Date 19/04/2023

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Experiment:

Experiment - 1

* **Aim:-** To measure the diameter of a thin wire using the phenomenon of diffraction.

* **Item Required:-** A Helium-Neon Laser, thin wire mounted in the holder, and a screen.

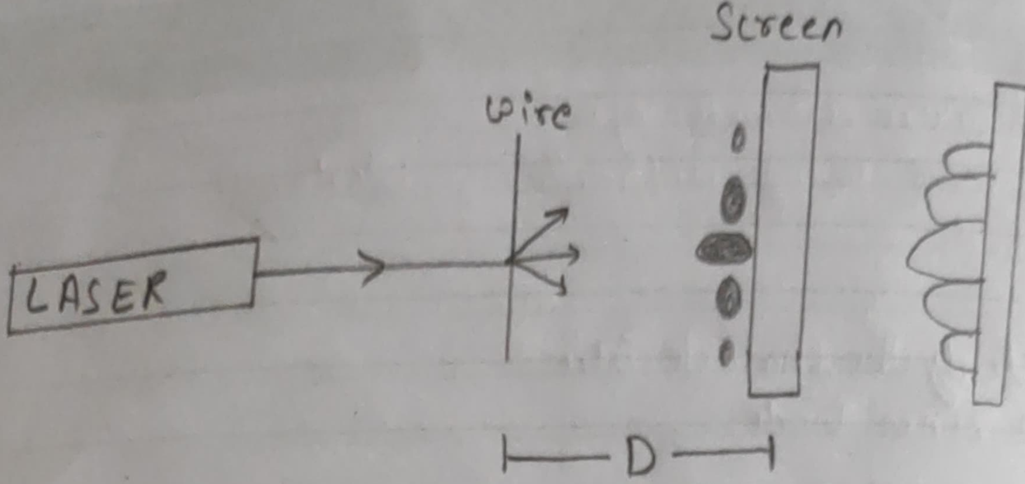
* **Theory:-** when a wire is illuminated by a laser beam, a diffraction pattern is observed on the screen. If 'd' is the diameter of the wire. diffraction is being observed at a distance 'D' from the screen and 'X' is the width of the central maxima then where 'λ' is the wavelength of laser light.

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

* **Procedure:-** Illuminate the wire with the laser beam as shown in the figure and observe the diffraction pattern on the screen. Measure the distance D of the screen from wire and width of wire. The wavelength of He-Ne Laser light is 6320 Å.

* **Result:-** Diameter of the given thin wire is found to be 0.023 cm.

CLASSTIME



* observation Table

S. No.	Distance from screen (D) cm	Width of central maxima (X) cm	Diameter of wire (d) cm
1.	100 cm	0.3 cm	0.021 cm
2.	150 cm	0.4 cm	0.023 cm
3.	200 cm	0.5 cm	0.025 cm

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

$$d_1 = 6328 \mathring{A} \times \frac{100}{0.3} = 0.021 \text{ cm}$$

$$d_2 = 6328 \mathring{A} \times \frac{150}{0.4} = 0.023 \text{ cm}$$

$$d_3 = 6328 \mathring{A} \times \frac{200}{0.5} = 0.025 \text{ cm}$$

$$d = \frac{0.021 + 0.023 + 0.025}{3} = 0.023 \text{ cm}$$

* 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 meter away.

* Application of Laser:-
1. One can calculate the wavelength of light (source) laser used in this experiment.
2. One can study the diffraction pattern of laser.
3. We can calculate the value of N.A by using laser.
4. Semiconductors lasers are used for printing.

SSTIME

Experiment-2,

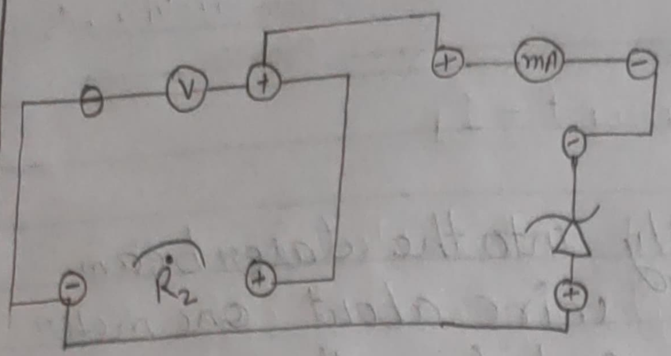
* Aim÷ To study the characteristic of a zener Diode.
* Apparatus:- zener diode setup
* Theory -

Semi-Conductor P.N. Junction Diodes are generally used as rectifier. They are suitable for converting AC into D.C. But they suffer from disadvantage that their maximum safe inverse voltage is relatively small when a reverse voltage is applied conduction steps 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 zener current. The zener Diode makes a virtue of it and operates at this very point.

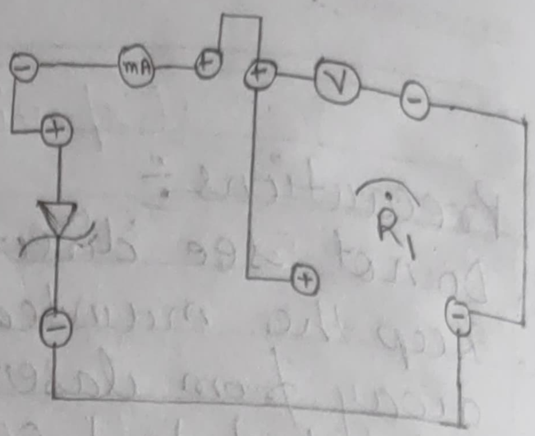
* Procedure ÷

→ Forward Bias Characteristics

1. Make all the Connections as shown in fig. 1.a.
2. Knob of potentiometer R_1 is kept fully anti-clockwise.
3. Now Switch ON the unit and set the voltage to OV.



Reverse Bias



Forward Bias

Table Forward

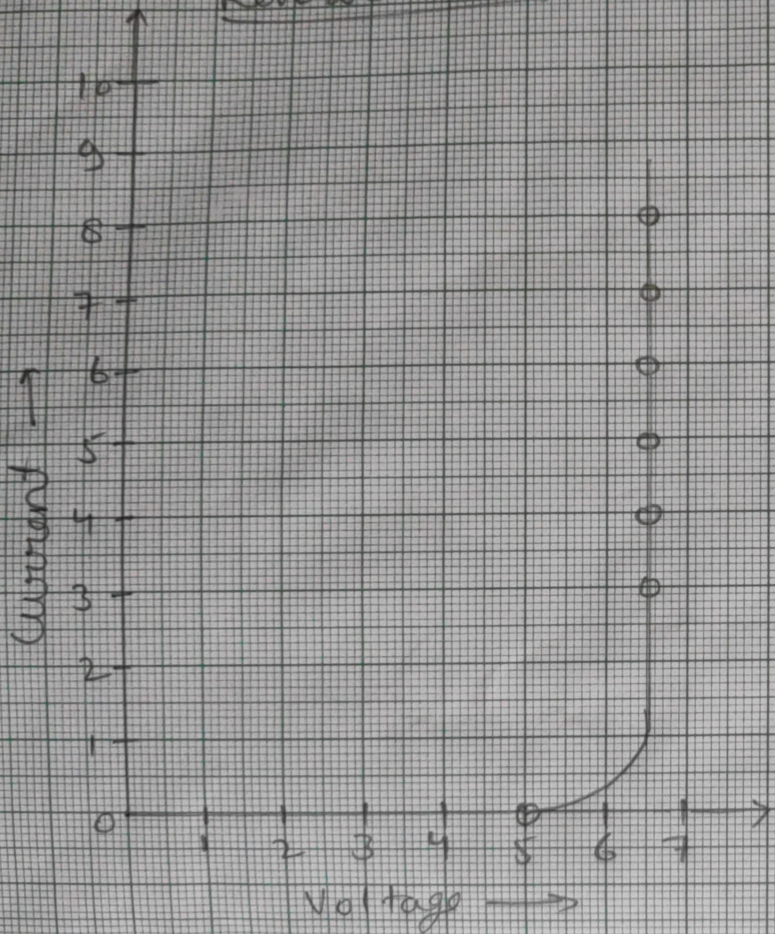
S.NO.	Volt. Reading (V)	Ammeter Reading (mA)
1	0.2	0
2	0.4	0
3	0.6	0
4	0.7	0
5	0.75	3
6	0.75	5.6
7	0.75	6.8
8	0.75	7.6
9	0.75	8.8
10	0.75	10

Table reverse

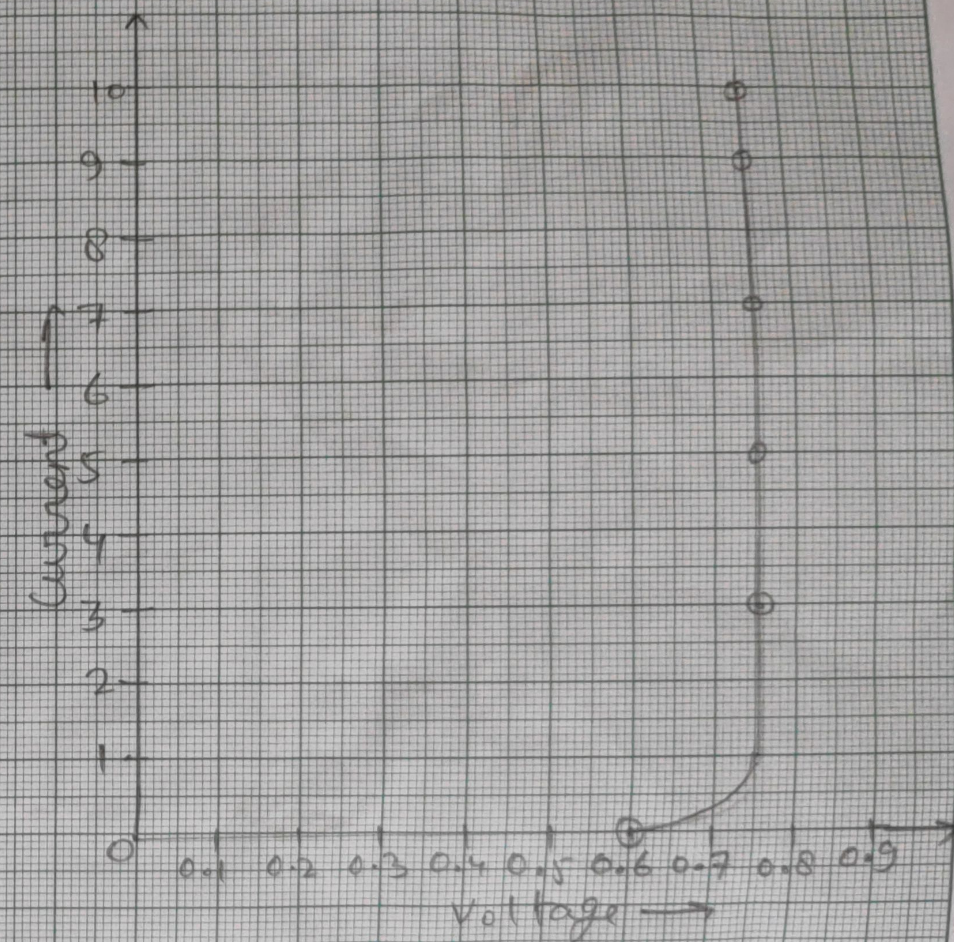
S.No.	Voltmeter Reading (V)	Ammeter Reading (mA)
1	0.8	0
2	2.4	0
3	4	0
4	5	0
5	6.4	1
6	6.4	3
7	6.4	4
8	6.4	5
9	6.4	7.2
10	6.4	10

Zener-Diode

Reverse Bias



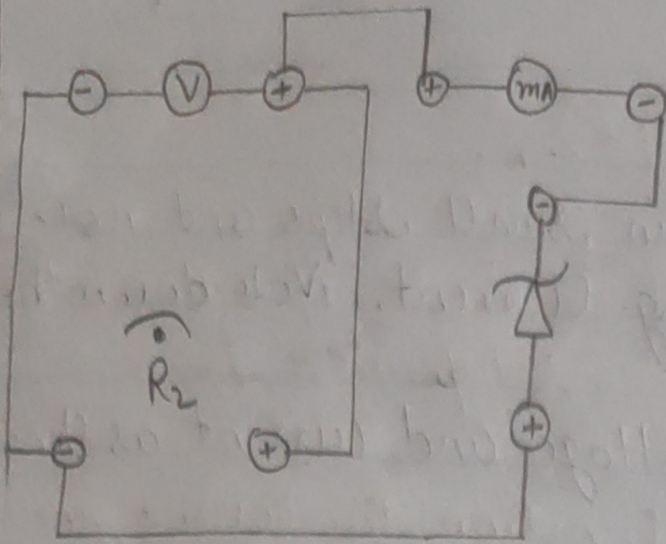
Forward Bias



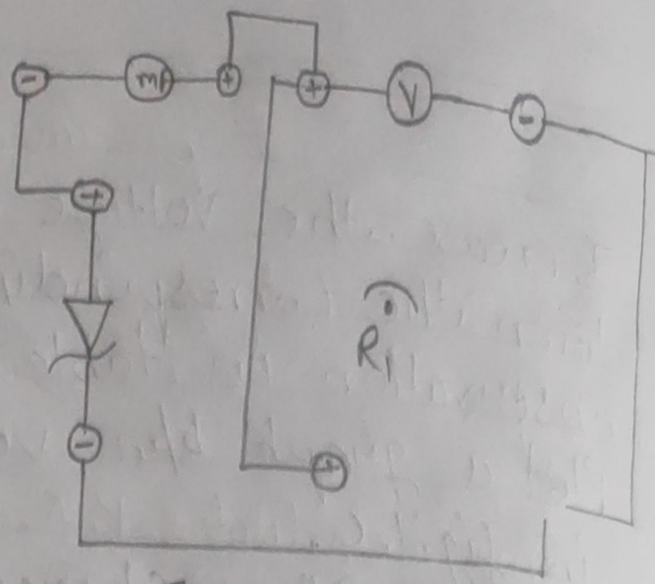
4. Increase the voltage in small steps and note down the corresponding current. Note down the observation in table.
5. Plot a graph b/w voltage and current as shown in fig. 1.c,

Reverse Bias Characteristics

1. Make all the connections as shown in fig. 2.a.
2. Knob of potentiometer R_g is kept fully anti-clockwise.
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 observati in table.
5. Plot a graph b/w voltage and current



Reverse bias



Forward bias

* observations

Forward biasing

S.No	voltage	current
1	0	0
2	0.1	0
3	0.2	0
4	0.3	0
5	0.4	0
6	0.5	0.6
7	0.55	0.7
8	0.6	0.8
9	0.7	10

Reverse biasing

S.No.	voltage	current
1	0	0
2	4	4
3	8	8
4	12	12
5	16	20
6	20	30
7	24	40
8	28	52
9	30	90

(Experiment - 3)

Aim → To study the V-I Characteristics of the P-N Junction diode in ① Forward Biasing ② Reverse biasing

Apparatus Required → PN Junction diode, battery.

Theory →

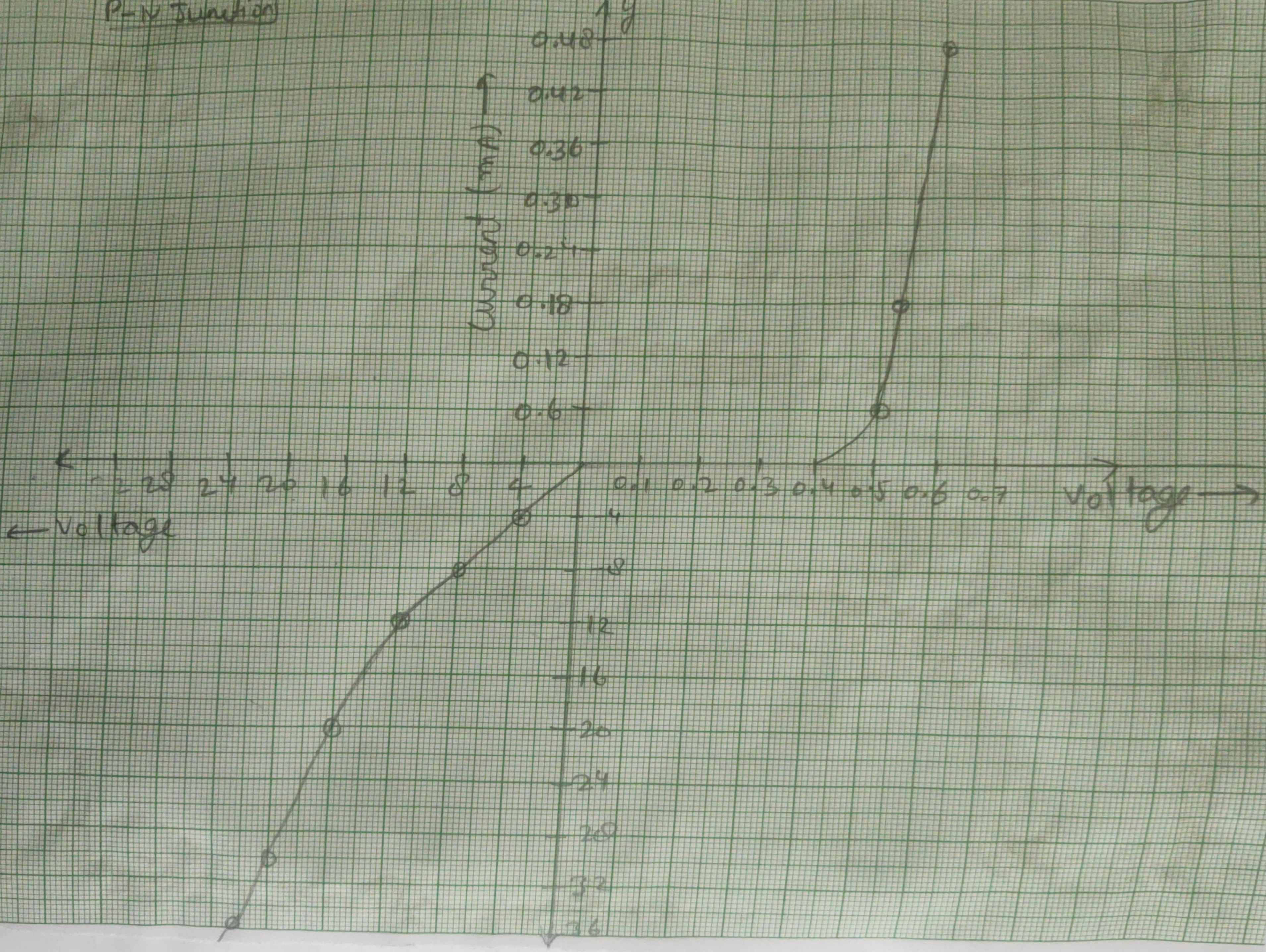
P.N. diode is formed by joining P type semiconductors with n type semiconductors. It is done by various joining techniques. The diode works only when some potential is applied to it. It can be applied in two ways:

a) Forward Biasing b) Reverse biasing

Forward Biasing

When P type is connected to +ve terminal and n type is connected to -ve terminal of battery, diode is said to be forward biased. As a result the width of potential barriers (0.1v to 0.3v) in diode is reduced. Therefore small voltage is needed to overcome the barrier. Once the potential barrier is eliminated the current starts flowing. This is called forward biasing current and in this biasing the resistance of diode almost become zero.

P-N Junction



y
0.48
0.42
0.36
0.30
0.24
0.18
0.12
0.6
Current (mA)
28
24
20
16
12
8
4
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Voltage
← Voltage
4
8
12
16
20
24
28
32
36

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Reverse Biasing

When P type is connected to -ve terminal and n type is connected to +ve 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 breakdown of junction occurs. This is characterised by sudden rise in reverse current and fall in resistance.

* Procedure →

→ Forward Bias characteristics

1) make all connections as shown in fig. 1a.
2) Knob of potentiometer R_1 is kept fully anti-clockwise.
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 1b.
5) Plot a graph b/w Voltage and current as shown in fig. 1.c.

Reverse Bias characteristics

1) Make all Connections as Shown in fig. 2a.
2) Knob of potentiometer R_2 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 2b.
5) Plot a graph b/w voltage and current as shown in fig. 2c.

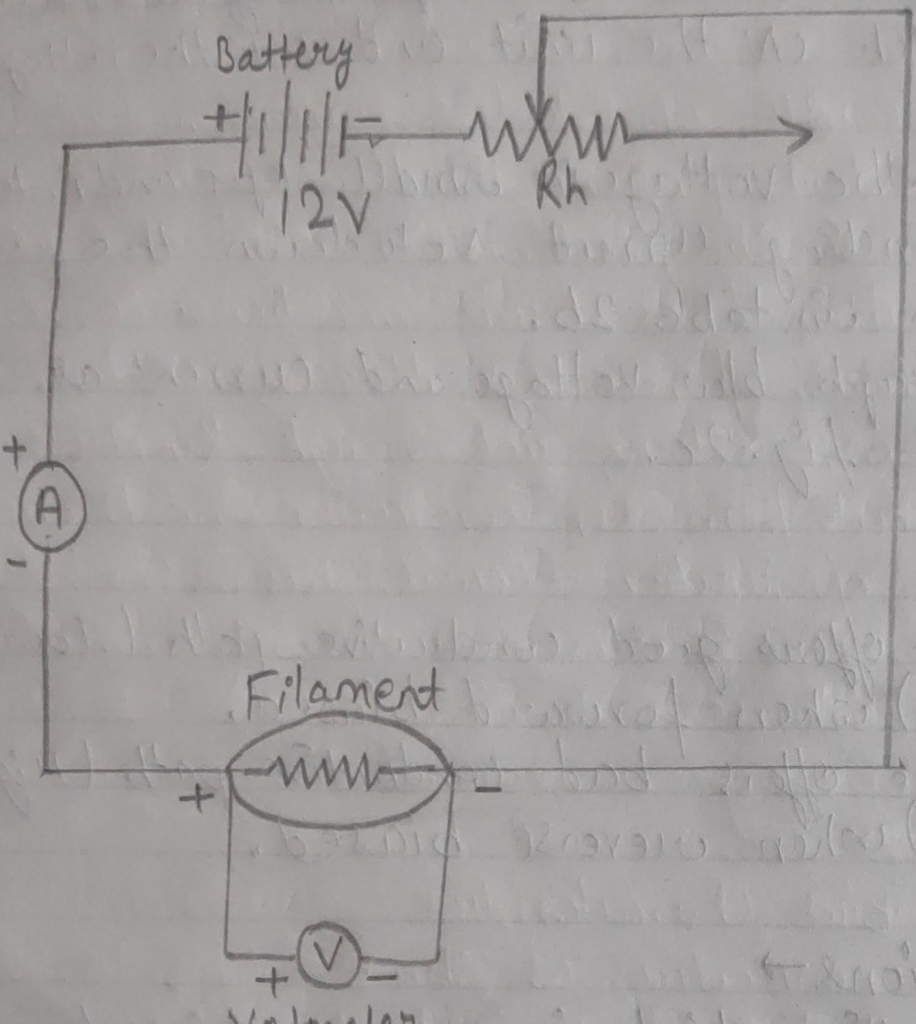
* Results→

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

* Implications→

1) P-N Junction diode is reverse biased configuration is sensitive to light from a range b/w 400nm to 1000nm. which includes visible light. Therefore it can be used as photodiode.
2) It can also be used as a solar cell.
3) P-N Junction forward bias condition is used in all LED light applications.
4) It is used as switches in digital logic circuits.

* Circuit diagram



$V = 1.5\,V$, $I = 40\,mA$

$$R_T = \frac{1.5}{40\times10^{-3}} = 37.5\,\Omega$$

we know, $\frac{R_T}{R_0} = 3.9 \Rightarrow R_0 = \frac{R_T}{3.9} = \frac{37.5}{3.9}$

$$\boxed{R_0 = 9.615\,\Omega}$$

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Experiment-4

*** Objective :-** To verify Stefan's law by electrical method (using Vaccum diode).

*** Apparatus :-** 6 volt battery, Vaccum diode valve EZ-81, D.C. voltmeter (0-10V), D.C. ammeter (0-1) and rheostat (100 Ω), usually all the above components are arranged in a single cabinet.

*** Theory and Formula used :-**

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

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

where 'σ' is the Stefan's constant. For the bodies other than the black body, the similar relation for the power emitted by a body at temp. T surrounded by another body at temperature T_0 is given by

$$P = C(T^a - T_0^a)$$

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

Further,

$$P = CT^a\left[1 - \frac{T_0^a}{T^a}\right]$$

if $T >> T_0$ then the above equation reduce to

$$P = CT^a$$

CLASSTIME

*Observation Table

S.No	Filament voltage V_f (volts)	Filament current I_f (mA)	Power radiated $P = V_f I_f$ (watt)	Filament resistence $R_T = V_f/I_f$ (ohm)	R_T/R_0	T(K)	$\log_{10} P$	$\log_{10} T$
1	1.5	40	60×10^{-3}	37.5	3.9	500	-1.25	2.690
2.	1.9	45	85.5×10^{-3}	42.2	4.38	600	-1.06	2.778
3.	2.3	50	115×10^{-3}	46	4.78	666	-0.94	2.8234
4.	2.7	55	148.5×10^{-3}	49.1	5.10	715	-0.82	2.8543
5.	3.1	60	186×10^{-3}	51.6	5.36	756	-0.73	2.878
6.	3.5	65	237.5×10^{-3}	53.8	5.6	793	-0.64	2.899
7.	3.9	70	273×10^{-3}	55.7	5.79	820	-0.56	2.914
8.	4.3	72	309.6×10^{-3}	59.7	6.20	876	-0.50	2.942
9.	4.7	75	352×10^{-3}	62.6	6.51	924	-0.45	2.965
10	5.1	80	408×10^{-3}	63.7	6.62	944	-0.36	2.974

* Calculation

$$\frac{\log_{10} P}{\log_{10} T} = \frac{AB}{BC} = \frac{1.25 - 0.36}{2.97 - 2.74} = \frac{0.89}{0.23} = 3.9$$

which is close to 4.

Taking logarithm on both side

$$\log_{10} P = a \log_{10} T + \log_{10} C$$

it is a form of $Y = mx + c$, straight line.
Therefore a graph b/w $\log_{10} P$ and $\log_{10} T$ should be straight line whose ~~slope~~ slope gives a if a is approximately equal to 4. then stefan's law is verified.

1. Power P radiated by the body – In this electrical method tungsten filament of the vaccum diode is used as the radiating body. In the steady state, if we neglect the power loss due to conduction and convention. $P = VI$
2. Temperature T of the radiating body – For tungsten filament $R_g/R_0 = 3.9$ where R_g is the resistance at glowing position and R_0 is the resistance at $0°c$. The temp. of the radiating body or filament is determined by using well known resistance - temperature radiation expressed as

$$\frac{R_T}{R_{273}} = \left[\frac{T}{273}\right]$$

* Procedure

1. Make the electrical connection as shown in fig. and main supply is switched on. Now keep the current at zero position by adjusting the current knob at minimum.

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2. Find the value of R_g where R_o is the resistance at glowing position i.e. when bulb started to glow. Now filament current I is increased and apply some filament Voltage V_1 by adjusting current control knob one by one at 0.2V, 0.4V, 0.6V.--- and measure the corresponding filament current I_r in the ammeter after steady state is reached. For steady state, wait for 3-4 min. before recording the observations after adjusting the filament voltage.

* **Result** -

The graph b/w $Log_{10} P$ and $Log_{10} T$ is a straight line and the slope of straight line is about 4 (---) Hence stefan's law is verified within the experimental error.

* **Precautions and Source of error** -

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

* Implications →

According to Stefan's law, the total energy radiated per unit surface area of a block body in unit time is proportional to the fourth power of absolute temperature of the black body i.e, $P \propto T^4$

This explains the fact that why hotter stars ~~are~~ radiated blue light and cooler stars appear red. Using this law Stefan could determine temperature of Sun's surface. Effective temperature of earth and other stars can be determined using Stefan's law.

The radius of stars can also be calculated using Stefan's law.

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

*Circuit diagram

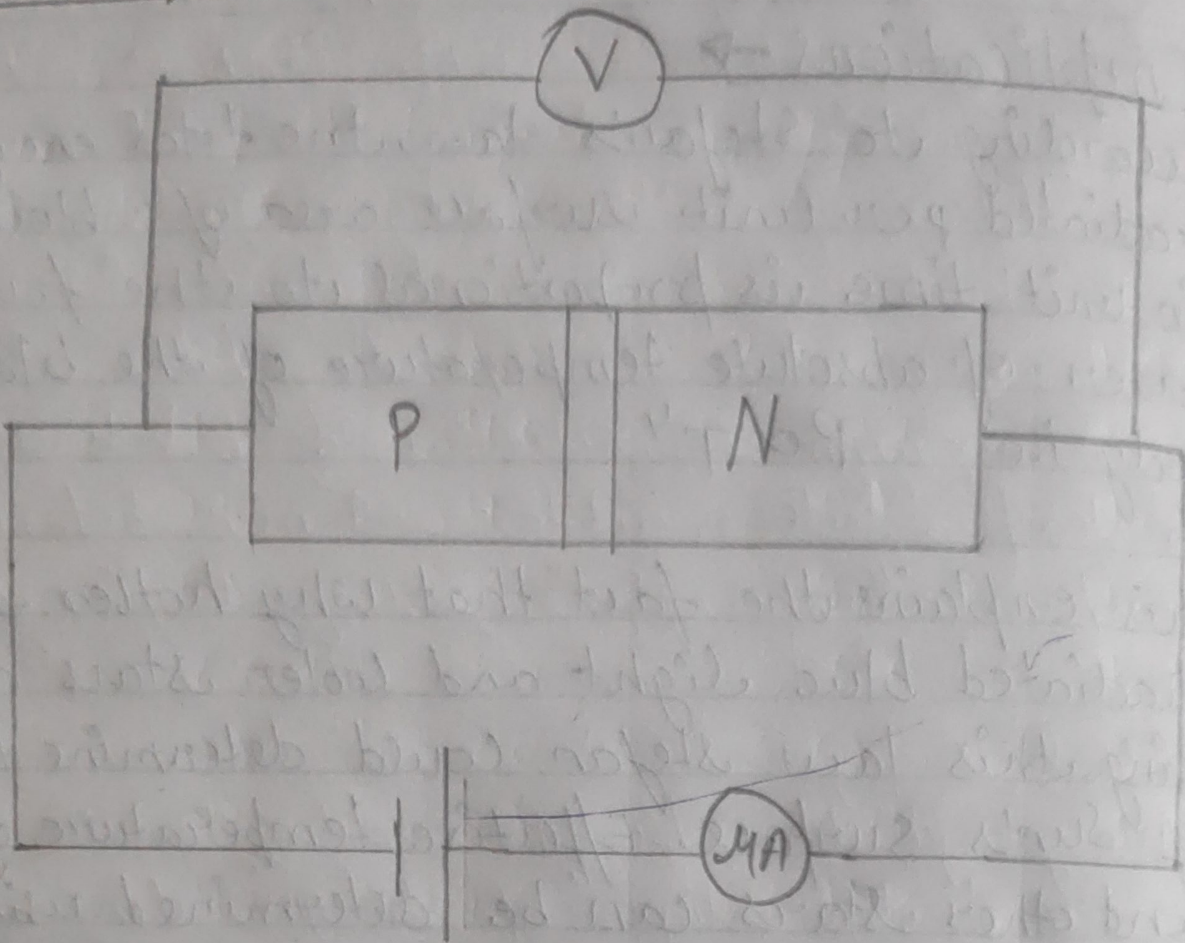

Fig 1.

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[Experiment - 05]

* **Objective** ÷ To determine the Forbidden energy Gap.

* **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 velence band to the conduction band. The energy so needed is the measure of energy gap ΔE between the two bands.
When a P-N junction is reverse biased as shown in fig. The current through the junction is due to the minority carriers i.e. due to the electrons in the P section & the holes in the N section. The concentration of these carriers is dependent upon the energy gap ΔE. The reverse current I_s (satenation value) function of the temperature of the junction diodes & varies according to the following relation:

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

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

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

the graph is plotted b/w $\log I_s$ & $10^3/T$.

* observations table :-

least count of microammeter = $\frac{20-0}{10}$ = 2 μA

Current in μA (I_s)	Temp. in Deg. C	Temp in Deg. K	$10^3/T$	$\log(I_s)$
28	80	353	2.83	1.44
23	75	348	2.87	1.36
19	70	343	2.91	1.27
16	65	338	2.95	1.20
13	60	333	3.00	1.11
10	55	328	3.05	1.00
8	50	323	3.095	0.90
6	45	318	3.14	0.77
5	40	313	3.19	0.69

* Calculations

$$\text{slope} = \frac{BC}{AB} = \frac{1.2-0.9}{3.09-2.95} = \frac{0.3}{0.14} = 2.142$$

$$\Delta E = \frac{2.142}{5.036} = 0.425\,V$$

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* Procedure :-

1. Rig up the circuit, as shown in fig. 1. 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 temp. to exceed upto 65 degrees C. As soon as the temp. reaches 65 degrees C. switch 'OFF' the oven, enabling the temp. to rise further & become stable at around 70 degre C.
6. Apply a suitable reverse bias to the P-N junction.
7. When the temperature becomes stable start taking the reading of the current & temp.
8. Plot a graph b/w the reading of $10^3/T$ on the X-axis & $\log I_s$ on the Y-axis.
9. Determine the slope of the line.

* Result :-

The slope of the line is 2.142.
and the band-gap is given as

$$\Delta E = \frac{\text{Slope of line}}{5.036} = \frac{2.142}{5.036}$$

$$\boxed{\Delta E = 0.425}$$

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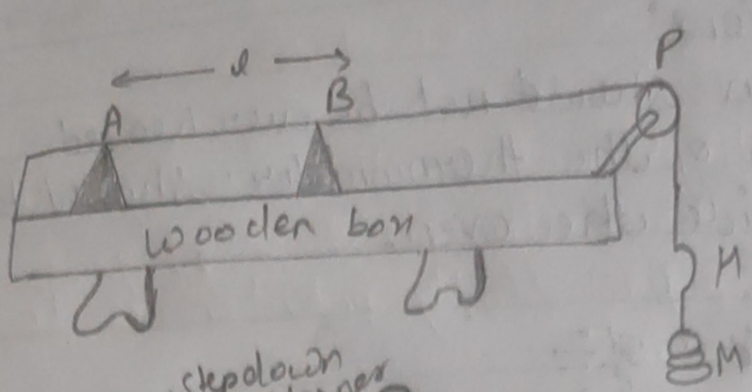
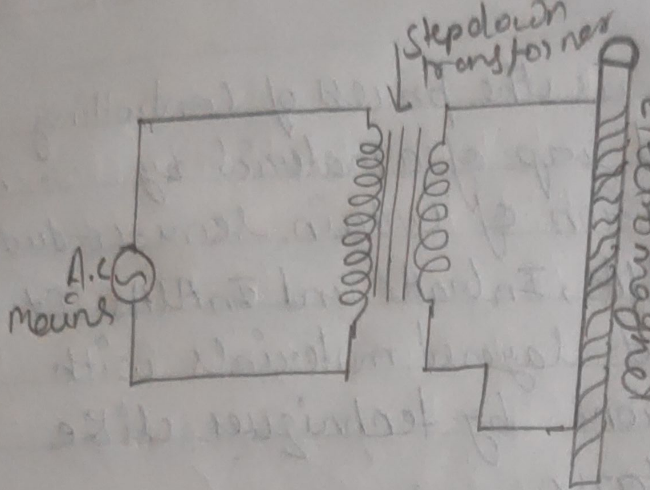
* Precautions:
1. The oven should not be over heated.
2. The bulb of the thermometer should be inserted well inside the oven.

* Applications of:-
i) Band gap engineering is the process of controlling an altering the band gap of a material by controlling the composition of certain semi-conductor 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 (HBTs), laser diodes and solar cells.
iii) In photonics, band gaps on stop bands are ranges of photon frequencies where, if tunneling are neglected, no photons can be transmitted through a material, The material exhibiting this behaviour is known as photonic crystal.
(iv) Similar physics applies to phonons in a phononic crystal.

CLASSTIME





* **observation table**

S.No.	Mass (gm)	Length (l)				Frequency
		A(cm)	B(cm)	B - A	Mean	$f = \frac{1}{4l}\sqrt{\frac{Mg}{m}}$
1.	1500g	35 34.5	62 61.5	27 27	27	47.27
2.	2000g	34 33	63.5 62.5	29.5 29.5	29.7	48.11
3.	2500g	33.5 33	65.5 66	32 31	32.5	48.80

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Experiment - 6

* **Objective:** To determine the frequency of the A.C. mains using Sonometer and an electromagnet

* **Apparatus:** A Sonometer with soft iron wire, an electromagnet, a step down transformer, hanger with slotted weights, a Calamp stand, meter scale, 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 plucked, it vibrates with a frequency given by

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

In this experiment, the length of the wire and the 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 a.c. mains is stepped down by a step-down transformer and then passed through the copper wire of the electromagnet.

CLASSTIME

* Calculations ÷

length of the wire = 150 cm

Weight of wire = 9.12 gm

mass per unit length = $\frac{9.12}{150}$ = 0.06 gm/cm

mass frequency = $\frac{47.29 + 48.11 + 48.80}{3}$

= $\frac{144.18}{3}$ = 48.06

Perentage error = $\frac{50 - 48.06}{50} \times 100$

= 3.88 %

The current magnetise the cylinder core twice during each cycle - first with one polarity when the current flows in one direction and then with the opposite polarity when the 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. If the frequency of a.c. mains is 50 Hz, 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 of the a.c. mains.

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

$\rho \rightarrow$ density of wire
$m \rightarrow$ mass per unit length of the wire
$m = \pi r^2 \rho$

* Procedure:

1. Set-up the sonometer as shown in fig 1.
2. Hold the electromagnet vertically in a clamp - stand about 2 to 3mm above the sonometer wire.
3. Bring the two wedges A and B close to each other.
4. Suspend a load of ~~500gm~~ 250gm on the hanger and switch on the a.c. supply. Slides the wedges gradually away from each other till the wire starts vibrating and the rider begins to flutter.

5. Measure the length of the wire between the two wedges A and B with a metre-scale.
6. Increase the distance b/w the two edges by a few centimeters.
7. Increase the load in steps and find out the resonant length l in each case. Take five such observations.
8. Switch off the a.c mains and remove the magnet. Take about ~~E~~ l metre of wire and find its weight by a sensitive balance and hence find the mass per unit length m. Another way to find m is using the formula $m = \pi r^2 \rho$ where r is the radius of the wire and ρ is the density of the material of the wire.
$\rho = 7.7$ gm/cc

* Result:

The frequency of the a.c. mains = 48.06 Hz
Standard value = 50 Hz
Percentage error = 3.88 %

* Precautions and source of error

1. String should be uniform, flexible and kink free.
2. friction in the pulley should be negligibly small
3. Sonometer wire should be a magnetic material like iron so that it is attracted by the electromagnet.

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Applications →

1. Sonometer is a diagnostic instrument used to ~~use~~ find the tension, frequency or density of wire.

2. Sonometer is used to determine hearing sensitivity.

3. It is also used to test for hearing loss and other problems of the ears.

4. Determine the frequency of a.c. mains.

5.