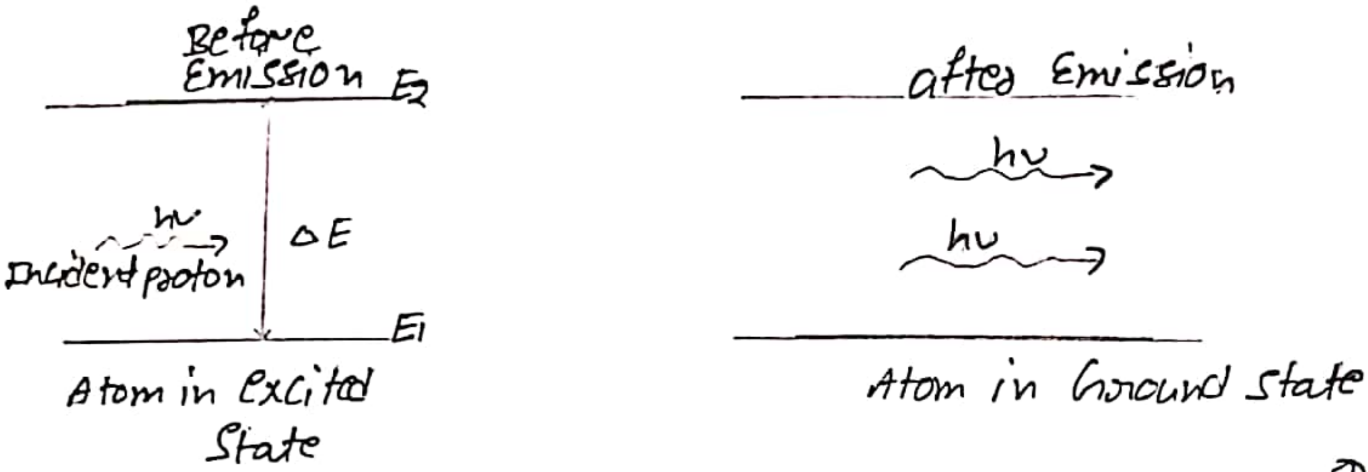
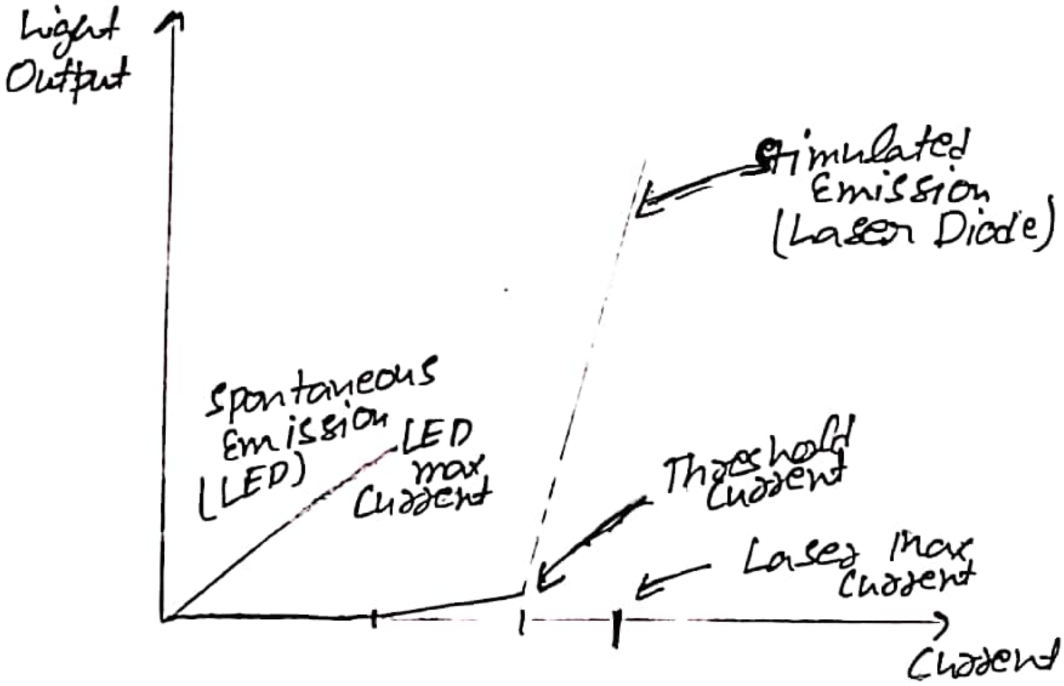


$$E_2 - E_1 = \Delta E = h\nu$$



LASER DIODE

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6 Laser Diode

Lasers are used to convert electrical signal to light signal. In direct energy band gap materials where high recombination velocities exhibit. Optical gain can be achieved by creating population inversion of carriers through high level current injection and by forming a resonant cavity. This cavity is usually produced by the high Fresonal reflectivity obtained from cleaving the material along faces perpendicular to the junction plane.
In this diode opposite ends of the junction are polished to get mirror like surfaces when free $e^{\ominus}$ recombine with holes.

Result
Comparative study on different diodes have been completed.

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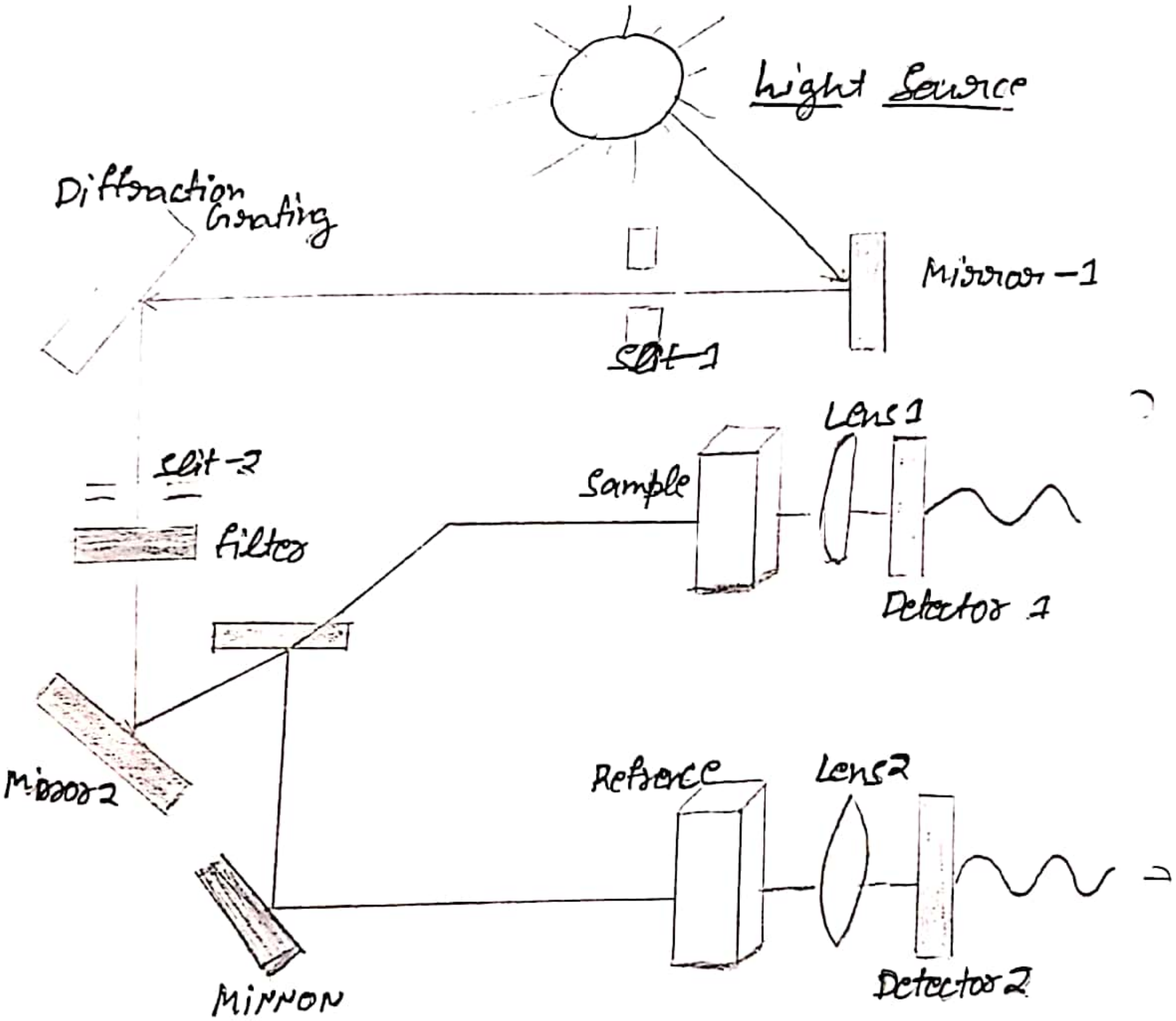

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INNOVATION - 2

Aim

Discuss and compare different methods to determine the band gap of semiconductors.

Method - I Via UV - Vis Spectra Method

The band gap of a semiconductor describes the energy needed to excite an electron from the valence band to the conduction band. This method is based on the assumption that the energy dependent absorption α can be expressed by

$$(\alpha . h\nu)^{1/\gamma} = B(h\nu - E_g)$$

where; $h \rightarrow$ Planck's constant
$\nu \rightarrow$ frequency of photon
$E_g \rightarrow$ Band gap of Energy
$\gamma \rightarrow$ Variable and depends upon the nature of transition of electron. [1/2, 2]

In this work, a complex dielectric transformation of UV-vis diffuse reflectance spectra is proposed to estimate the optical band gap energies of an array of materials as conductors, semi-conductors and insulators. The results are compared with more common Kubelka - Munk (K-M) transformation. The results shows a close match between

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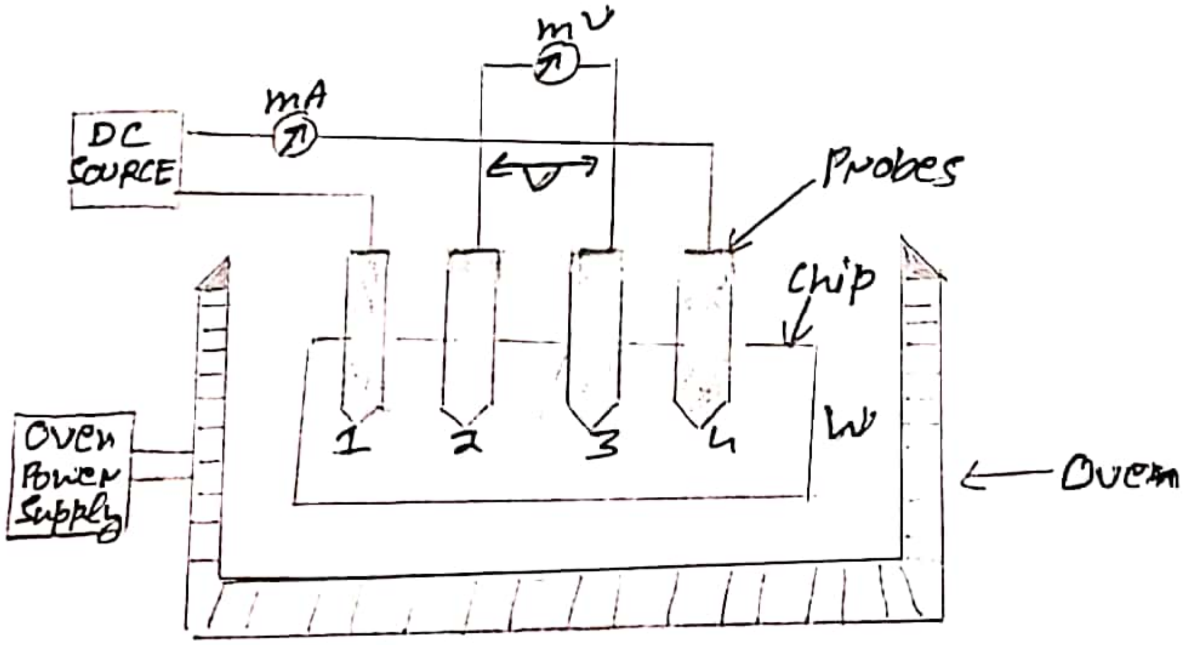

Four Probe Experiment Setup

the proposed method and the Tauc model based on the well-established dielectric transformation is unique in a way to estimate band-gap energy when there remain unresolved or multiple absorption peaks in the diffuse reflectance spectra. The complex dielectric transformation method also distinguishes the class of the material which is of paramount importance to validate and substantiate the band-gap energy values.

Method-II Four Probe Method

By ohm's law, the electric field intensity E at a point in a material is proportional to the current density, J that is induce at that point. The proportionality constant is called electrical resistivity, ρ of the material is

$$E = \rho J$$

For a sample with a long wire like geometry with uniform cross-section. ρ can be measured by simply passing a known current through sample and measuring voltage. This method has several disadvantage. These difficulties can be overcomed by applying four-probe method.

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In this 4 pointed collinear equally spaced probes are placed in preesure contact with the plane surface of the sample. A current is injected into sample through 2 probes (1,4). The potential distribution is measured via two inner probe(2,3). The voltage drop V for current I is given by a sample expression, if certain conditions are specified. Assumption is surface of sample is flat.

The diameter of contact b/w each plate and sample should be small compared to the distance b/w the probes. Thickness d of the sample is assumed to be smaller than the distance, s b/w two probes. Under such conditions

$$V = \frac{I}{\pi d} \rho \ln 2$$

ρ is the resistivity of semiconductor sample

Temprature variation is given by

$$\rho = \rho_0 \exp\left(\frac{E_g}{KT}\right)$$

E_g known as band gap energy can be calculate as

$$E_g = 2K \frac{2.3026 \times \log_{10} \rho}{1/T} \text{ eV}$$

[Boltzmann constant] $K = 8.6 \times 10^{-5}$ eV/deg

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

V and I are the voltage and current across and through the crystal and s is distance b/w probes and d is the thickness of semiconductor crystal.

Result

The energy band gap $[E_g]$ for the given semiconductor can be calculated.

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