01 Expt. No. | 01 Page No. | 27/3/23 Date

Aim

To study the VI characteristics of P-N Junction diode in (I) Forward Biasing (II) Reverse Biasing.

Apparatus

P-N Junction Diode Kit.

Theory

P-N diode is formed by joining p type semiconductor with n type semiconductor. It is done by various joining techniques. The diode works only when some potential is applied to it. It can be applied in two ways:

a) Forward Biasing   b) Reverse Biasing

Forward Biasing

When p type is connected to positive terminal and n type is connected to negative terminal of battery, diode is said to be forward biased. As a result the width of potential barrier (0.1 to 0.3 V) in diode is reduced. Therefore small fwd. voltage is needed to overcome the barrier. Once the potential barrier is eliminated the current starts flowing.

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- Forward Bias

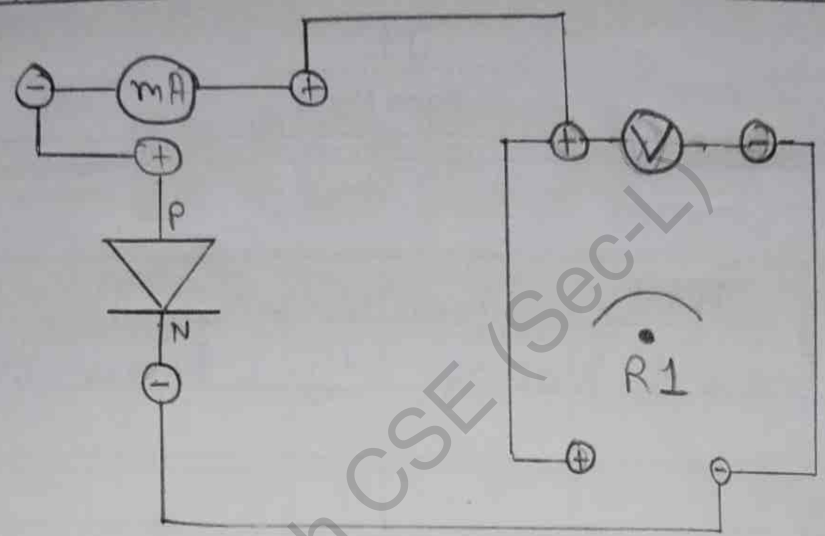


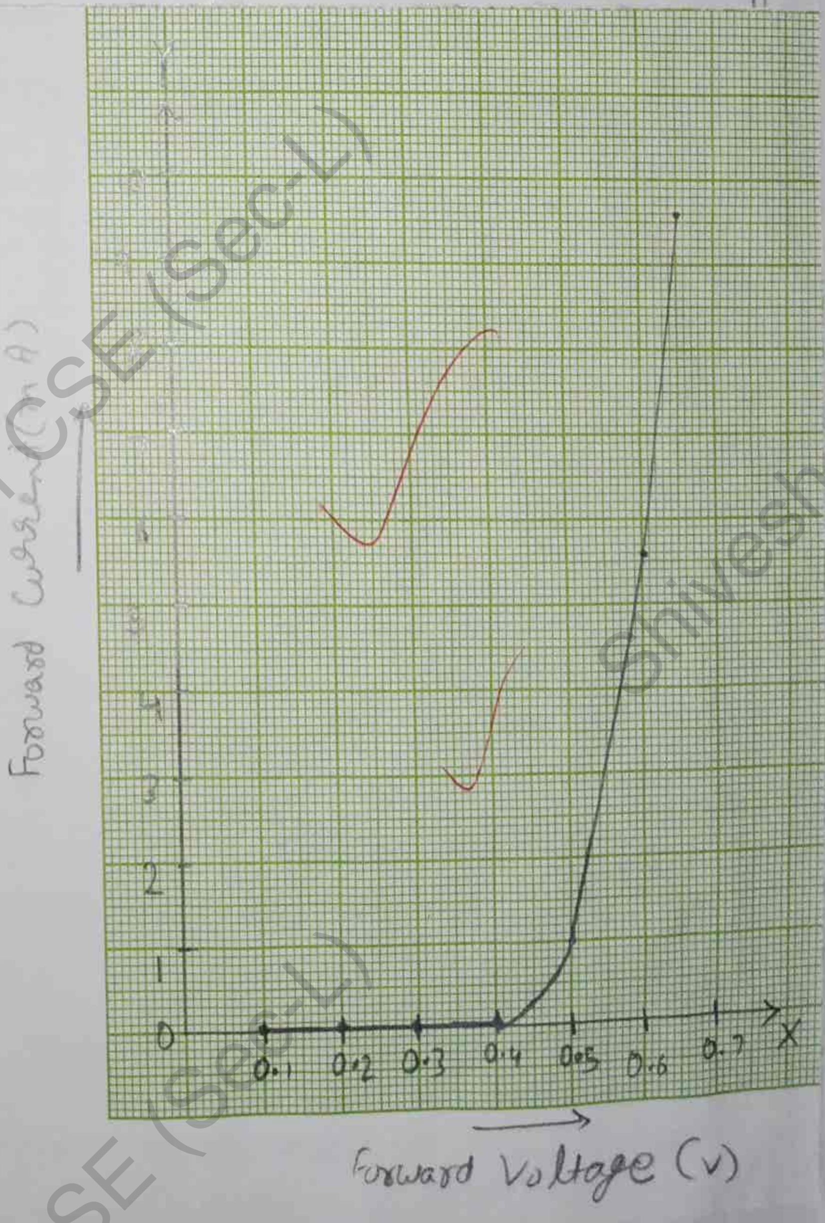
Fig. 1a
Of Forward Bias

Observation

S. No.	Forward Voltage (V)	Forward Current (mA)
1.	0.1	0
2.	0.2	0
3.	0.3	0
4.	0.4	0
5.	0.5	1
6.	0.6	5.6
7.	0.65	9.6

Fig. 1 b

Graph



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This is called forward current and in this biasing the resistance of diode almost becomes zero.

Reverse Biasing

When p type is connected to negative terminal and n type is connected to positive terminal of battery, diode is said to be reversed biased. As a result the width of potential barrier in diode is increased and it prevents the flow of charge carriers across the junction. Thus a high resistance path is established for circuit and hence current does not flow. If reverse voltage is continued to increase then electrons get enough kinetic energy to knock out from semiconductor and then break down of junction occurs. This is characterized by sudden rise in the reverse current and fall in resistance.

- Procedure

Forward Bias Characteristics

1) Make all connections as shown in Fig. 1 a.
2) Knob of potentiometer R1 is kept fully anticlockwise.
3) Now switch on the unit and set the charge to 0V.
4) Increase the voltage in small steps and note down the corresponding current. Note down the observation in

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- Reverse Bias

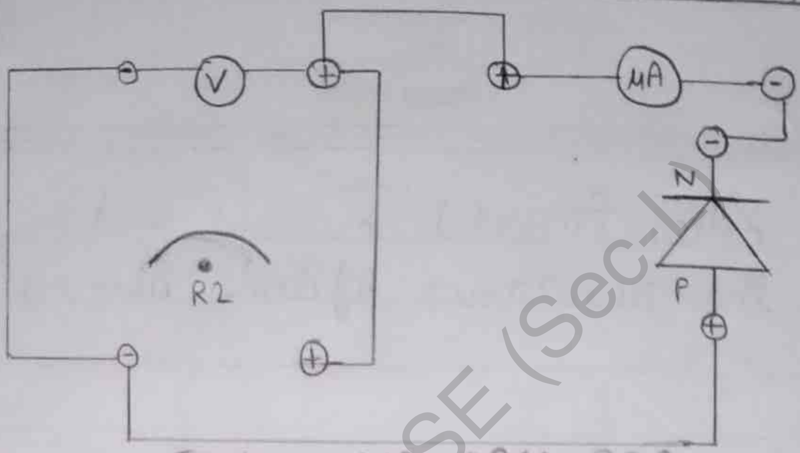
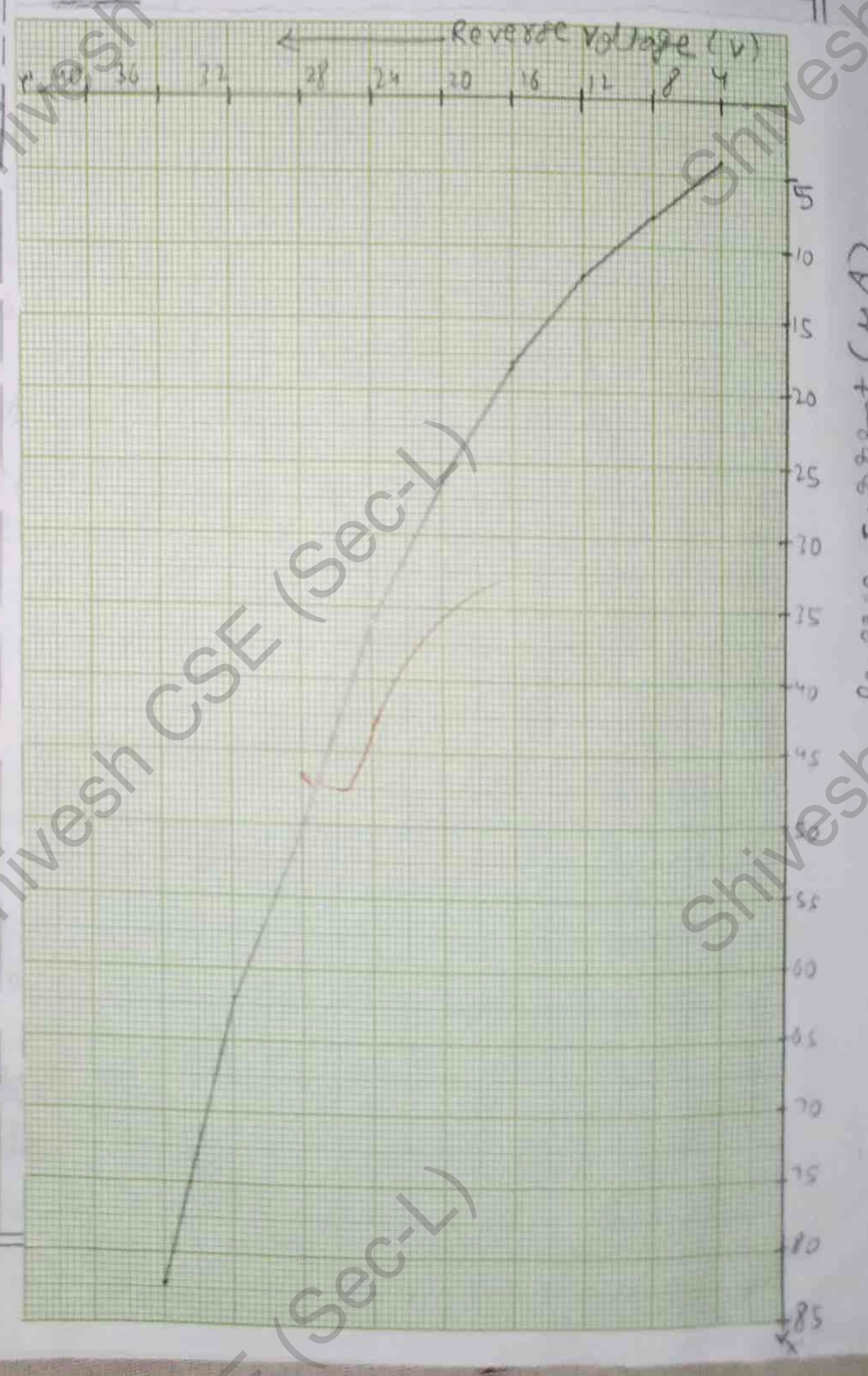


Fig. 2a of REVERSE BIAS

- GRAPH



- Observation

S.No.	Reverse Voltage (V)	Reverse Current (µA)
1.	4	4
2.	8	8
3.	12	12
4.	16	18
5.	20	26
6.	24	36
7.	28	50
8.	32	62
9.	36	82

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table 1 b.

5) Plot a graph between voltage and current as shown in Fig 1 c.

Reverse Bias Characteristics

1) Make all connections as shown in fig. 2 a.
2) knob of potentiometer R2 is kept fully anticlockwise.
3) Now switch on the unit and set the voltage to 0V.
4) Increase the voltage in small steps & note down the corresponding current. Note down the observation in table 2 b.
5) Plot a graph between voltage and current as shown in Fig 2 c

- Result

The diode offers good conductive path (Low resistance) when forward biased.
The diode offers bad conductive path (High resistance) when reverse biased.

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Implications

Implications of P-N Diode

1. P-N Junction diode in reverse biased configuration sensitive to light from a range between 400 nm to 1000 nm which includes visible light. Therefore, it can be used as a photodiode.

2. It can also be used as a solar cell.

3. P-N Junction forward bias condition is used in all LED lightning applications.

4. The voltage across biased P-N junction is used to create temperature sensors and reference voltage.

5. It is used in many circuits like rectifiers, varactors for voltage controlled oscillators.

6. It is used in clipping circuits as wave shaping in computers, radios, radars, etc.

7. It is used as switches in digital logic circuits.

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17/04/23

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- AIM

To study characteristics of a Zener Diode

- APPARATUS REQUIRED

Zener Diode Kit / Setup.

- THEORY

Semi-Conductor P.N. Junction Diodes are generally used as rectifier. They are suitable for converting AC into DC. But they suffer form the disadvantage that their maximum safe inverse voltage is relatively small. When a reverse voltage is applied conduction stops and the P.N. Junction Diode blocks the reverse current like any other rectifier. As the reverse voltage increases a small current flows in the circuit. If however, the reverse potential is increased beyond a limit, the reverse current increases sharply to a high value. At the voltage where the current increases suddenly is called Break Down Voltage. This sudden increase in current is known as AVALANCHE or ZENER CURRENT. The Zener Diode Makes a virtue of it and operates at this very point.

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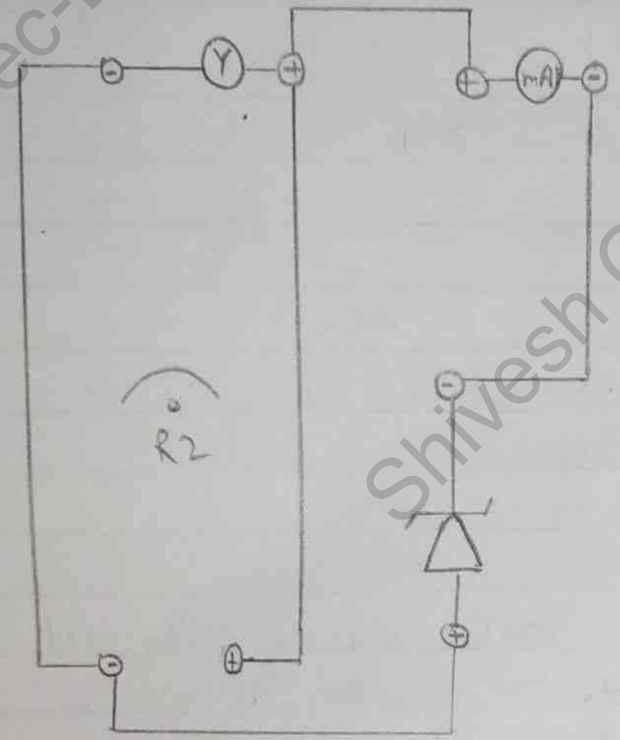
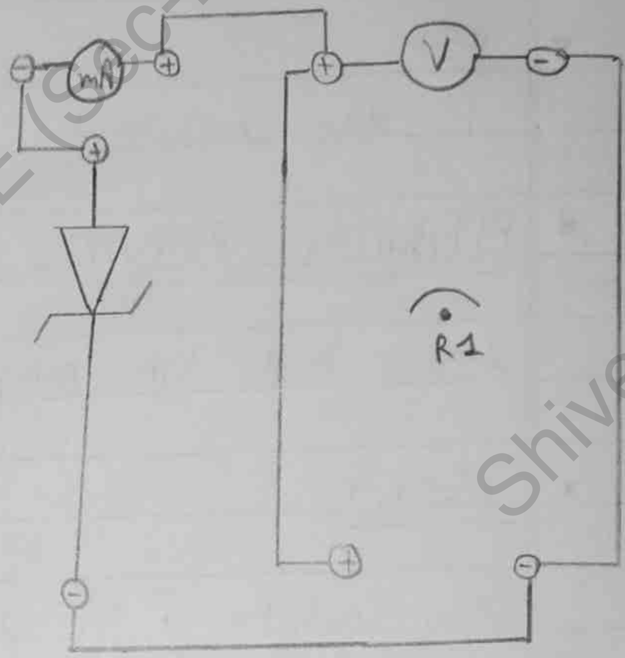
- Diagram



REVERSE BIAS

Fig 2A



FORWARD BIAS

Fig 1A

- OBSERVATION TABLE

S.NO.	Reverse Voltage (V)	Reverse Current (mA)
1.	0.8	0
2.	1.6	0
3.	2.4	0
4.	3.2	0
5.	4	0
6.	4.8	0
7.	5.6	0
8.	6.4	0.2
9.	6.6	2

REVERSE BIAS

S. No.	Forward voltage (V)	Forward current (mA)
1	0.1	0
2	0.2	0
3	0.3	0
4	0.4	0
5	0.5	0
6.	0.6	0.2
7.	0.7	3
8.	0.750	9.4

FORWARD BIAS

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PROCEDURE

Forward Bias Characteristics

1. Make all connections as shown in fig 1a.
2. Knob of potentiometer R1 is kept fully anticlockwise.
3. Now switch ON the unit and set the voltage to 0V.
4. Increase the voltage in small steps and note down the corresponding current. Note down the observation in table.
5. Plot a graph b/w voltage and current as shown in fig 1c.

Reverse Bias Characteristics

1. Make all the connections as shown in fig 2a.
2. Knob of potentiometer R2 is kept fully anticlockwise.
3. Now switch ON the unit and set the voltage to 0V.
4. Increase the voltage in small steps and note down the corresponding current. Note down the observation in table.
5. Plot a graph b/w voltage and current as shown in fig 2c.

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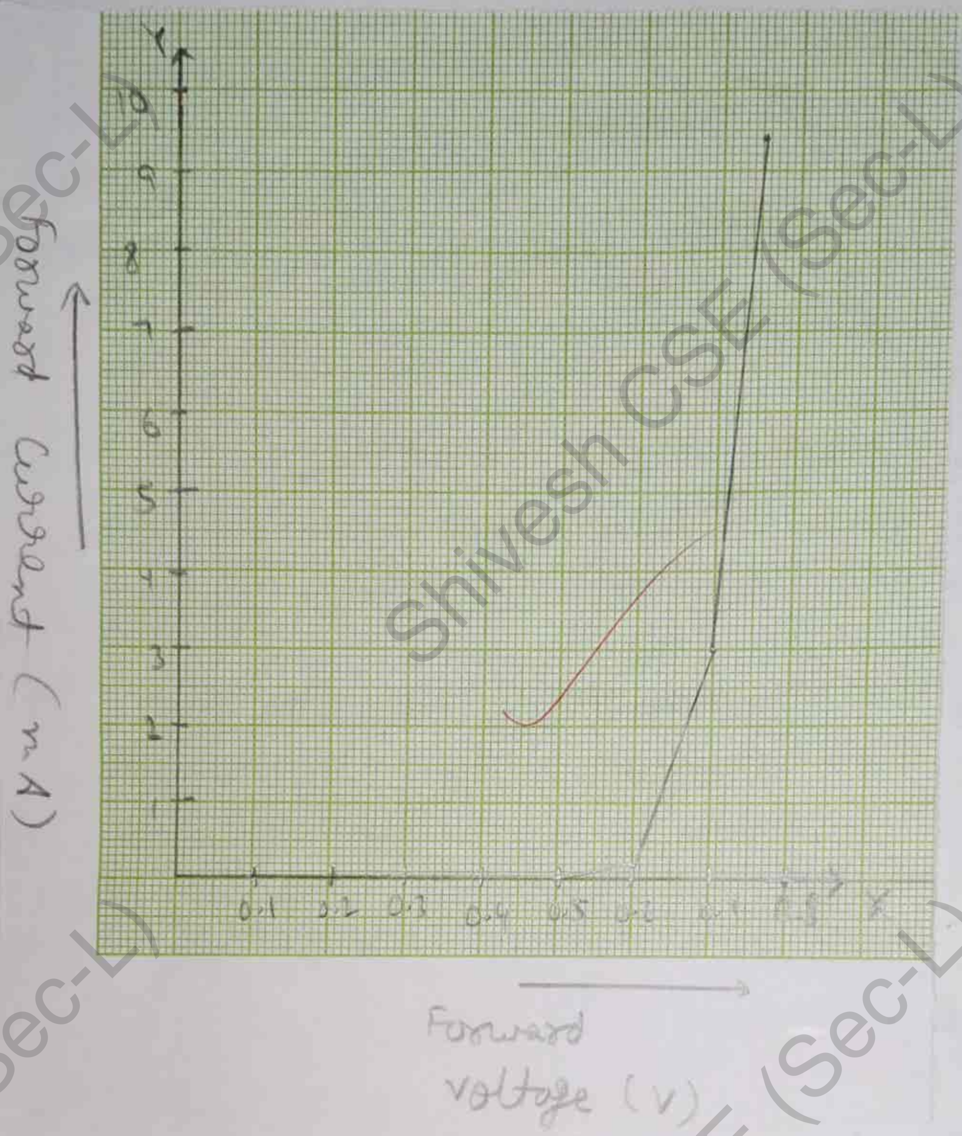

Fig 1(C)

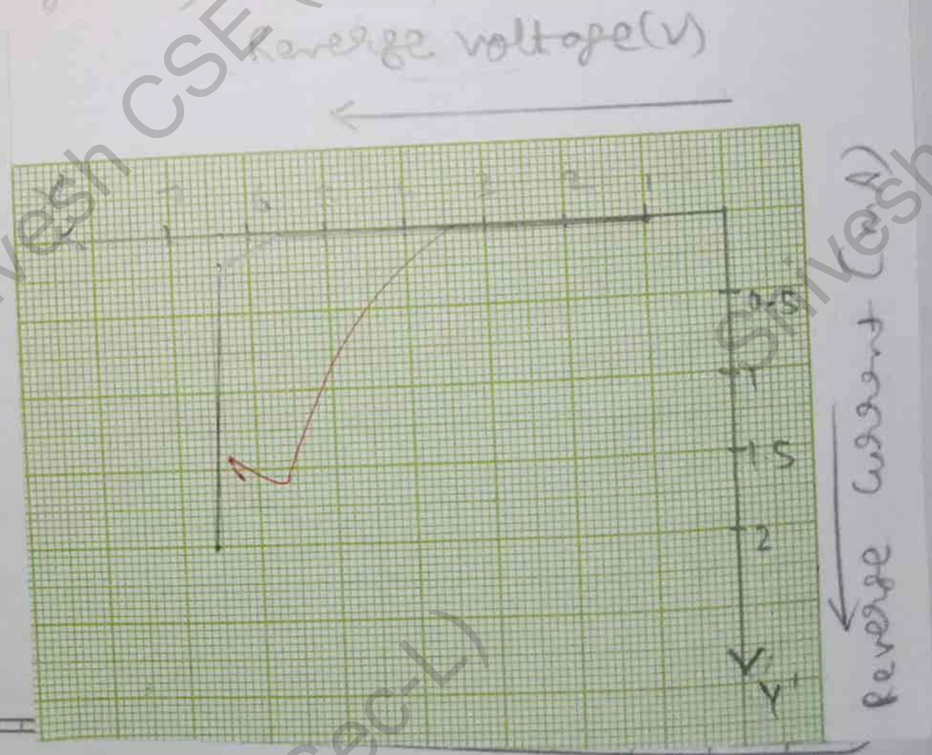

Fig 2 (C)

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Implications of Zener Diode

① In a DC circuit, Zener diode can be used as a voltage regulator ~~or~~ to provide voltage reference.

"The main use of zener diode lies in the fact that the voltage across a ~~zer~~ zener diode remains constant for a larger change in current." This makes it possible to use a zener diode as a constant voltage device or voltage regulator.

→ Working applications of zener diode
With growing popularity of smart phones, android based project are being preferred these days.

These projects involve use of Bluetooth technology based device. These Bluetooth devices require about 3V voltage for operation. In such cases, a zener diode is used to provide a 3V reference to Bluetooth device.

② Waveform clippers (consists of two zener diodes) can be used not only to reshape a signal, but also to prevent voltage spikes from affecting circuits that are connected to power supply.

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09/05/23

• Observation Table

S. No.	Distance from screen (D)	Width of central Maxima	Diameter of wire
1.	100	0.5	0.012656
2.	150	0.6	0.0158
3.	200	0.7	0.0180

$$d = \frac{0.012656 + 0.0158 + 0.0180}{3}$$

$$\Rightarrow \underline{\underline{0.01548 \text{ cm}}}$$

• DIAGRAM

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- **Objective**

To measure the diameter of a thin wire using the phenomenon of diffraction.

- **Item Required**

A He - Ne Laser, thin wire mounted in holder.

- **Theory**

When a wire is illuminated by a laser beam, a diffraction pattern is observed on the screen. If 'd' is the diameter of the wire, diffraction is being observed at a distance 'D' from the screen and 'X' is the width of central maxima then

$$d = \frac{\lambda D}{X}$$

where 'λ' is the wavelength of laser light

- **Procedure**

Illuminate the wire with the laser beam as shown in fig and observe the diffraction pattern on screen. Measure the distance D of the screen from wire & width of central maxima X. Now, apply the formula given above and find out the diameter of the wire. The wavelength of He - Ne laser light is 6328 Å.

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- **Result**

Diameter of given thin wire is found to be 0.01548 cm.

- **Precautions**

① Do not see directly into the laser beam.
② Keep the mounted wire about one meter away from laser and from the screen about 1 to 1.5 m away.

- **Implication of Laser**

1. We can calculate wavelength of light (source) laser used in this experiment.
2. One can study diffraction pattern of LASER.
3. We can calculate the value of N.A. by using LASER.
4. LASER can be very useful in measurement of atmospheric pollutants such as dust, smoke & flysha. Pulsed laser are used for this kind of work.
5. S/C Laser used for printing.

09/05

- # OBJECTIVE

To determine forbidden energy band gap in semi-conductor diode.

- ## Apparatus

Energy band gap kit.

- ## Theory

A semiconductor, doped or undoped, always possesses an energy gap b/w its conduction & valence bands for conduction of electricity a certain amount of energy is to be given to the electron, so that it goes from valence band to conduction band. The energy so needed is measure of energy gap ΔE b/w two bands.

When a P-N junction is reverse biased; the current through the junction is due to minority carriers, i.e., due to electrons in the P section & holes in N section. The ~~connection~~ concentration of these carriers is dependent upon energy gap ΔE. The reverse current I_s (saturation value) is function of temperature of junction diode & varies according to following relation:

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$$\log I_s = \log\left[A e^{n} N_n N_p \left(V_n/P_p + \frac{V_p}{N_n}\right)\right] - \frac{e\,\Delta E}{KT} \quad \text{---- (1)}$$

where N_n = Density of electrons in N material
P_p = Density of holes in P material
V_p = Velocity of holes
V_n = Velocity of electrons
A = Area of junction
K = Boltzman Constant
T = Absolute temperature of junction

$$N_n = \frac{2\,(2\pi m_n kT/e)^{3/2}}{h^3}$$

$$N_p = \frac{2\,(2\pi m_p KT/e)^{3/2}}{h^3}$$

m_n = mass of electron

m_p = Effective mass of hole.

For small range of temperature relation (1) can be put as

$$\log I_s = \text{Constant} - 5.036\,E\,(10^3/T) \quad \text{---- (2)}$$

Therefore; if a graph is plotted between $\log I_s$ & $10^3/T$. A straight line would be obtained where slope of the line = $5.036\,\Delta E$ (ΔE is in eV).

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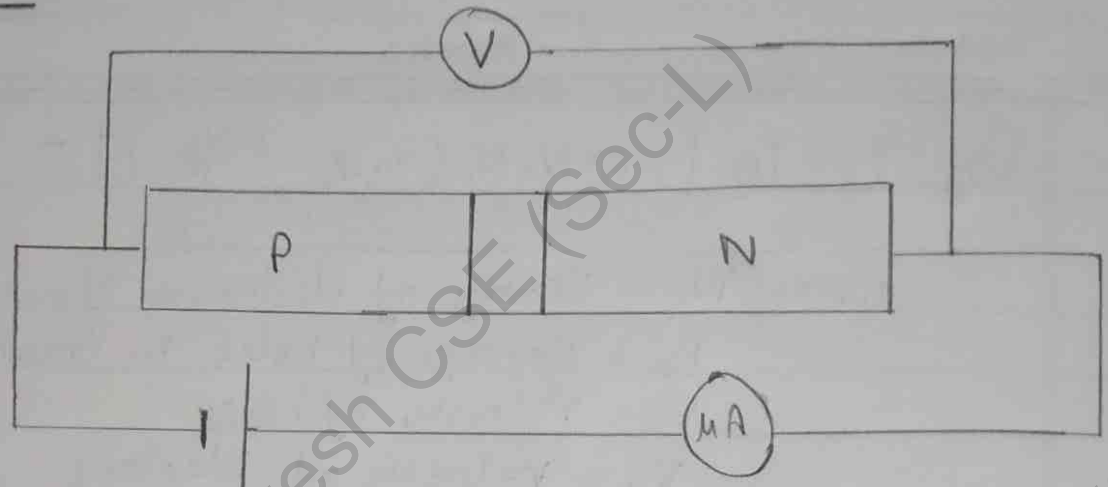
- Diagram



- Observation Table

Current (I_s) (μA)	Temp in °C	Temp in K	$10^3/T$	$\log I_s$
52	85	358	2.79329	1.71600
43	80	353	2.83286	1.63346
34	75	348	2.87356	1.53147
27	70	343	2.91545	1.43136
22	65	338	2.95858	1.34242
17.5	60	333	3.00300	1.24303
13.5	55	328	3.04878	1.13033
11	50	323	3.09598	1.04139

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• Panel Description

Besides the main ON/OFF switch & the PILOT LAMP, there is one ON/OFF switch provided for the heater alongwith a 3 position rotary heat control switch. This switch controls the rate of flow of ~~control~~ current to the heater & hence controls the rate at which the temperature rises.

There are two meters provided on the front panel, the voltmeter is used to measure the voltage ~~supplied across~~ applied across the reverse biased diode & the microammeter is used to measure the current in circuit. The voltage to be applied can be varied (from 0 – 10V) by the potentiometer on the lower right side of the panel.

Between two meters is a bakelite cover with a hole for inserting the thermometer. The diode is mounted beneath this bakelite cover & the terminals are brought out for connections. The diode is wrapped in glass wool to provide uniform & stable heating & placed in a container. At the base of the container is the heater.

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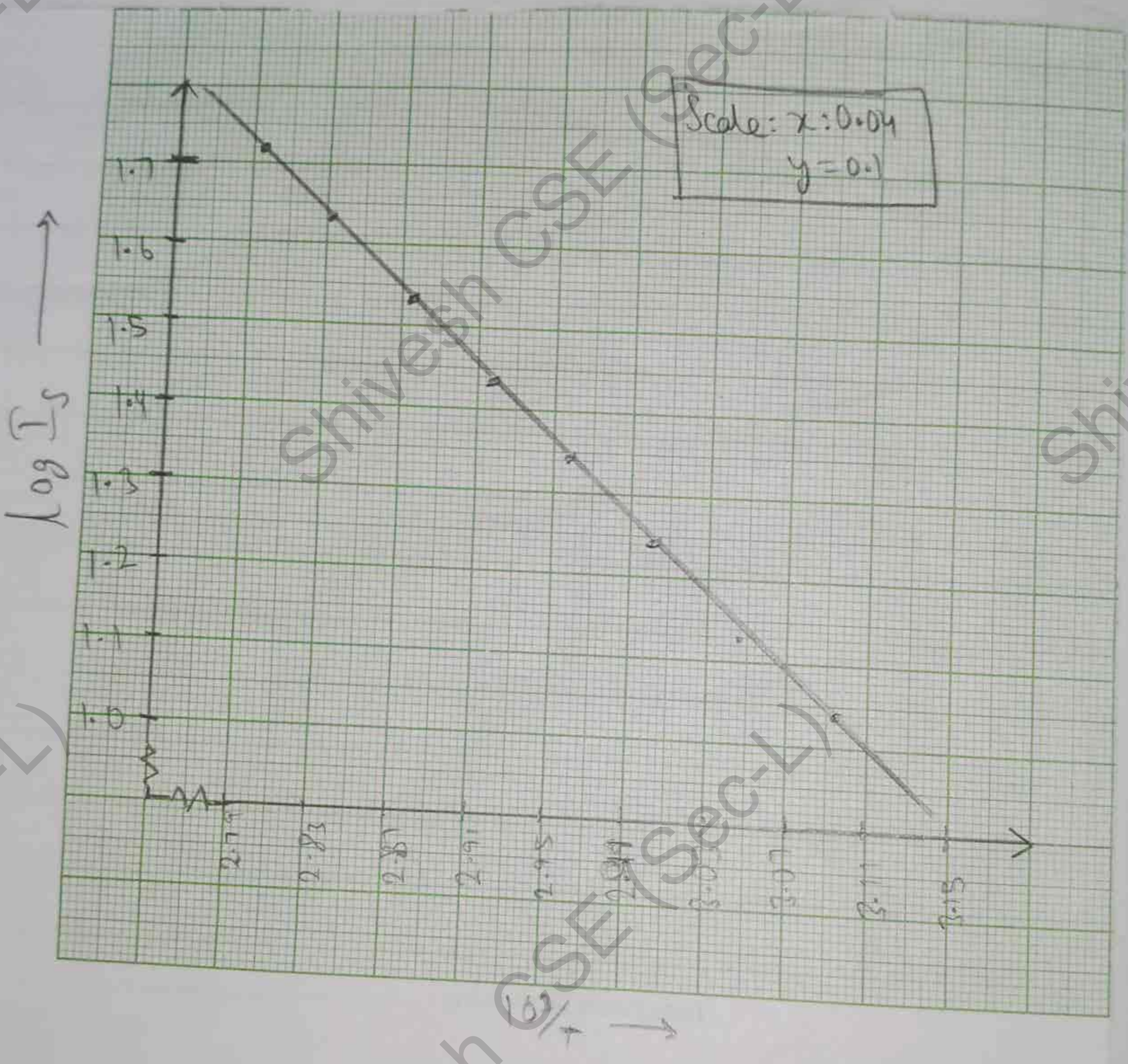
• Graph



$$\boxed{\text{Slope} = 2.22871}$$

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- Procedure

1. Rig up the circuit, using the diode, meters & the power supply.
2. Set the power supply potentiometer (0-10V) fully anticlockwise.
3. Switch 'ON' the main unit.
4. Set the temperature control switch to any desirable position & switch 'ON' the heater.
5. Allow the oven temperature to exceed upto 65°C. As soon as the temperature reaches 65°C. Switch 'OFF' the oven, enabling the temperature to rise further & become stable at around 70°C.
6. Apply a suitable reverse bias to PN Junction.
7. When temperature becomes stable start taking the reading ~~to~~ of the current & temperature.
8. Tabulate the Reading.
9. Plot a graph b/w the reading of $10^3/T$ on the X-axis and $\log I_s$ on Y-axis.
10. Determine the slope of the line.

- Result

Band Gap

$$\Delta E = \frac{\text{Slope}}{5.036} = \underline{0.44255} \text{ eV}$$

- **Precautions**

1. The oven should not be over heated.
2. The bulb of thermometer should be inserted well inside oven.

- **Implications**

i) Band gap engineering is the process of controlling or altering the band gap of a material by controlling the composition of certain semiconductor alloys, such as GaAlAs, InGaAs and InAlAs. It is possible to construct layered materials with alternating compositions by techniques like molecular beam epitaxy.

ii) These methods are exploited in the design of heterojunction bipolar transistors (HBT), laser diodes and solar cells.

iii) In photonic; band gaps or stop bands are ranges of photon frequencies where tunelling effects are neglected no photons can be transmitted through a material. The material exhibiting this behaviour is known as photonic crystal. By applying the technique in super symmetric quantum mechanics; a new class of optically disordered materials have been suggested.

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iv) Similar physics applies to phonons in a phononic crystal.

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- **Objective**

To determine the frequency of A.C. mains using sonometer and an electromagnet.

- **Apparatus**

A sonometer with soft iron wire, an electromagnet, a step down transformer, hanger with fitted weights, a ~~drop~~ clamp stand, meterscale, screw gauge, 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 checked, it vibrates with a frequency given by

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

In this experiment, the length of wire and tension are so adjusted that the natural frequency of ~~a~~ wire is equal to frequency of 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 & then passed through the copper wire of electromagnet. The current magnetises the cylindrical core twice during

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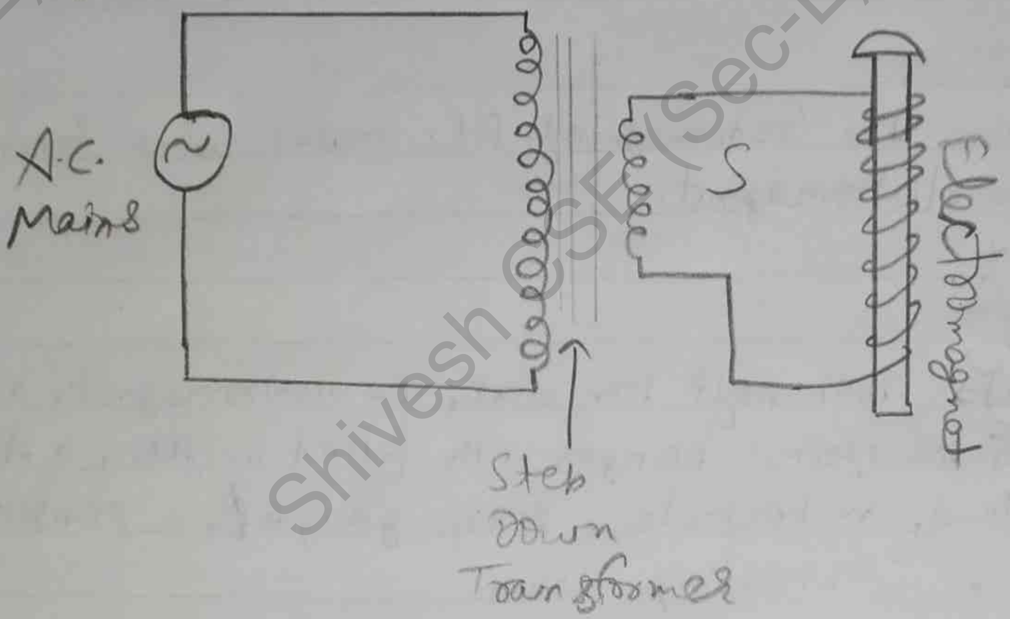
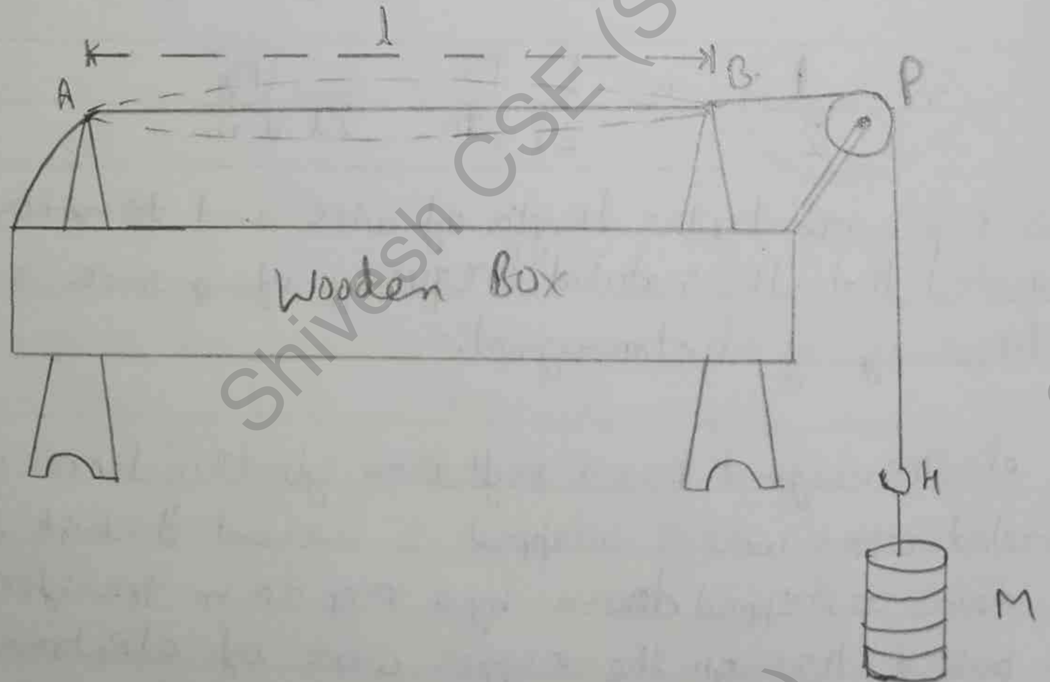
• Diagram


A.C. Mains
S
Electromagnet
Step Down Transformer


l
A
B
P
Wooden Box
H
M

each cycle – first with the polarity when the current flows in one direction and then with the opposite polarity when the current is in opposite direction. When the tip of ~~or~~ this cylindrical core is kept very close to the stretched soft iron core of the ~~sonometer~~ sonometer, the wire will be pulled towards the tip twice during each cycle. Thus, if frequency of AC mains is 50Hz, the wire will be pulled towards the tip of the core 100 times per second.

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

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

As; T, l and m can be measured, n and hence f can be determined. The value of mass per unit length m can be determined either by ~~weight~~ weighing a definite length of wire or by measuring the radius r and ~~tat~~ taking the density ρ of the material of the wire from table (soft iron; ρ = 7.8 g/cc). Then mass per unit length of wire is given by formula; $m = \pi r^2 \rho$.

- **Procedure**

1. Set up the sonometer.
2. Hold electromagnet vertically in a clamp stand about 2 to

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• Observation Table

Length of wire = 150 cm = 1.5 m

Mass of wire = 9.12 g = 0.00912 kg

Mass per unit length (m) = $\frac{9.12}{150} = \frac{0.00912}{1.5} = 0.00608$ kg/m

Acceleration due to gravity (g) = 9.8 m/s^2

S. No.	Load (M) (gm)	Length for resonance, l			Frequency $f = \frac{1}{4l}\sqrt{\frac{Mg}{m}}$ (Hz)
		Wedges moving outward (cm)	Wedges moving inward (cm)	Mean l (cm)	
1.	1500	27	27	27	45.528477
2.	2000	29.5	30	29.75	47.712183
3.	2500	31.5	32	31.75	49.987599
4.	3000	34	34	34	51.130844

Mean frequency = $\frac{\Sigma f_i}{4} \simeq 48.58878$ Hz

Experimental Value = 48.58878 Hz

Standard Value = 50 Hz

Percentage Error = $\frac{|50 - 48.58878|}{50} \times 100$

$= \boxed{2.82245\%}$

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3 mm above sonometer wire.

3. Bring two wedges A and B close to each other.
4. Suspend a load of 2kg on the hanger and switch on the AC supply, slide the wedges gradually away from each other till the wire starts vibrating and the rider begins to flutter.
5. Measure the length of wire between the two wedges, increase by a few centimetres.
6. Increase the distance between the two wedges by a few centimetres.
7. Increase the load in steps and find out resonant length l in each case. Take five such observations.
8. Switch off the AC mains and remove the magnet. Take about 1 metre of wire and find its weight by a positive balance and hence find the mass per unit length m. Another way to find m is using the formula $m = \sigma^2 \rho$ where σ is radius of wire and ρ is the density of material of wires ($\rho = 7.7\ g/cc$).

• Precautions & Source of error

1. String should be uniform, inextensible and kink free.
2. Friction in the pulley should be negligibly small otherwise the tension would be less than that of 1
3. Weight of M in formula should include weight of hanger.

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4. The resonance position should be obtained carefully first by increasing distance b/w the wedges then by decreasing it.
5. The sonometer wire should be of a magnetic material ~~so~~ like iron so that it is attracted by the electromagnet.

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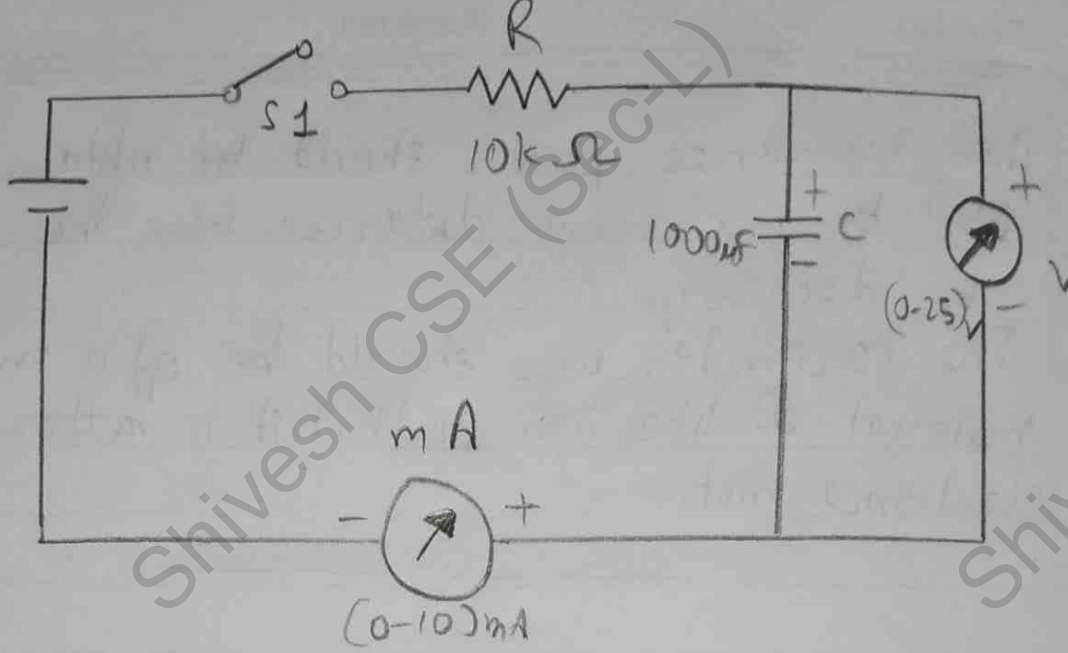
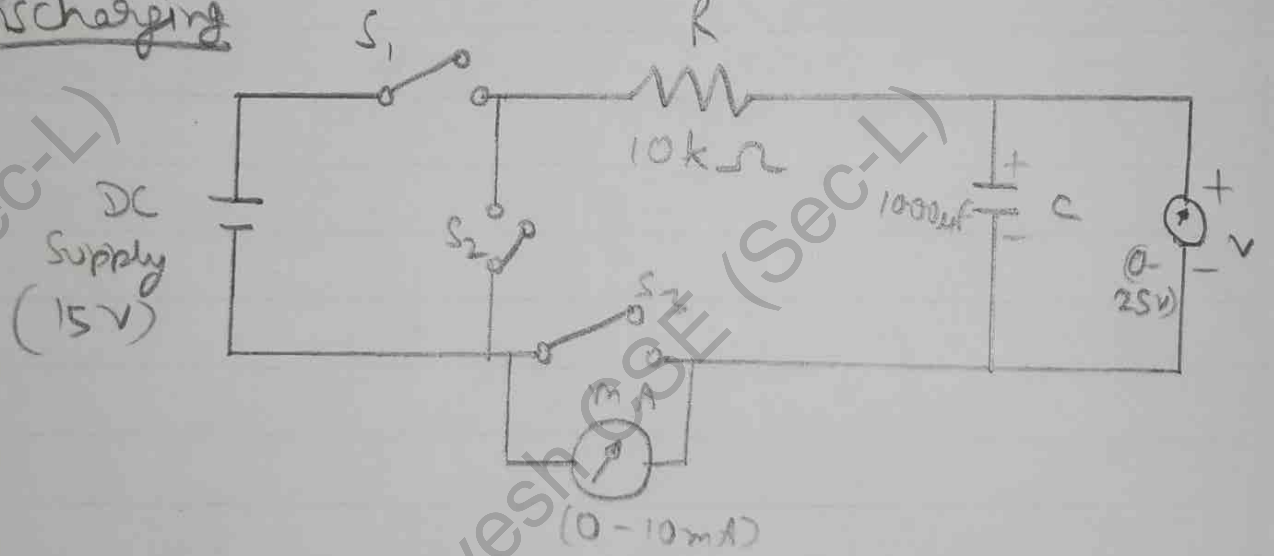
• Diagram

Charging



Discharging



- AIM

To study charge and discharge of a condenser through a resistor.

- Apparatus :

DC Supply (15 volts, 25 mA), Resistance (10 kΩ, 50 kΩ), Capacitors (500 μF, 1000 μF), DC voltmeter (0-25V), DC Milliammeter (0-10 mA), Toggle switches, Stop clock.

- Theory:

① Charging equation for capacitor, C through a Resistor R is given by:

$$q = q_0 \left(1 - e^{-t/RC}\right)$$

where RC is time constant and q_0 is maximum charge acquired by capacitor. The corresponding current equation is

$$i \frac{dq}{dt} = \frac{q_0}{RC} e^{-t/RC} = \frac{CE}{RC} e^{-t/RC} = i_0 e^{-t/RC}$$

② The discharge equations are

$$q = q_0 e^{-t/RC}$$

and $i = -i_0 e^{-t/RC}$

where $i = E/R$ and time constant is RC.

- Observation Table

For Charging of Condenser

$R = 10\ k\Omega$; $C = 1000\ \mu F$

S. No.	Time (in seconds)	Voltage (V)	Current (mA)
1	5	3.4	0.6
2	10	5.4	0.4
3	15	6.8	0.3
4	20	7.4	0.2
5	25	7.8	0.15
6	30	8.2	0.10
7	35	8.2	0.10

For discharge of Condenser :-

$R = 10\ k\Omega$

$C = 1000\ \mu F$

S. No.	Time (in seconds)	Voltage (V)	Current (mA)
1.	5	8.2	0.55
2.	10	5.2	0.40
3.	15	3.4	0.30
4.	20	2.1	0.20
5.	25	1.5	0.15
6.	30	01	0.10
7.	35	0.7	0.06
8.	40	0.6	0.05
9.	45	0.4	0.05

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• Procedure

(A) For Charging of ~~Conductor~~ Condenser

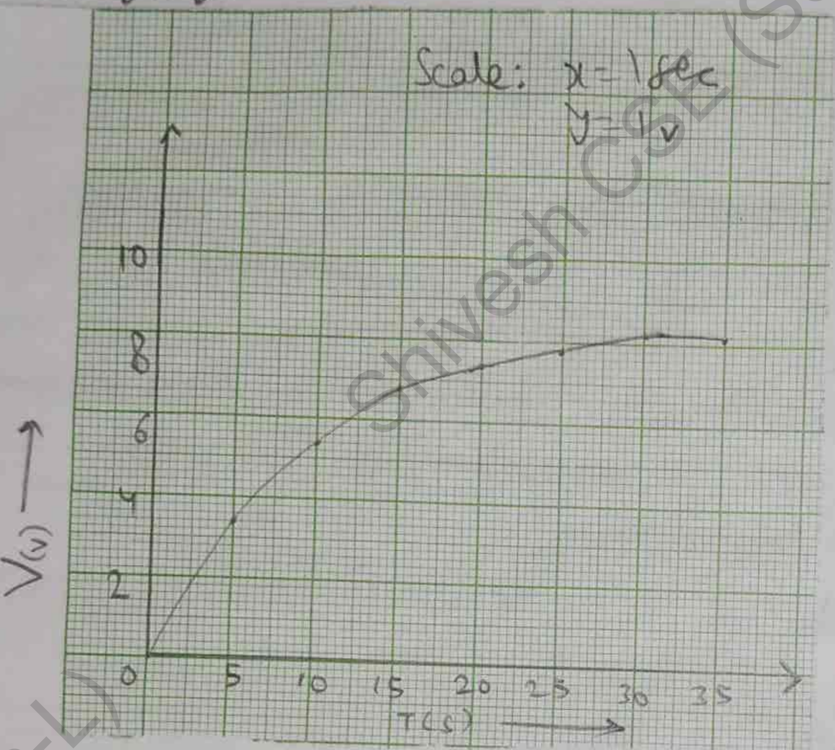
i) Link the circuit. Switch S_1 is open.
ii) Close switch S_1 and simultaneously start a stopclock.
iii) Reading in voltmeter will increase while current in milliammeter will decrease. Record readings of voltmeter and milliammeter after every 1 sec or 2 sec till voltage reaches a max and current a minimum.
iv) Repeat the experiment by changing R and C.

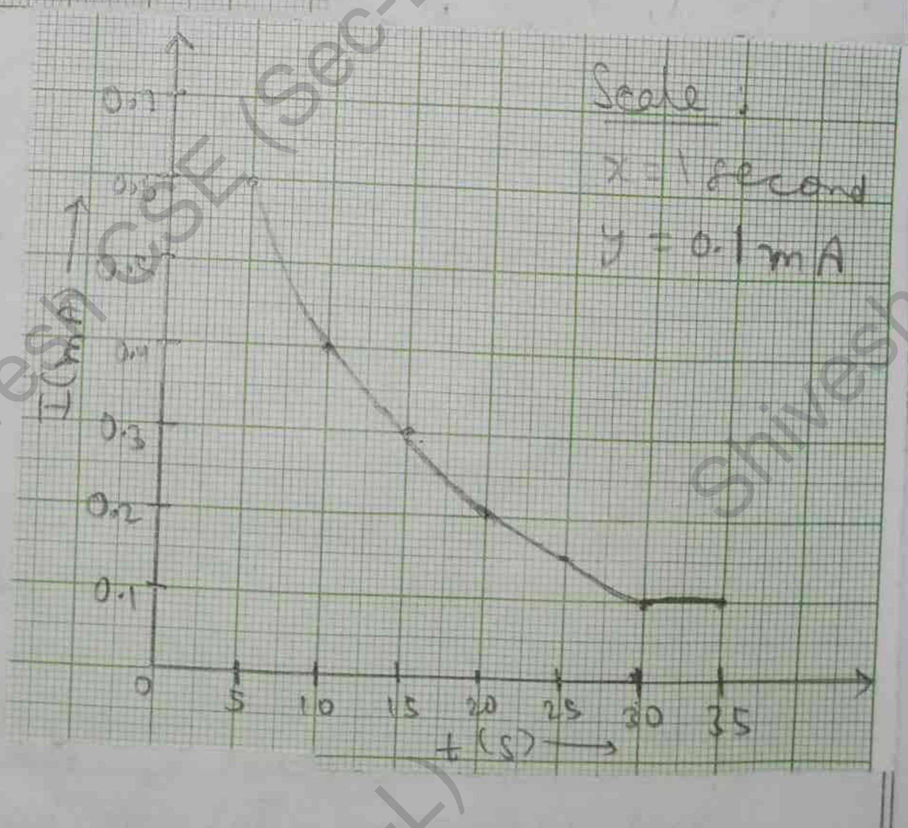
(B) For discharge of Condenser

i) Link circuit. Keep S_1 and S_2 switches open while S_3 closed.
ii) Close S_1 till reading in voltmeter teeches max value.
Then open S_1, close S_2. S_3 is already closed. Condenser will start discharging across R. Reading in voltmeter will decrease. Take reading of voltmeter after every 1 or 2 seconds till reading becomes a minimum.
iii) For discharge current open S_2. Again close S_1, so that reading in voltmeter reaches a max. Then open S_1, open S_2, close S_3. Reading in milliammeter will start increasing. Take its readings after every 1 or 2

• Graph

Charging :-





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seconds.

iv) Repeat experiments by changing R & C.

- Result

Time constant of circuit from graph = ___ sec.

Theoretical value of time constant = ___ sec.

- Precautions and Source of error

i) It is better to use voltmeter and milliammeter having small least count.

ii) Condensers should not be leaky.

iii) Appropriate values of R and C, given quite a good no. of observations, should be used.

- Implications

A capacitor can store electric energy during charging & it can dissipate that stored energy & can be used like temporary battery. Capacitors can provide upto 360 J/kg of energy density. It can be used in car audio system, for amplifier to use on demand.

Especially constructed low inductance high voltage capacitor can be used in supplying high pulses of current for many pulsed applications.

This pulsed supply can be used in EM forming, Marx generators, pulsed laser, fusion research & particle accelerator.

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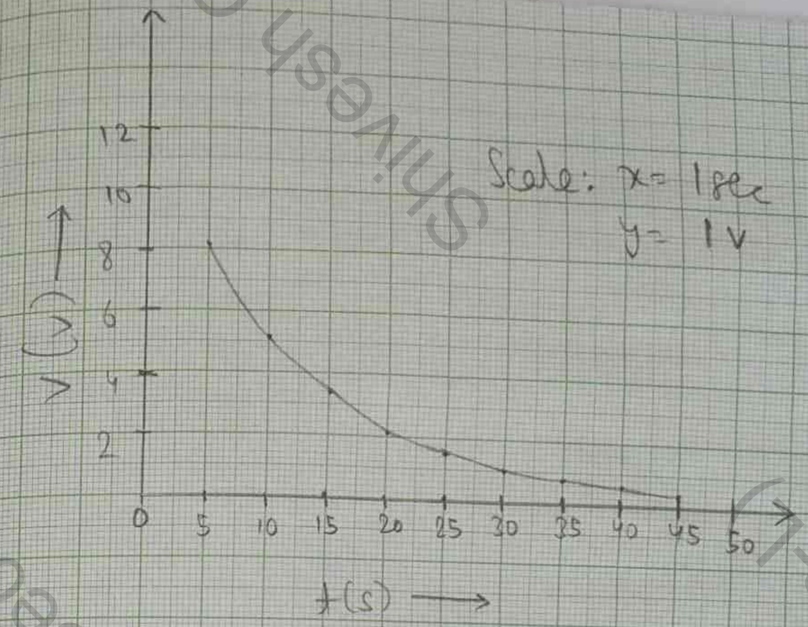
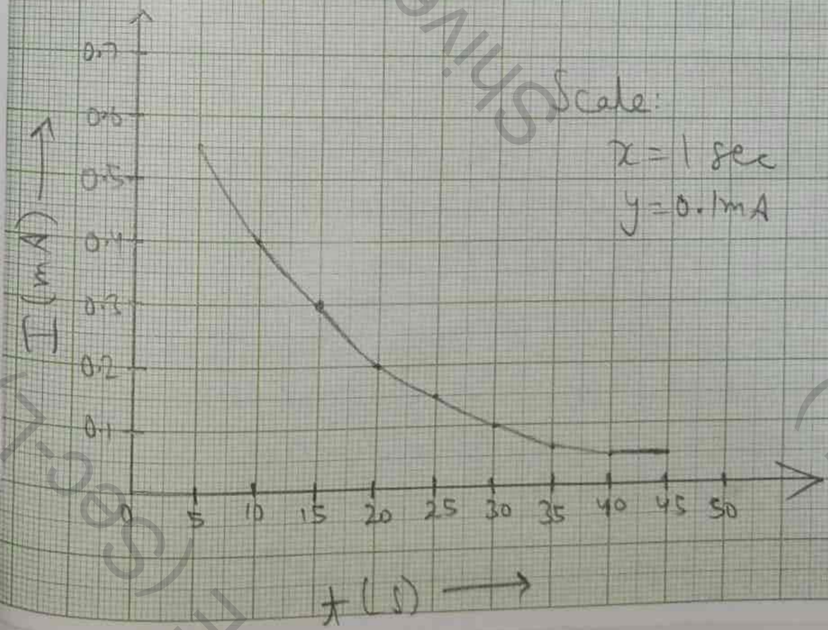
Graph:

Discharge →





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- AIM

To verify Stefan's law by electrical method (using vacuum diode).

- Apparatus

6V battery to heat the filament of diode, vacuum diode valve EZ-81, DC voltmeter (0-10V), DC ammeter (0-1 Amp) and rheostat (100 Ω). Usually all the above components are arranged in a single cabinet.

- Description of Apparatus

In this experiment; we use a vacuum diode EZ-81 which has a cylindrical made of nickel. The ~~together~~ tungsten heater filament is ~~closely~~ closely fitted inside cathode sleeve. A mix of barium & strontium oxides is sprayed over the outer surface of the nickel sleeve from which thermionic emission takes place. Since the cathode sleeve and heater filament are in close physical contact we take the temperature of cathode as temperature of filament. To connect the voltmeter across the valve, the two wires are soldered to base point of valve. A battery, rheostat R_h & an ammeter are connected in series with the filament of valve. ~~of~~

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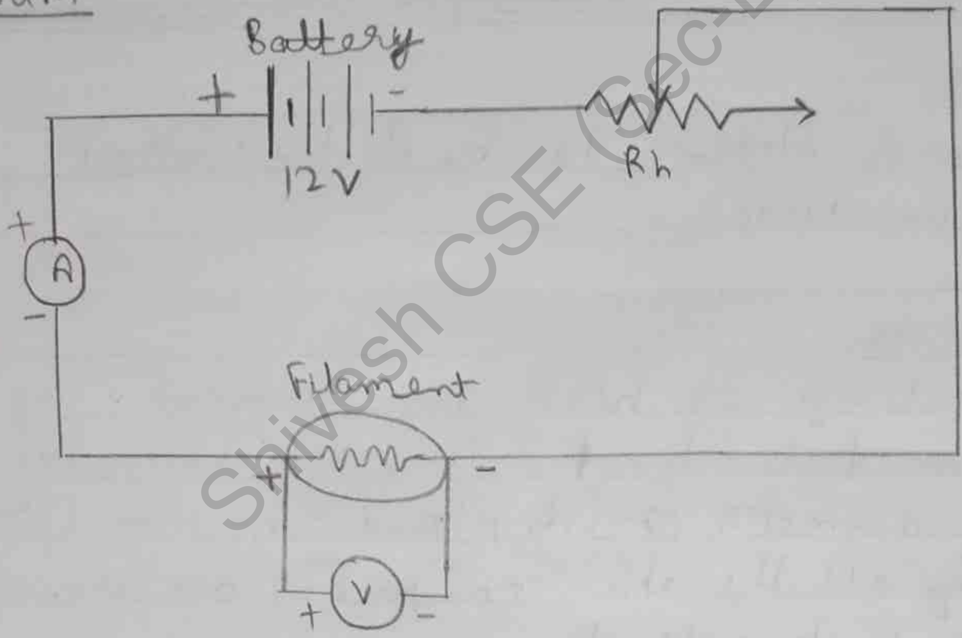
• Diagram



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- Theory & Formula Used

If E be energy radiated per second from a unit surface area of a black body at temperature T. surrounded by another body at ~~tempera~~ temperature T_0 then by Stefan's law, we have

$$E = \sigma (T^4 - T_0^4) \quad - (1)$$

where σ = Stefan's constant.

For bodies other than the black body, the similar relation for the power emitted by a body at temp T surrounded by another body at temp T_0 is given by.

$$P = C(T^\alpha - T_0^\alpha) \quad - (2)$$

where C is some constant which depends on material & area of body and 'α' is power very close to 4.

Further; $P = CT^\alpha \left(1 - \frac{T_0^\alpha}{T^\alpha}\right)$

If $T >>> T_0$; then above relation reduce to;

$$P = CT^\alpha \quad --- (3)$$

Take log on both sides;

$$\log_{10} P = \alpha \log_{10} T + \log_{10} C \quad --- (4)$$

Eqn (4) is a form of straight line equation like $y = mx + C$.

Therefore, a graph b/w $\log_{10} P$ and $\log_{10} T$ should be a straight line whose slope gives α; if α is approx equal to 4, then Stefan's law is verified. Hence to verify.

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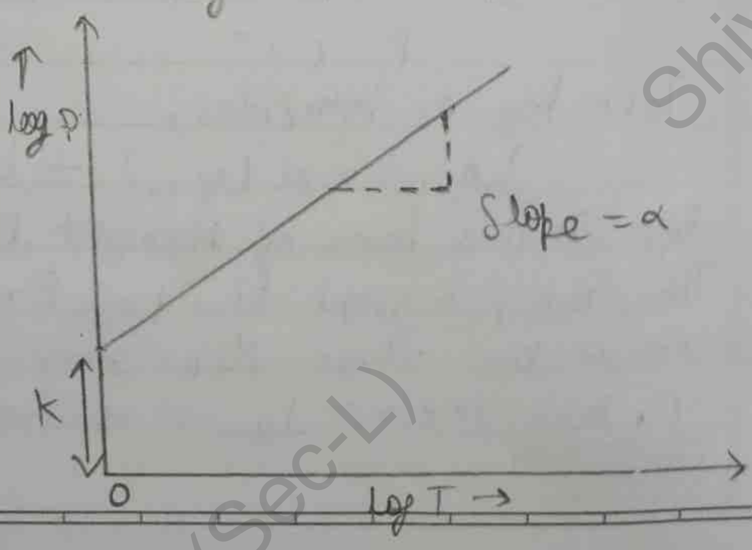
• Observation

S. No	Current Increasing		Resistance $R_T = \frac{V_f}{I_f}$	$\frac{R_T}{R_0}$	Temp (K)	Power (watt)
	Voltage V_f (volts)	Current I_f (Amp)				
1.	2.25	0.6	3.75	3.9	789.7	1.35
2.	4.5	0.85	5.30	5.52	1054.3	3.83
3.	6.75	1.10	6.14	6.40	1178.3	7.43
4.	8.75	1.25	7.00	7.30	1327.6	10.94
5.	11	1.4	7.86	8.19	1462.4	15.4
6.	12.5	1.5	8.33	8.68	1538.6	18.75

$\log_{10} P$	$\log_{10} T$
0.13	2.90
0.58	3.02
0.87	3.07
1.04	3.12
1.19	3.17
1.27	3.19

$P = C\,T^{\alpha}$

$\log P = k + \alpha \log T$



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Stefan's law, we have to measure the following quantities.

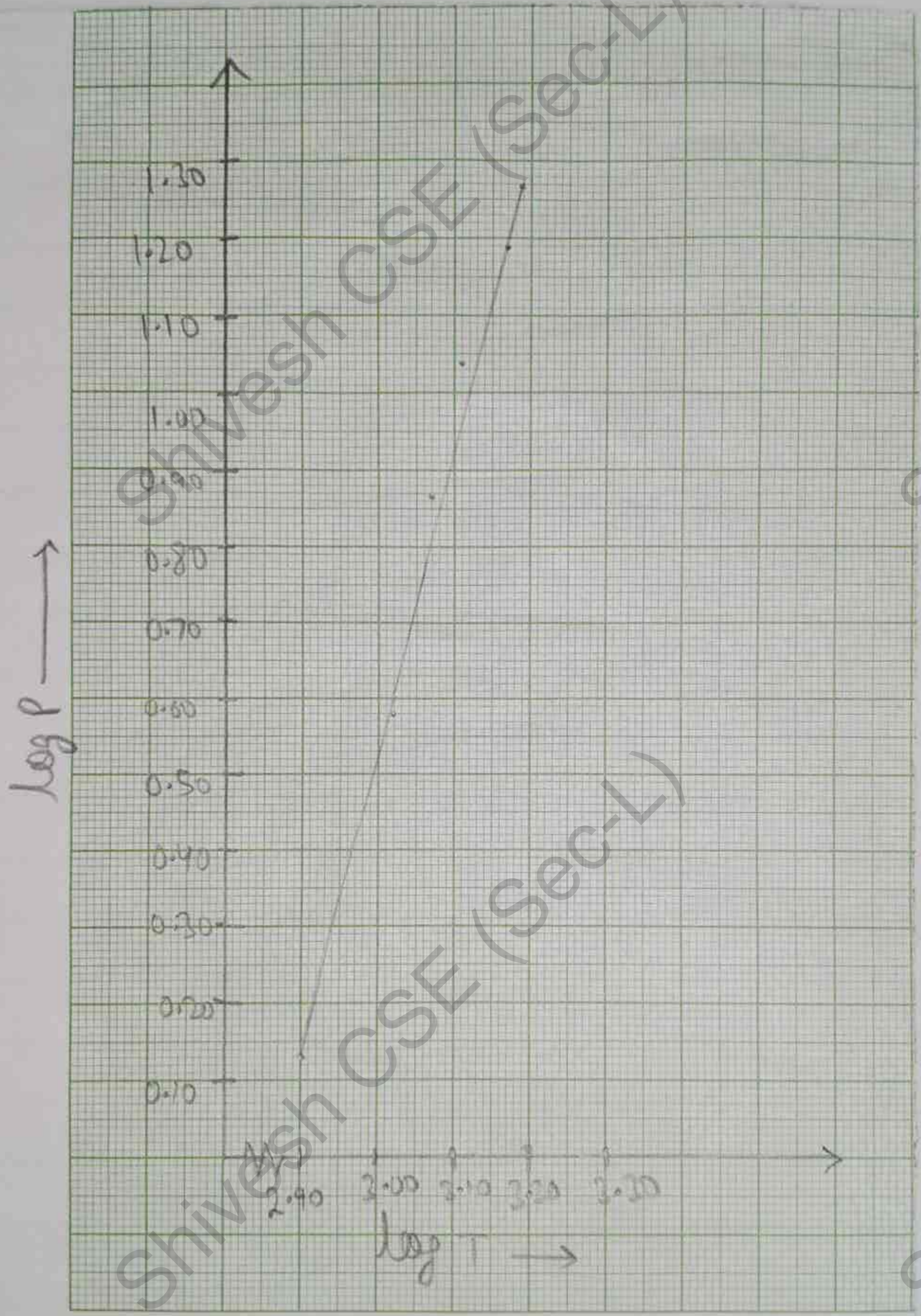
(1) Power P radiated by body
In this electrical method; tungsten filament of vacuum diode is used as radiating body. In the steady state, if we neglect the power loss due to conduction and connection (Power lost in the leads and through gas in valve), the electrical power (VI) should be equal to power P radiated by body (or tungsten filament).

(2) Temperature T of radiating body → for tungsten filament $R_g/R_0 = 3.9$, where R_g is resistance at glowing position and R_0 is resistance at 0°C. The temp of radiating body or filament is determined by using well known resistance-temperature relation expressed as

$$\frac{R_T}{R_{273}} = \left[\frac{T}{273}\right]^{1.2} \quad \text{--- (A)}$$

∴ The operating temp of filament is determined by measuring its electrical resistance. For the use of above formula, we need filament resistance R_{273} at 0°C which can be measured by determining resistance at room temperature, that is R_{300} and the

• Graph



Scale:

x axis →
1cm = 0.10

y axis →
1cm = 0.05

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temp coefficient of resistance, $\alpha = 0.0053 K^{-1}$ [$R_t = R_0(1+\alpha t)$].
R_{300K} can be determined by measuring the filament resistance at low filament voltage (< 1 volt) extrapolating their resistance to 0 volt. For EZ-81 vacuum tube R_{300} is 0.6. Therefore, it is convenient to use a graph b/w T and R_T/R_{300} instead of using relation (A) for determination of filament temp for tungsten from published results, the results are not valid if filament deteriorates due to prolonged use or due to oxidation of surface of tungsten filament. For electrical insulation, the filament placed inside cathode ~~steeve~~ ~~sleeve~~ sleeve is covered with thin coating of plaster of paris & diode is evacuated to high ~~degreee~~ degree of vacuum.

- Procedure

① Make electrical connections and main supply is switched on. Now keep current at zero position by ~~adjust~~ adjusting current control knob at minimum.

② Find value of R_g, where R_g is resistance at glow position i.e. when bulb started to glow. Now filament current I is increased and apply some filament voltage V_f by adjusting current control knob one by one at 0.2 V, 0.4 V, 0.6 V, ... volts etc. & measure corresponding filament current I_f in ammeter after steady state is reached. For steady state, wait for

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• Calculations

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1.27 - 0.13}{3.19 - 2.90}$$

$$\Rightarrow \frac{1.14}{0.29} \Rightarrow 3.93$$

$$\text{Percentage error} = \frac{(4 - 3.93)}{4} \times 100$$

$$\Rightarrow \frac{0.07}{4} \times 100$$

$$\Rightarrow \underline{\underline{1.75\,\%}}$$

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3 or 4 minutes before recording the observations after adjusting the filament voltage.

3. Repeat experiment for sufficient no. of set of observation so that a graph can be plotted. Record each observation in table.

- Result

The graph b/w $\log_{10} P$ & $\log_{10} T$ is a straight line and these slope of straight line is about 3.93.

Hence, stefan's law is verified with experimental error.

- Precautions

1. Slope of straight line should be determined as accurate as possible.
2. To get accurate resistance at a particular temp the filament voltage V_f and filament current I_f should be read every time after achieving a steady state or time difference b/w each observations should be about 3 or 4 minutes.

- Implication

1. Acc to stefan's law, the total energy radiated by a unit surface area of black body in unit time

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is proportional to forth power of absolute ~~power~~ temperature of black body i.e.

$P \alpha T^4$

This explains the fact that why hotter stars radiate blue light and cooler stars appears red.

2. Using this law, stefan could determine temp of sun's surfaces. Effective temp of earth & other stars can be determined using Stefan's law.

3. The radius of star can also be calculated using stefan's law.

4. This law can be applied to any object emitting a thermal spectrum, Insulating metal burners on electric stoves and filament in light bulbs.

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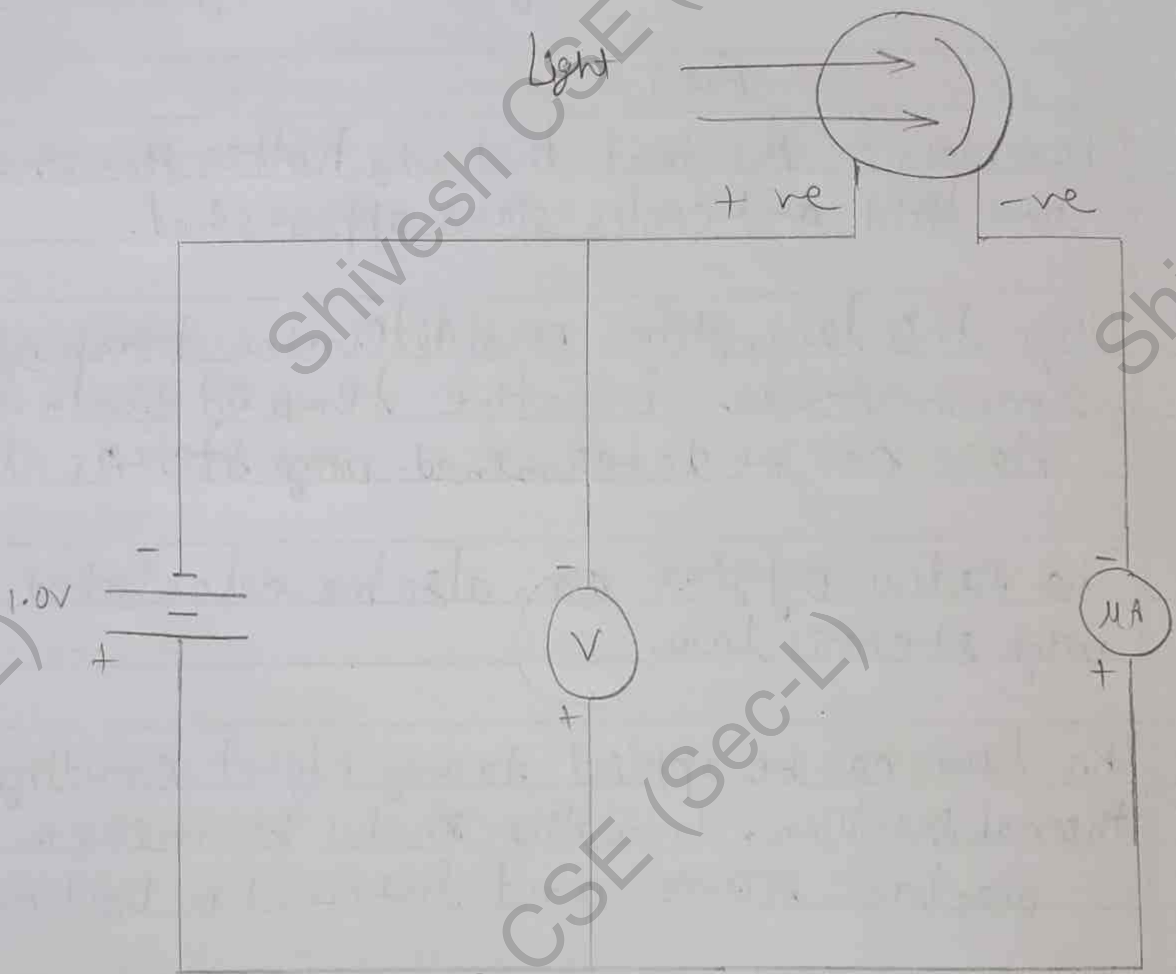
• Diagram



Shivesh CSE (Sec-L)

Expt. No. 8

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Date 06/6/23

- Objective

To determine the value of Planck's constant h by a photo cell.

- Apparatus Used

Photo emissive cell mounted in a box provided with a wide slit D.C. power supply with digital meters set of filter light source.

- Formula

$$h = \frac{e(V_2 - V_1)\lambda_1 \lambda_2}{c(\lambda_1 - \lambda_2)}$$

where e = Electronic charge

V_2 = Stopping potential corresponding to wave length with filter 2.

V_1 = Stopping potential corresponding to wave length with filter 1

c = Velocity of light

λ_1 = Wave length of filter 1

λ_2 = Wave length of filter 2

Minimum negative potential applied to anode to reduce the photo electric current to zero.

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• Procedure

1. Make the connections.
2. Light source is arranged and the light is allowed to fall on the tube which is enclosed in a box. The distance b/w photo cell and light source is adjusted such that there is sufficient flow of current.
3. Now a suitable filter of known wave length λ_2 is placed in the path of light (in the slit provided).
4. A reading is observed in the Micro - Ammeter. This corresponds to zero Anode potential with the particular filter.
5. A small negative potential is applied and is gradually increased in step and each time reading in voltmeter and micro-ammeter is noted till the micro - ammeter reading comes to zero. This is stopping potential V_2 corresponding to filter with wave length λ_2.
6. The experiment is repeated with another filter of known wavelength λ_1 and λ_3 and corresponding stopping potential V_1 and V_3 are noted.
7. A graph is plotted by taking negative anode potential on X-axis and corresponding reading in Micro - Ammeter on Y - axis.
8. By using above values Planck's constant 'h' is calculated by the formula given. Standard values of e, c and wave length of standard filters are given below.

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Observation

S. No	Colour of filter	Stopping Potential (V_h)	Wavelength
1	Blue	$0.568\ V_1$	$5265 \times 10^{10}\ m$
2	Green	$0.405\ V_2$	$5645 \times 10^{-10}\ m$
3	Orange	$0.228\ V_3$	$6125 \times 10^{-10}\ m$

(Blue + green)

$$h = \frac{e(V_2 - V_1)\lambda_1 \lambda_2}{c(\lambda_1 - \lambda_2)}$$

$$e = 1.6 \times 10^{-19} C$$

$$c = 3 \times 10^{8}\ m/s$$

$$h = \frac{1.6 \times 10^{-19} \times (0.568 - 0.405) \times 5265 \times 10^{-10} \times 5645 \times 10^{-10}}{3 \times 10^{8} \times (5645 - 5265) \times 10^{-10}}$$

$$\Rightarrow 6.799 \times 10^{-34} \text{ Joule sec}$$

for (Green + orange)

$$h = \frac{1.6 \times 10^{-19} (0.405 - 0.228) \times 5645 \times 10^{-10} \times 6125 \times 10^{-10}}{3 \times 10^{8} (6125 - 5645) \times 10^{-10}}$$

$$\Rightarrow 6.8 \times 10^{-34} \text{ Joule sec}$$

$\Rightarrow$ Similarly; we will calculate for orange & blue.

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$e = 1.6 \times 10^{-19}$ ~~Colo~~ Coulombs
$c = 3 \times 10^{8}$ m/sec $= 3 \times 10^{10}$ cm/sec

~~Wave length of yellow filter $\lambda_1 = 5780 \times 10^{-8}$ cm~~
Wave length of yellow filter $\lambda_1 = 5780 \times 10^{-8}$ cm
Wavelength of green filter $\lambda_2 = 5460 \times 10^{-8}$ cm
Wavelength of red filter $\lambda_3 = 6900 \times 10^{-8}$ cm
Wavelength of violet filter $\lambda_4 = 4050 \times 10^{-8}$ cm
Wavelength of blue filter $\lambda_5 = 4360 \times 10^{-8}$ cm
Wavelength of orange filter $\lambda_6 = 6232 \times 10^{-8}$ cm

$$h = \frac{e(V_2 - V_1)\lambda_1 \lambda_2}{c(\lambda_1 - \lambda_2)}$$

- Result

Planck's constant $h = 6.8 \times 10^{-34}$ J sec
Actual value $= 6.6 \times 10^{-34}$ J sec.
Percentage Error $= 2.6\%$

- Sources of error and precautions

1. Care should be taken to ensure that when no light is falling on cathode, the deflection in the ~~glv~~ galvanometer is zero.
2. The position of mercury lamp should not be changed during

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the experiment.

- Implications

▶ In the experiment, we are able to demonstrate the dependence of energy on wavelength or frequency of radiation and determine the constant of proportionality i.e. Planck's constant (h).

▶ The planck's constant describes the behaviour on microscopic scale and plays an important role in quantum mechanics.

▶ Planck's constant provided theoretical explanation for the empirically discovered laws such as black body radiation and photoelectric effect. These effects could not be explained on the basis of classical wave theory.

▶ Significance of Planck's constant is that light is emitted or absorbed in discrete energy packets (or quanta) determined by frequency of radiation and value of planck's constant. ($E = h\nu$)

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