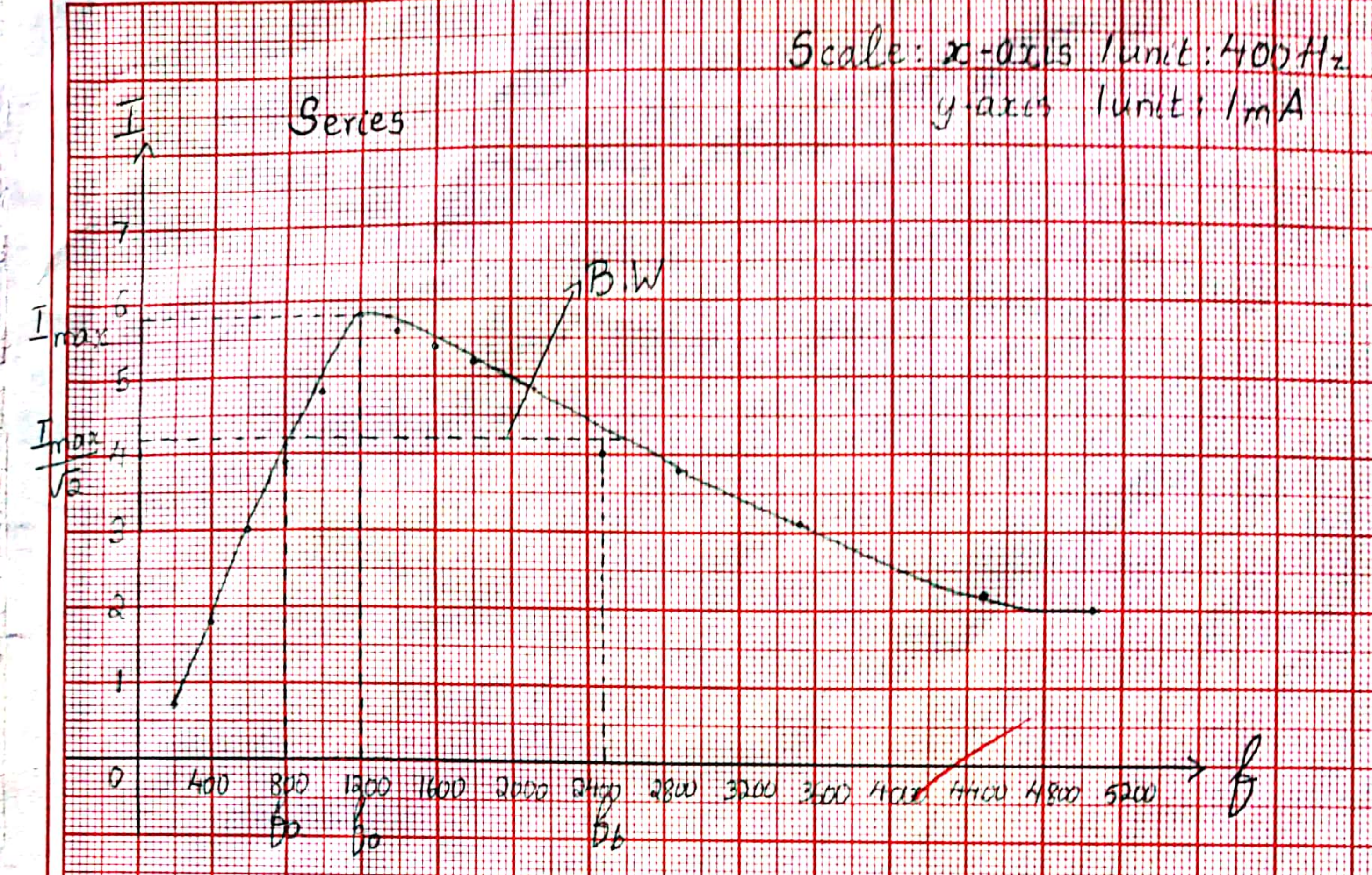

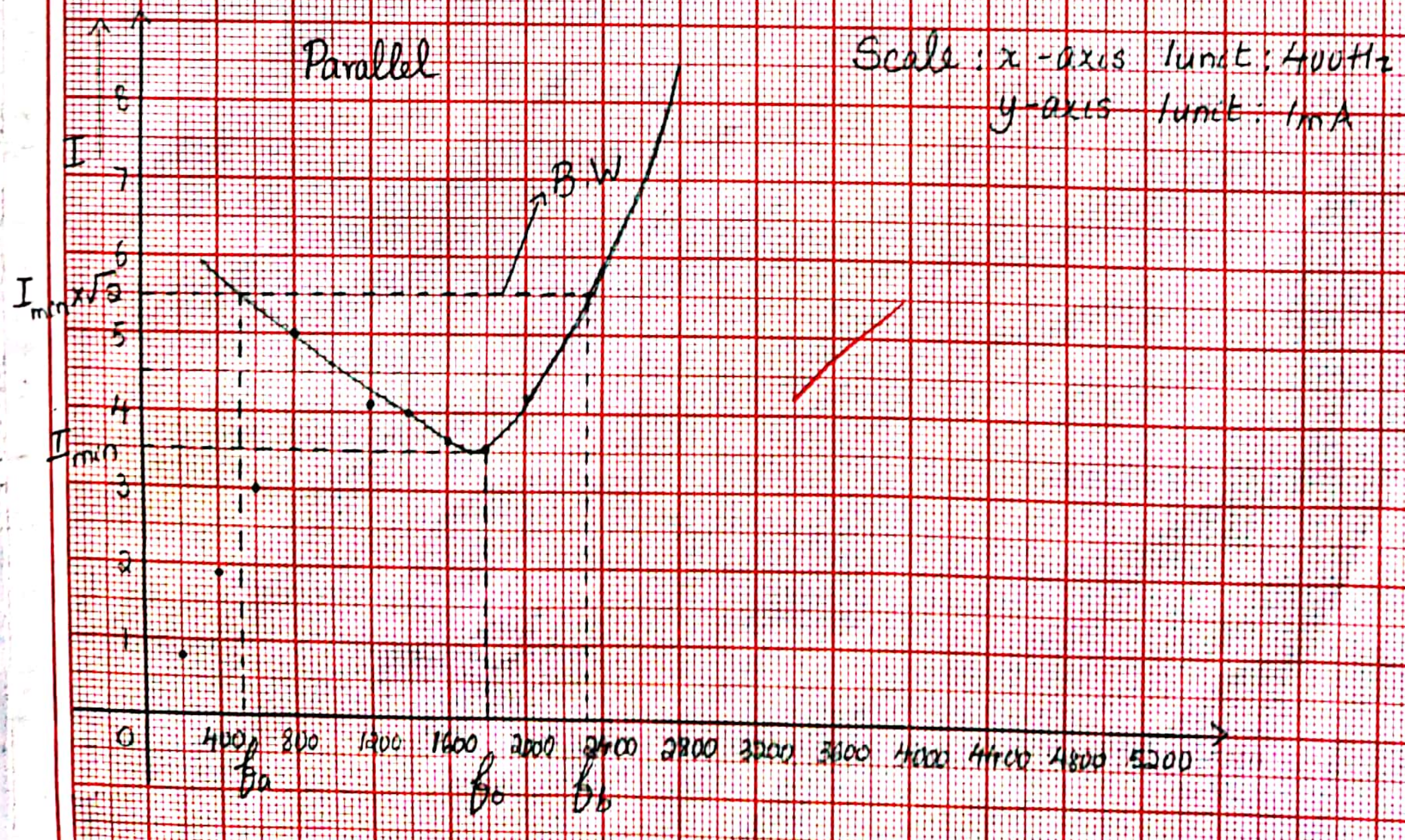

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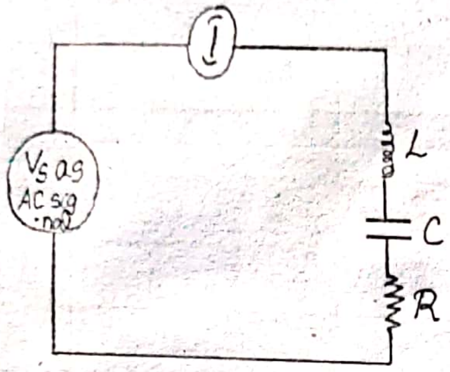
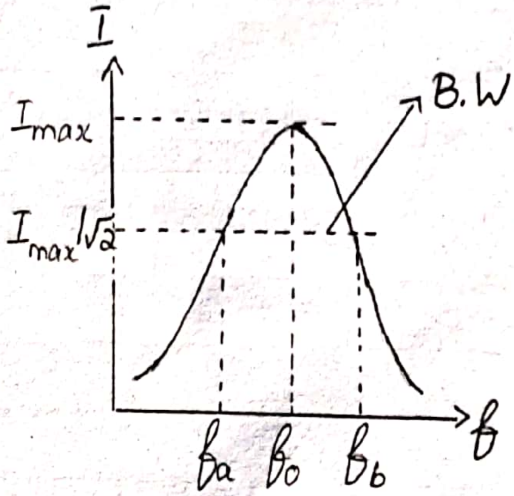
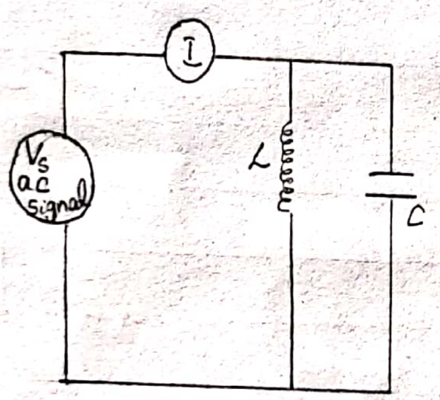
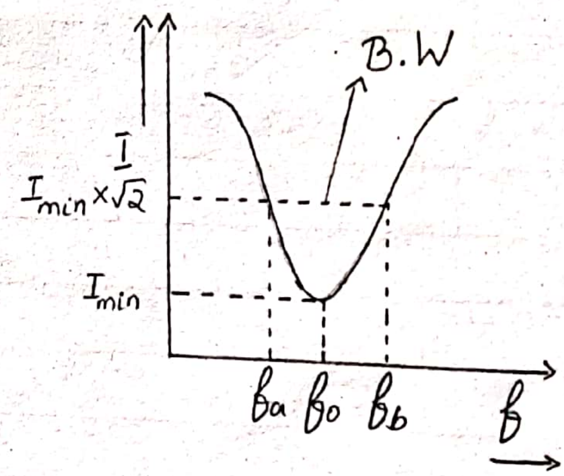
Circuit Diagram and Nature of the Graphs :



Series Resonance Circuit







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1. SERIES AND PARALLEL LCR CIRCUIT

Aim: a) To study the frequency response of the series and parallel resonance circuits.

b) To determine the inductance value of the given inductor

c) To determine the band width and quality factor of the circuit in series resonance.

Apparatus and Components required:

Audio frequency oscillator and LCR apparatus [consists of a.c. milliammeter, inductors of unknown value, resistors and capacitors of known values]

Theory: In series LCR ~~circuit~~ in the circuit is given by,

$$I = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$$

where X_L is the inductive reactance

X_C is the capacitive reactance

When $X_L = X_C$, the resonance occurs and the current reaches its maximum value. i.e., $\omega L = \frac{1}{\omega C}$.

Thus resonance frequency, $f_r = \frac{1}{2\pi\sqrt{LC}}$;

Therefore, $L = \frac{1}{4\pi^2 f_r^2 C}$ —①

In parallel resonance the current in the circuit is minimum and is given by $I_{min} = \frac{V}{\frac{L}{CR}}$

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Observations / Tabular Column:

Frequency (in Hz)	Series resonance I (in mA)	Parallel resonance I (in mA)
200	0·87	6·18
400	1·98	5·59
600	3·00	5·56
800	3·93	5·06
1000	4·76	4·63
1200	5·85	4·19
1400	5·63	4·10
1600	5·41	3·98
1800	5·39	3·87
2000	5·19	4·20
2500	4·09	6·57
3000	3·85	8·72
3500	3·13	10·44
4000	2·86	11·78
4500	2·33	12·73
5000	2·06	13·53

Formula:

Bandwidth $\Delta f = (f_b - f_a)$

The Quality factor from the graph

$Q_{graph} = f_0 / \Delta f$ — ②

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The quality factor Q is defined as the ratio of the energy stored in the coil to the energy dissipated in it. It gives the figure of merit and is used to compare different coils.

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Procedure: The circuit is connected as shown. The output voltage of the oscillator is set to some suitable value and kept it constant throughout the experiment. The frequency f is increased in suitable steps and the corresponding current is noted. The resonance frequency for a maximum current must be determined with maximum accuracy. A graph of I vs f is plotted as shown. The resonance frequency is noted from the graph. The inductance value of the coil is determined by eq(1). The quality factor Q of the circuit is evaluated using eq(2)

For parallel resonance, the experiment is repeated as in series resonance. The readings are plotted. From the graph the resonance frequency for minimum current is noted. The unknown inductance value is determined using eq(1)

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Calculations:

1. For series resonance

$$\frac{I_{max}}{\sqrt{2}} = \frac{5.85}{\sqrt{2}} = 4.13 \qquad C_s = 0.1\ \mu F$$

$$L_s = \frac{1}{4\pi^2 f_0^2 C_s} = \frac{1}{4 \times (3.14)^2 \times (1200)^2 \times 0.1 \times 10^{-6}}$$

$$= \frac{1}{4 \times 9.85 \times 1440000 \times 0.1 \times 10^{-6}}$$

$$= \frac{1}{5673600 \times 10^{-6}} = \frac{1}{5.6736}$$

$$L_s = 0.1763\ L = 176.3\ mH$$

2. For parallel resonance

$$I_{min} \times \sqrt{2} = 3.87 \times \sqrt{2} = 5.47 \qquad C_p = 0.1\ \mu F$$

$$L_p = \frac{1}{4\pi^2 f_0^2 C_p} = \frac{1}{4 \times (3.14)^2 \times (1800)^2 \times 0.1 \times 10^{-6}}$$

$$= \frac{1}{4 \times 9.85 \times 3240000 \times 0.1 \times 10^{-6}}$$

$$= \frac{1}{12765600 \times 10^{-6}} = \frac{1}{12.765}$$

$$L_p = 0.0783\ L = 78.3\ mH$$

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Results :

Results	Series Circuit	Parallel Circuit
1. Inductance (H)	176.3 mH	78.3 mH
2. Bandwidth (Hz)	$\Delta f = f_b - f_a$	$\Delta f = f_b - f_a$
	$= 2500 - 800$	$= 2300 - 500$
	$= 1500 Hz$	$= 1800$
	$= 1.5 kHz$	$= 1.8 kHz$
3. Quality factor	$Q = f_o / \Delta f$	$Q = f_o / \Delta f$
	$= 1200/1500$	$= 1800/1800$
	$= 0.8$	$= 1$

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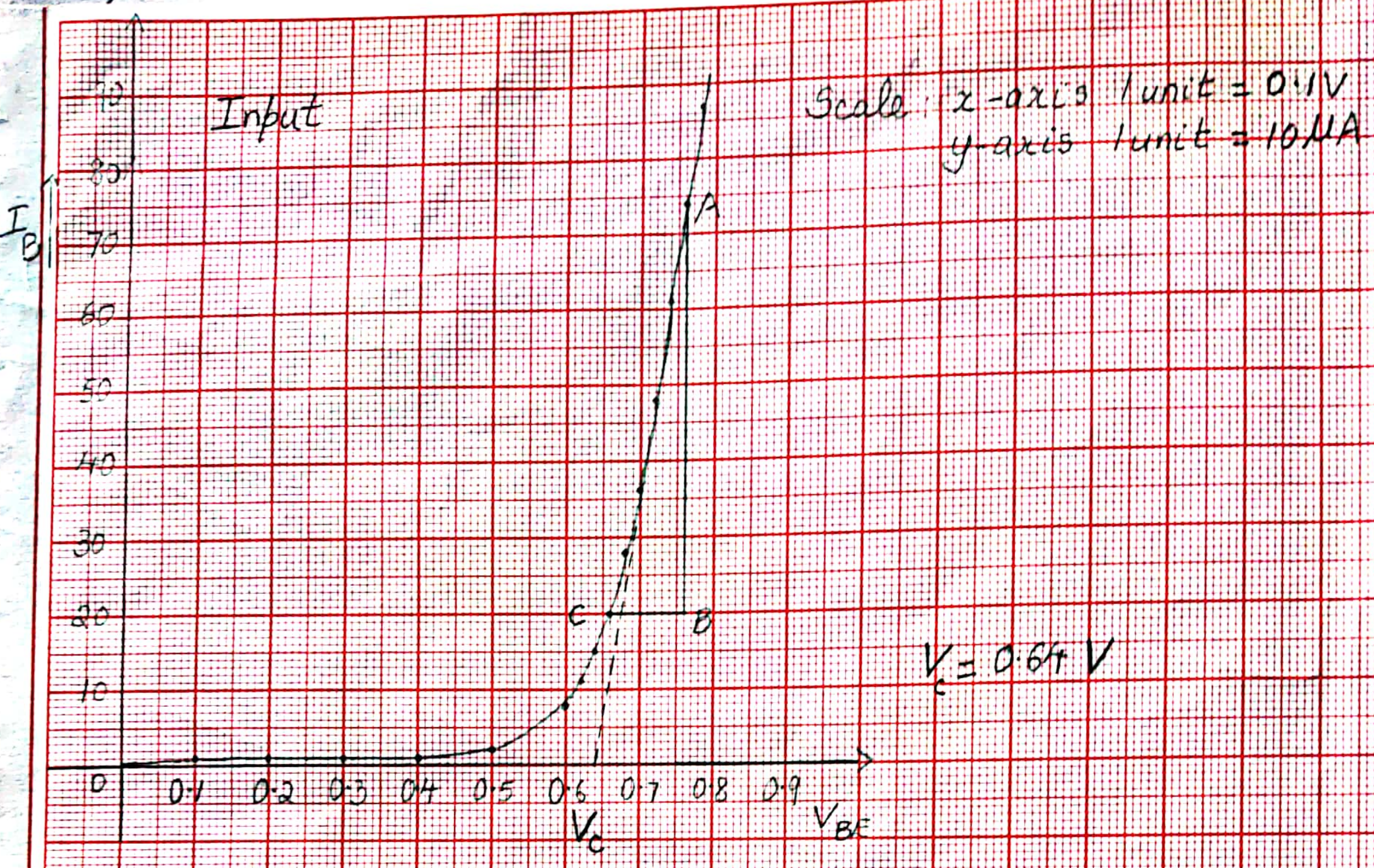

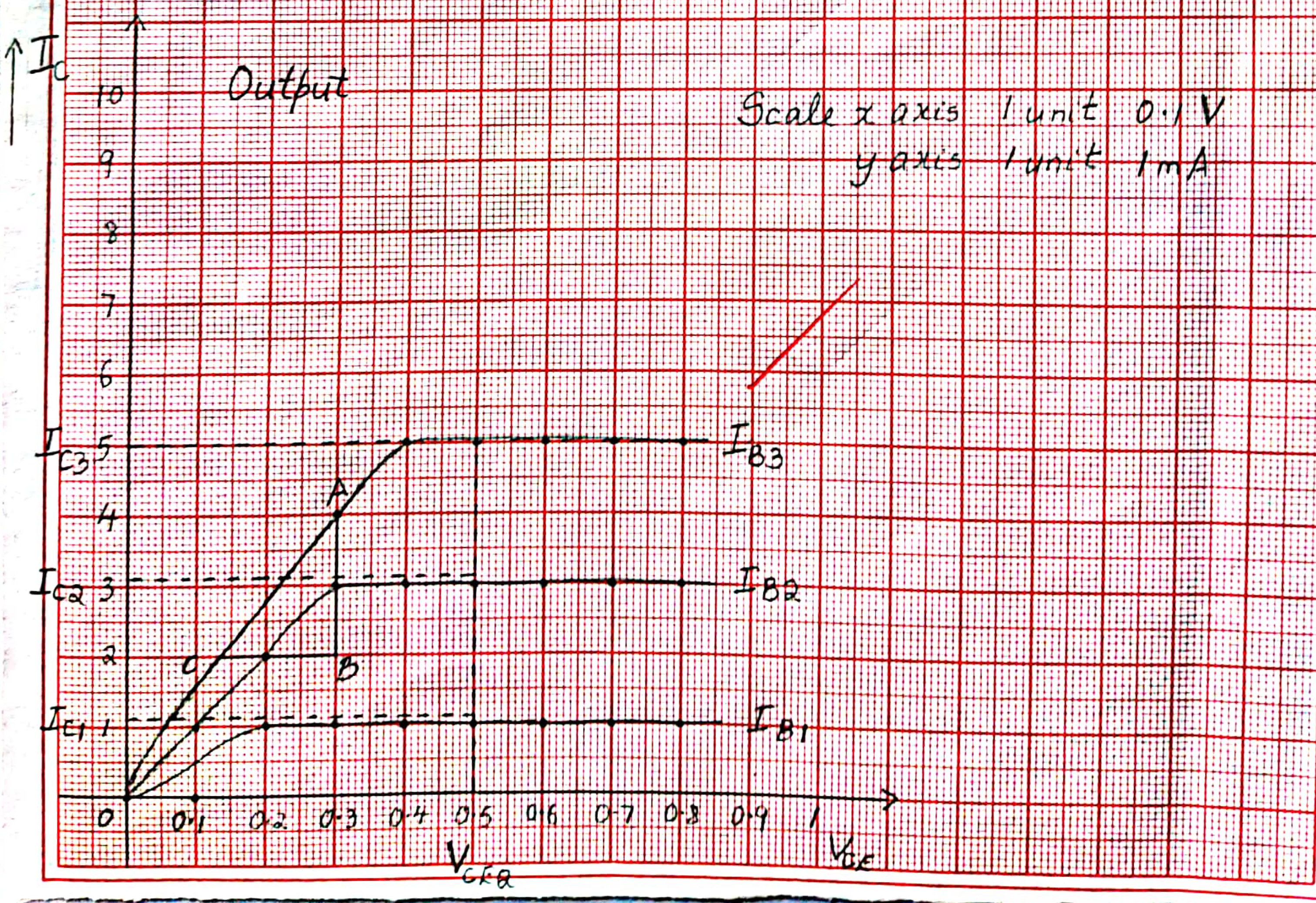

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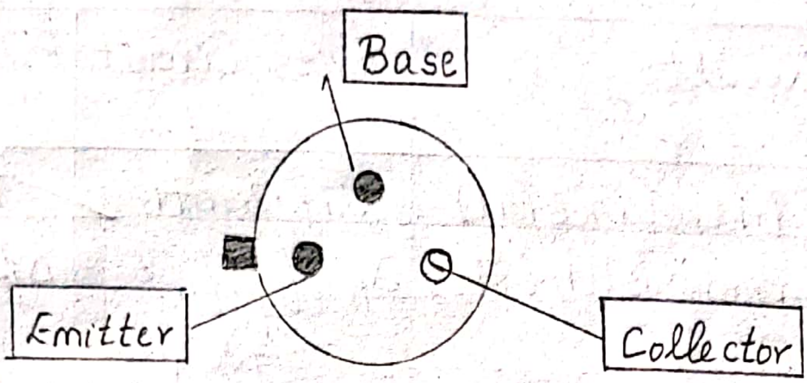
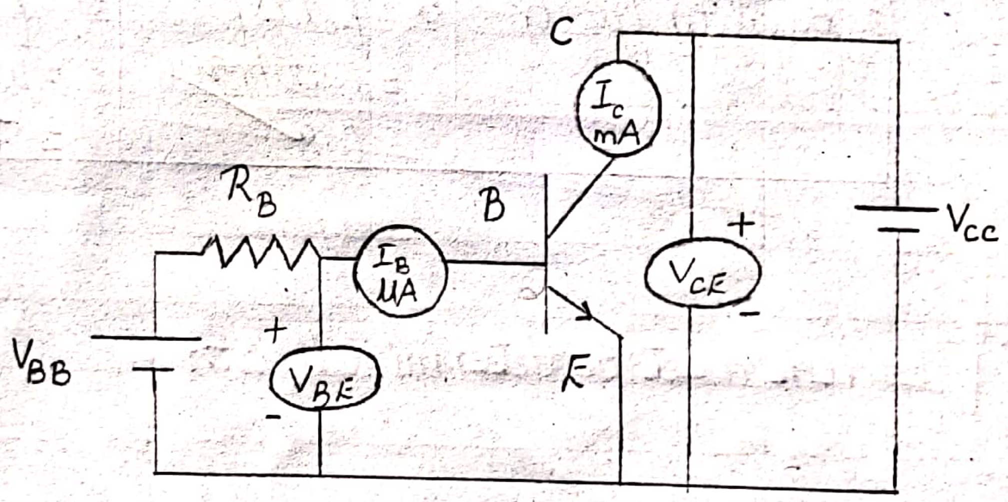
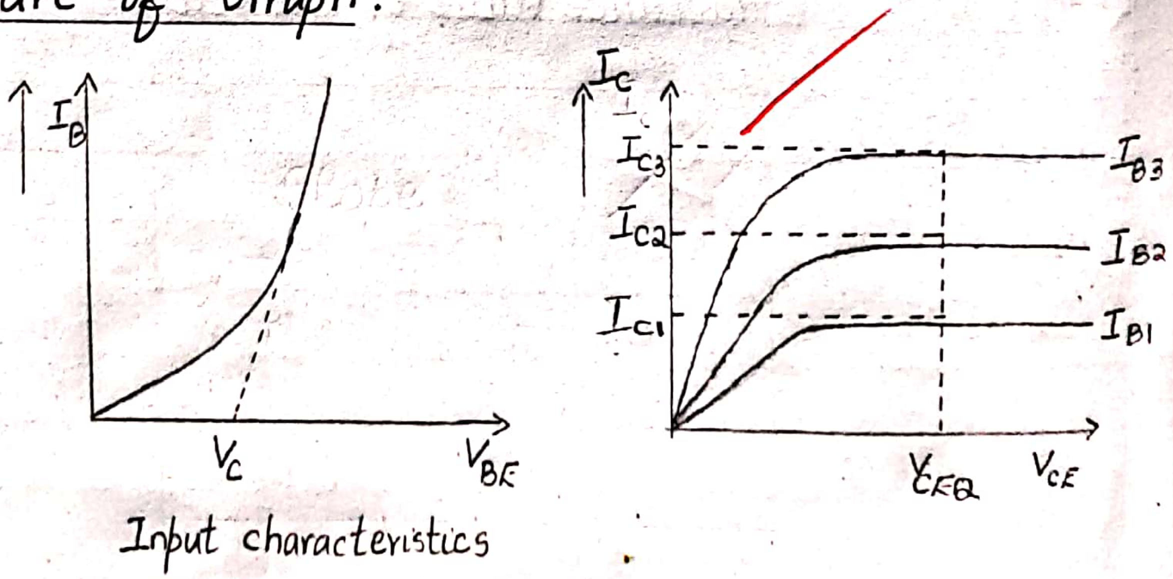
Transistor terminals:



Circuit Diagram:



Nature of Graph:



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2. Determination of the Characteristics of a TRANSISTOR

Aim: To draw the input and output characteristics of a transistor and hence transistor to determine its current gain and the knee voltage.

Apparatus and components required:
Transistor characteristics apparatus [includes variable DC sources, ammeters, voltmeters, transistor and resistors]

Theory: A transistor is a semiconductor device, which consists of three terminals emitter, base and collector. It is regarded as two diodes joined back to back. The base region is lightly doped and made very thin. The doping level in the emitter is more than in the collector.
The emitter-base junction is forward biased and hence junction resistance is large.
At the base ~~of~~ an NPN transistor, the electrons coming from the emitter are attracted by the reverse biased collector. The collector current I_C is slightly less than the emitter current I_E. Due to the recombination of the electrons at the base, a small base current I_B flows through the base terminals. Always $I_E = I_C + I_B$.

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Observations / Tabular column :

a) Input characteristics : Dependence of I_B on V_{BE} for constant V_{CE}

V_{BE} in (V)	Set $V_{CE} = 2V$ I_B (μA)
0	0
0·1	1
0·2	1
0·3	1
0·4	1
0·5	2
0·6	8
0·62	11
0·64	15
0·66	20
0·68	28
0·7	36
0·72	48
0·74	61
0·76	74
0·78	87
0·8	105

Formula : $R_i = \frac{1}{\text{slope}} = \frac{AB \times X\text{-Scale}}{BC \times Y\text{-Scale}}$

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The two current gains are defined as
$\alpha = \frac{I_c}{I_E}$ and $\beta = \frac{I_c}{I_B}$ where α is the emitter current amplification factor and β is base current amplification factor. Input characteristics is a plot of input voltage and input current with output voltage kept constant.

Procedure: The circuit connections are made as shown. To draw the input characteristic set the value of voltage V_{CE} for some convenient value, say 2V. Then by varying the source voltage V_{BE} for different values note down base current I_B. The graph of V_{BE} versus I_B is drawn from which the input resistance R_i is calculated. The knee voltage can be determined by the graph.

To draw the output characteristics set the value of I_B for some convenient value, say 25 µA. Then for different values of V_{CE} note down the current I_C. A graph of V_{CE} versus I_C is drawn. Repeat the experiment for two or more values of I_B. Then current gains α and β can be calculated.

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b) Output Characteristics: Dependence of I_c on V_{CE} for constant I_B

Trial 1		Trial 2		Trial 3	
$I_{B1} = 25\,\mu A$		$I_{B2} = 50\,\mu A$		$I_{B3} = 75\,\mu A$	
V_{CE}(volt)	I_c(mA)	V_{CE}(volt)	I_c(mA)	V_{CE}(volt)	I_c(mA)
0	0	0	0	0	0
0.1	0	0.1	1	0.1	2
0.2	1	0.2	2	0.2	4
0.3	1	0.3	3	0.3	5
0.4	1	0.4	3	0.4	5
0.5	1	0.5	3	0.5	5
0.6	1	0.6	3	0.6	5
0.7	1	0.7	3	0.7	5
0.8	1	0.8	3	0.8	5

Formula: Evaluation of current amplification factor

$$\beta = \frac{\Delta I_c}{\Delta I_B} = \frac{I_{C2} - I_{C1}}{I_{B2} - I_{B1}}, \text{ Current gain } \alpha = \frac{\beta}{1+\beta}$$

Calculations: a) Input characteristics

$$R_i = \frac{1}{slope}. \text{ Now, } Slope = \frac{AB}{BC} = \frac{AB \times X\text{-}Scale}{BC \times Y\text{-}Scale} = \frac{5 \times 10 \times 10^{-6}}{1.4 \times 0.1} = 357.1 \times 10^{-6}$$

$$R_i = \frac{1}{Slope} = \frac{1}{35.714} \times 10^5 = 2.8\,k\Omega$$

b) Output characteristics

$$\beta = \frac{\Delta I_c}{\Delta I_B} = \frac{I_{C2} - I_{C1}}{I_{B2} - I_{B1}} = \frac{3 \times 10^{-3} - 1 \times 10^{-3}}{50 \times 10^{-6} - 25 \times 10^{-6}} = 80 \quad \therefore \alpha = \frac{80}{1+80} = 0.98$$

Output resistance: $\frac{AB \times X\text{-}scale}{BC \times Y\text{-}scale} = \frac{4 \times 0.1}{2 \times 10^{-3}} = 200\,\Omega$

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Results:

Knee Voltage	0·64 V
Input resistance	2·8 kΩ
Output resistance	200 Ω
Current Gain (α)	0·98
Current Amplification factor (β)	80

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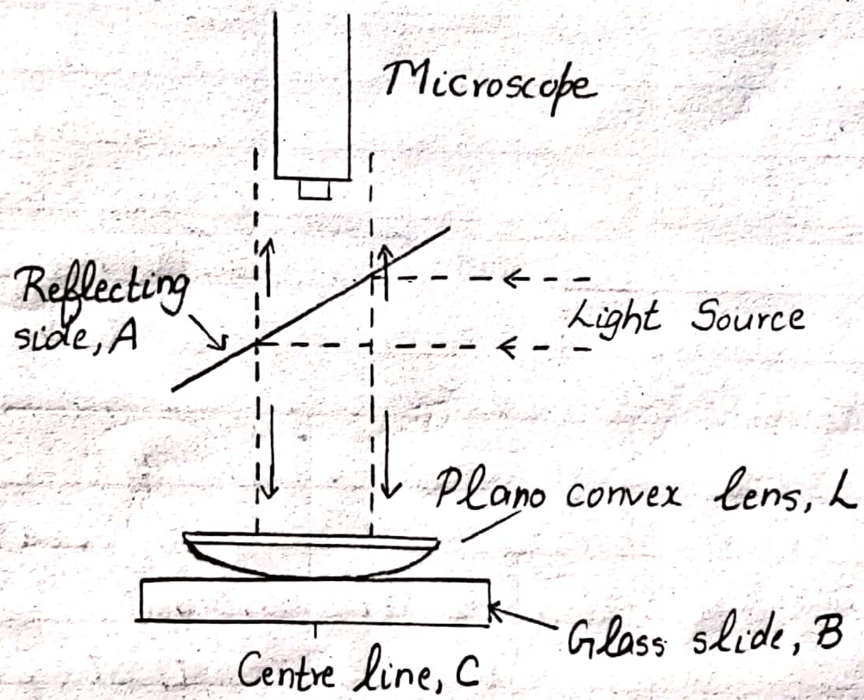
Formula: $$R = \frac{D_m^2 - D_n^2}{4(m-n)\lambda} \; m$$

where, D_m = diameter of the m^{th} dark ring
D_n = diameter of the n^{th} dark ring
$(m-n)$ = difference between m^{th} and n^{th} dark ring
λ = wavelength of sodium light $= 5893 \times 10^{-10}$ m

Figure:



Observations:

Least Count of the travelling microscope

$$\text{Pitch} = \frac{\text{Distance moved on the pitch scale}}{\text{No. of rotations given to the head scale}} = \underline{1} \text{ mm}$$

$$L.C = \frac{\text{Pitch}}{\text{No. of division on the head scale}} = \underline{0.01} \text{ mm}$$

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3. NEWTONS RINGS

Aim: To determine the radius of curvature of a plano convex lens by Newton's ring method.

Apparatus used: Newton's ring apparatus, travelling microscope, Monochromatic light source etc.,

Procedure: The apparatus is set up as shown in the figure. The travelling microscope is placed such that its objective is directly above the plano-convex lens. The inclined glass plate is tilted so that the light rays form the monochromatic source are reflected on the plane glass plate and the field of view is brightly illuminated. The focus of the microscope is adjusted such that the Newton's rings are clearly seen. The travelling microscope is adjusted such that the point of intersection of the cross wires coincides with the center of the ring system. The microscope is moved towards the left so that the vertical cross wire is tangential to the 8^{th} dark ring and the reading of microscope is taken. The microscope is now moved towards right and the reading of every ring is noted down till the 8^{th} dark ring on the other side is reached. The reading are entered in the tabular column and the mean value of $(D_m^2 - D_n^2)$ is calculated. Knowing the wavelength of source light, the radius

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Tabular Column:

1. to find D_m^2

Ring No. "m"	T.M Reading LEFT			T.M Reading RIGHT			Ring Diameter (mm)	D_m^2 in mm^2
	PSR mm	HSR	TR R_1 mm	PSR mm	HSR	TR R_2 mm	$D_m = R_2 - R_1$	
8	45	32	45.32	40	26	40.26	5.06	25.60
7	45	21	45.21	40	38	40.38	4.83	23.32
6	44	08	44.08	40	51	40.51	4.57	20.88
5	44	94	44.94	40	65	40.65	4.26	18.40

2. to find D_n^2

Ring No. "n"	T.M Reading LEFT			T.M Reading RIGHT			Ring Diameter (mm)	D_n^2 in mm^2	$D_m^2 - D_n^2$ (mm^2) [For m-n=4]
	PSR mm	HSR	TR R_3 mm	PSR mm	HSR	TR R_4 mm	$D_n = R_4 - R_3$		
4	44	79	44.79	40	79	40.79	4	16	9.6
3	44	63	44.63	40	98	40.98	3.65	13.32	10
2	44	44	44.44	41	19	41.19	3.25	10.56	10.32
1	44	22	44.22	41	41	41.41	2.81	7.84	10.51

Here $(m-n) = 4$ Mean $(D_m^2 - D_n^2) = 10.10\ mm^2 = 0.1010 \times 10^{-4}\ m^2$

Calculations: $R = \dfrac{D_m^2 - D_n^2}{4(m-n)\lambda}\ m = \dfrac{0.1010 \times 10^{-4}}{16 \times 5893 \times 10^{-10}} = 1.071\ m$

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of curvature of the plano convex lens is calculated using the formula,

$$R = \frac{D_m^2 - D_n^2}{4(m-n)\lambda} \; m$$

Result: The radius curvature of the given plano convex lens = 1.071 m

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Formula:

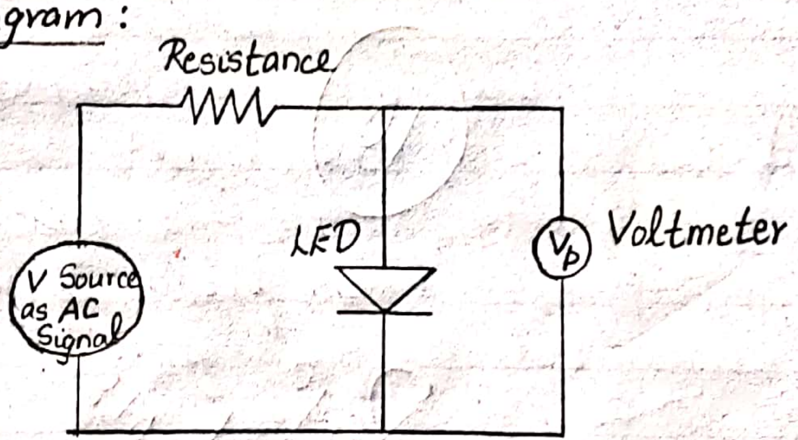
1\. Planck's constant:

$h = \frac{e\lambda V_{average}}{c}$, where h is the Planck's constant $= 6\cdot625 \times 10^{-34}$ Js, e is the charge of the electron $= 1\cdot6 \times 10^{-19}$ C and c is the velocity of light $= 3 \times 10^{8}$ m/s

2\. To determine the wavelength of IR LED:

$$\lambda_{IR} = \frac{\lambda V_{average}}{V_{IR}}$$

Circuit Diagram:



Observations:

Colour	Wavelength λ (nm)	Knee voltage (V)	λV (nmV)
Yellow	535	1·93	1109·75
Green	500	2·08	1040
Blue	350	3·20	1120
Red	600	1·70	1020

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4. Determination of PLANCK'S CONSTANT using LED

Aim: To determine the Planck's constant using LED

Apparatus and components needed:

Planck's constant apparatus: [includes wave generator, digital peak reading voltmeter, six different known wave length LED's, resistance etc.]

Theory: LED is a two terminal solid state lamp, which emits light with very low voltage and current. The light energy radiated by forward biasing is given by equation $E = \frac{hc}{\lambda}$ ..... ① where

c is the velocity of light, λ the wave length of light emitted and h is Planck's constant. If V is the forward voltage applied across the LED terminals that makes it emit light (it is also called forward knee voltage) then the energy given to the LED is given by $E = eV$ .... ② where e is electronic charge.

LEDs are very high efficiency diodes and hence this entire electrical energy is converted into light energy, then equating equations 1 and 2,

$$eV = \frac{hc}{\lambda} \quad .... ③$$

From this equation Planck's constant is given by,

$$h = \frac{eV\lambda}{c} \quad .... ④$$

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Calculations:

1. Planck's constant

$$h = \frac{e\lambda V_{average}}{c}$$

$$= \frac{1.6 \times 10^{-19} \times 1072.43 \times 10^{-9}}{3 \times 10^{8}}$$

$$= 571.9627 \times 10^{-36}$$

$$= \underline{5.7196 \times 10^{-34}} \text{ Js}$$

2. To determine the wavelength of IR LED:

$$\lambda V_{average} = 1072.4375 \text{ nmV}$$

now, $$\lambda_{IR} = \frac{\lambda V_{average}}{V_{IR}}$$

$$= \frac{1072.4375 \times 10^{-9}}{1.06}$$

$$= 1011.73 \times 10^{-9}$$

$$= \underline{1011} \text{ nm}$$

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For different wavelengths of light, the forward knee voltage is determined and the value of h is calculated. Moreover, $\frac{e}{c} = 5.33 \times 10^{-28}$ coulomb-sec/meter is a universal constant and hence the product λV must be a constant. This enables the determination of Planck's constant. The wavelength of IR LED can be determined by noting the knee voltage V_{IR} and the value substituted in the equation

$$\lambda_{IR} = \frac{\lambda V_{(average)}}{V_{IR}} \quad \text{-----} \ (5)$$

Procedure: The circuit is connected as shown. The input to the LED is an ac signal. Using a digital peak reading voltmeter the voltage across the LED is measured and recorded. For given colour LED light. Trial is repeated by changing the LED and the corresponding knee voltage is noted. The product of wavelength and knee voltage is determined and its average value is calculated. Planck's constant is calculated using equation 4.

The IR LED is now connected and the knee voltage V_{IR} is observed. The wavelength is calculated using eq (5)

Result:

Parameters	Theoretical	Experimental
Planck's constant (Js)	6.626×10^{-34}	5.7196×10^{-34}
Wavelength of IR LED (nm)	910	1011
λV (nmV)	1240	1072.4375

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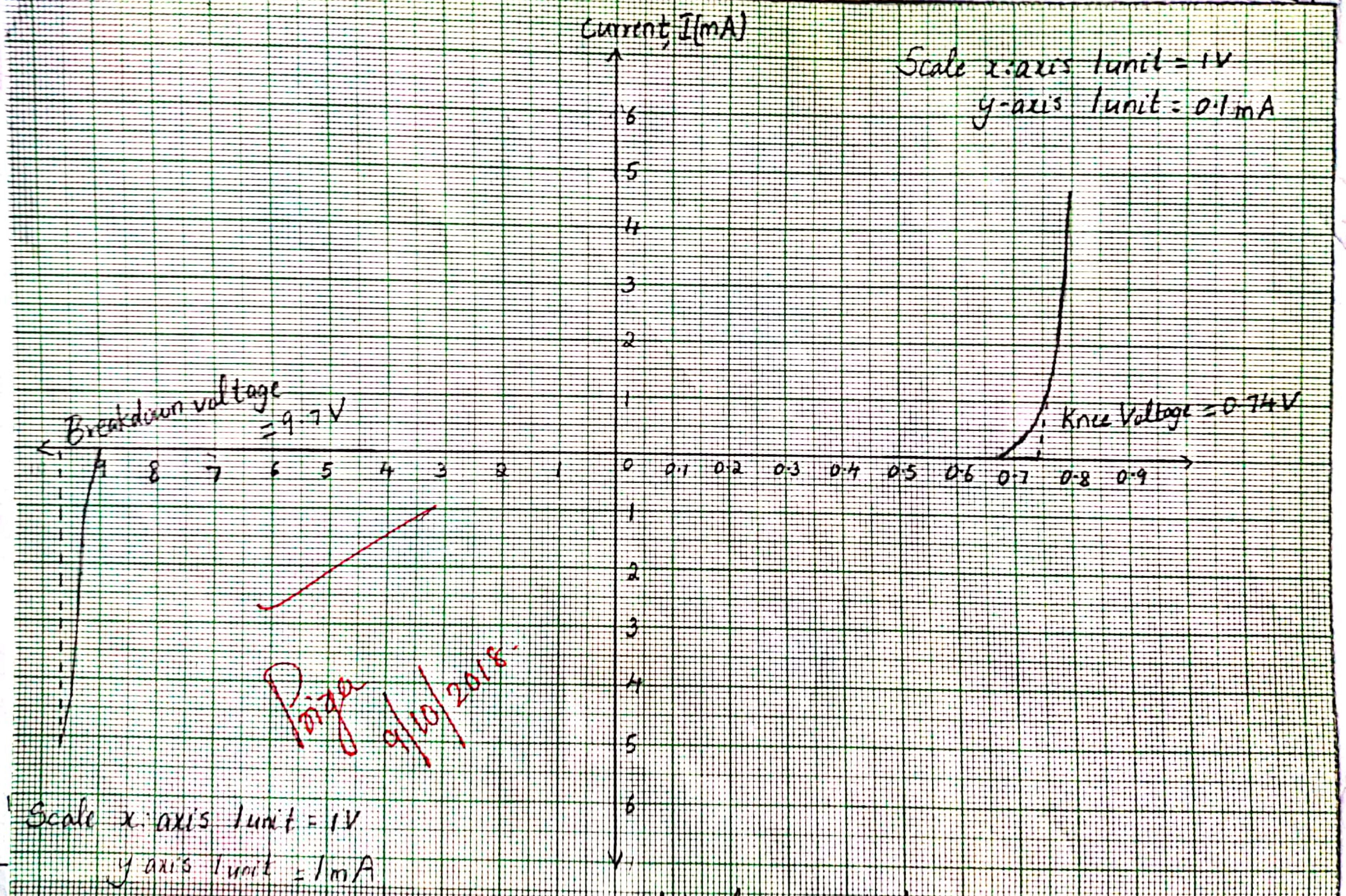

I-V plot of Zener diode

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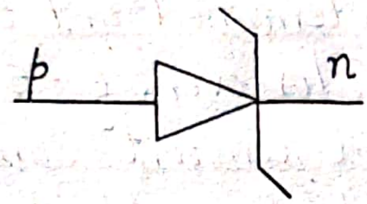
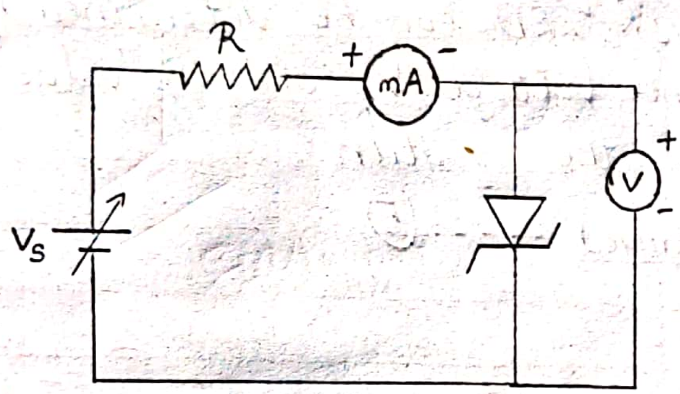
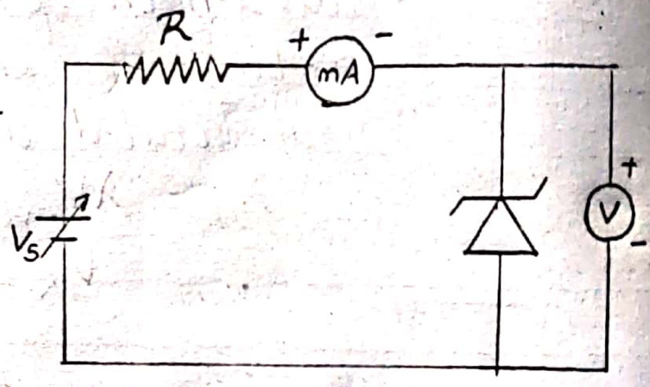
Figure:



Circuit Diagrams:

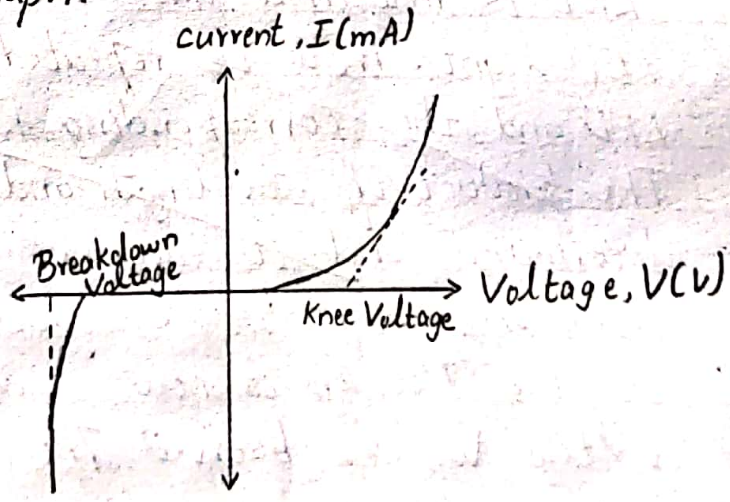


Forward Bias



Reverse Bias

Nature of Graph:



I-V plot of Zener diode

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5. Study of ZENER DIODE Characteristics

Aim: To study the current voltage characteristics of the given Zener diode.

Apparatus and Components required:
Zener diode apparatus [contains D.C power supply, Voltmeter, Ammeter and Zener diode]

Theory: A zener diode is a junction diode in which the p-type and n-type material are heavily doped and hence the depletion width is narrow. As a result in the reverse bias condition the diode exhibits a sharp break down at a particular voltage after showing high resistance at lower voltages.

At this break down voltage the bottom of the conduction band in the N-type material assumes a position lower in the energy than the top of the valance band in the P-type resulting in a large tunneling current to flow across the junction. The voltage limiting characteristics of the Zener diode makes it a good voltage reference source and hence used in voltage stabilizers.

The current across the junction is given by the equation $I = I_0[\exp(eV/kT) - 1]$ where I_0 is saturation current and V is the applied voltage. When V is positive (forward bias) the current varies exponentially with the voltage. When V is negative([illegible] bias) the

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Observations:

Forward Bias

Voltage V(V)	Current I(mA)
0	0
0·1	0
0·2	0
0·3	0
0·4	0
0·5	0
0·6	0
0·68	0·2
0·70	0·4
0·72	0·9
0·74	1·5
0·76	2·8
0·78	5·1

Reverse Bias

Voltage V(V)	Current I(mA)
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
8·94	0·1
8·96	0·1
8·98	0·2
9	0·3
9·02	0·6
9·04	0·9
9·06	1·4

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current is practically constant at I_0 as shown in I vs V graph.

Procedure: Connect the forward bias circuit. Vary the source voltage gradually and note down the voltage across the diode and note down the corresponding current values. Remove the circuit connections and reconnect, which is the reverse bias circuit. Change the values of voltage in the range and the corresponding current values. Plot the I vs V graph.

Result:

i) The current-voltage characteristics of the Zener diode are studied

ii) The cut-off voltage or knee voltage = 0.74 V

iii) The break down voltage of the Zener diode = 9.7 V

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Formula: $\rho = \frac{V}{I} 2\pi S$ where,

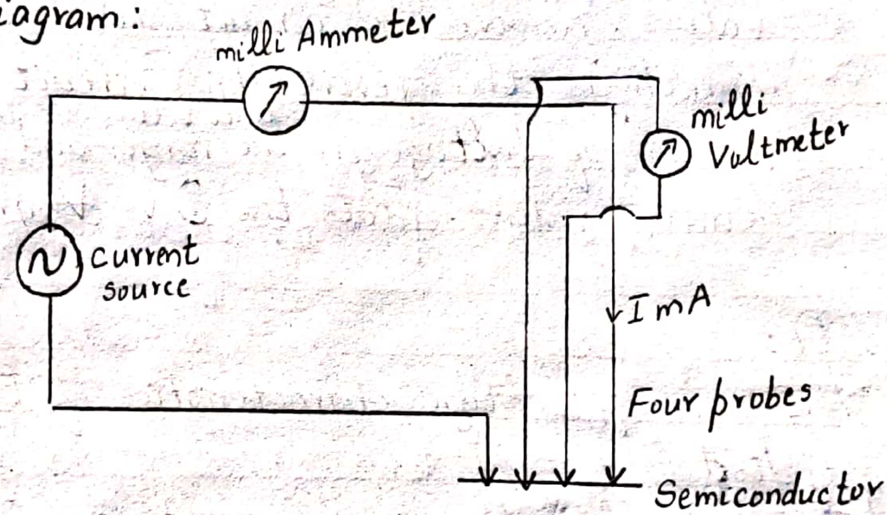
ρ is the resistivity of the Ge crystal

V is the voltage

I is the current flowing

S is the distance b/w the probes

Circuit diagram:



Observation:

Current (I) = 2mA

Sl.no.	Temperature (°C)	Voltage (V)	Temperature (k)	Resistivity ρ (ohm.cm)
1	80	47.1	353	276.32
2	77	46.9	350	294.53
3	74	50.4	347	316.51
4	71	54.3	344	339.74
5	68	57.8	341	362.98
6	65	61.6	338	386.84
7	62	65.2	335	409.45
8	59	69.8	332	438.34

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6. FOUR PROBE TECHNIQUE
- Resistivity Measurement of a Semiconductor

Aim: To determine the resistivity of a semiconductor

Apparatus used: Probes arrangement, Ge crystal sample, oven, four probe set-up (measuring unit)

Procedure:

1. Put the sample on the base plate of the four probe arrangement. Unscrew the pipe holding the four probes and let the four probes rest in the middle of the sample. Apply a very gentle pressure on the probes and tighten the pipe in the position. Check the continuity b/w the probes for proper electrical contacts.
2. Connect the outer pair of probes (red/black) leads to the constant power supply and the inner pair (Yellow/Green) leads to the probe voltage terminals
3. Place the four probe arrangement in the oven and fix the thermometer in the oven through the hole provided.
4. Switch on the AC mains of four probe setup and put the digital panel meter in current mode.
5. Now, put the digital panel meter into voltage mode. Read the voltage between the probes
6. Connect the oven power supply. Rate of heating may be selected as low or high. Switch on the power to oven

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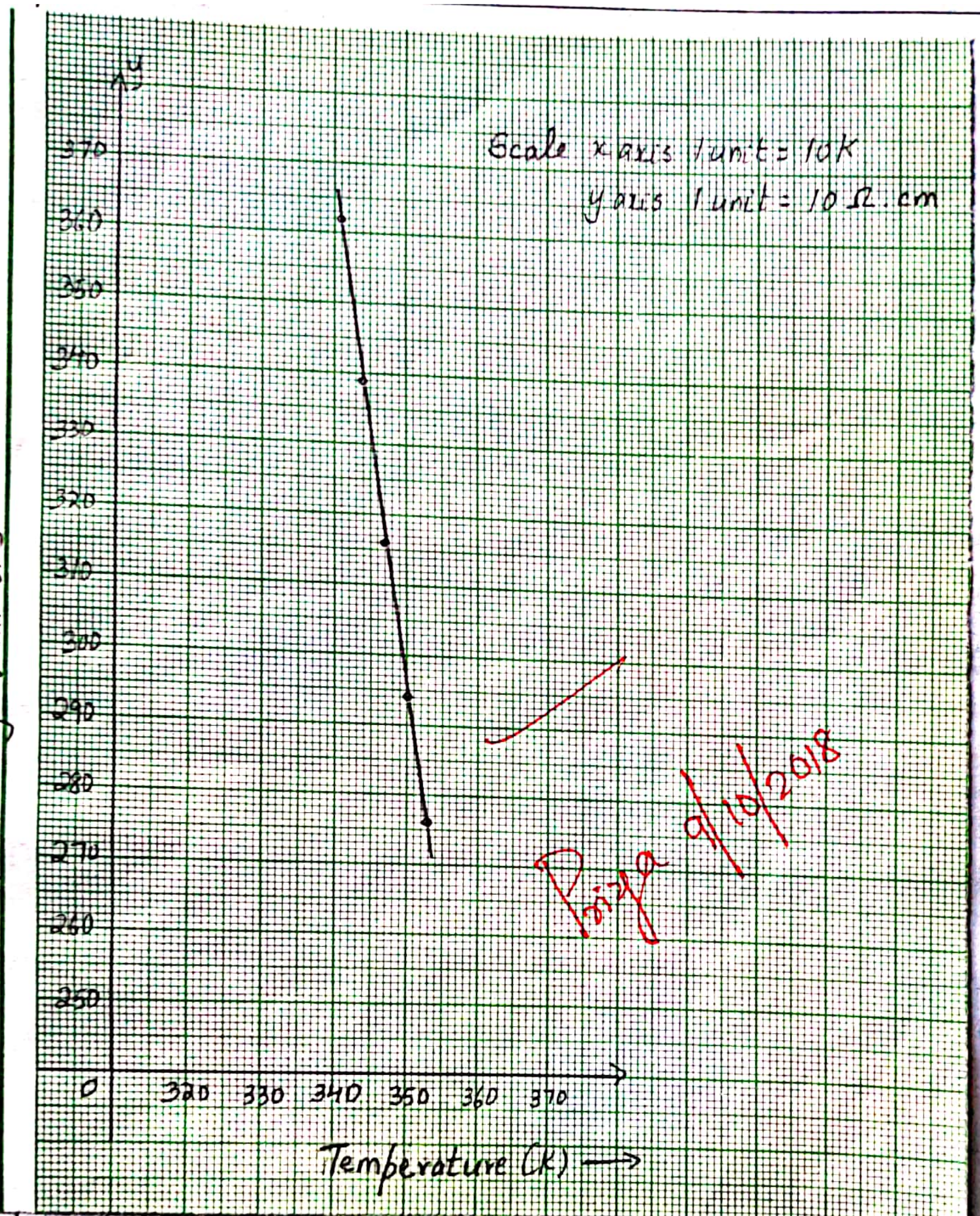

5. $\frac{57.8 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 362.98$

6. $\frac{61.6 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 386.84$

7. $\frac{65.2 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 409.45$

8. $\frac{69.8 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 438.34$

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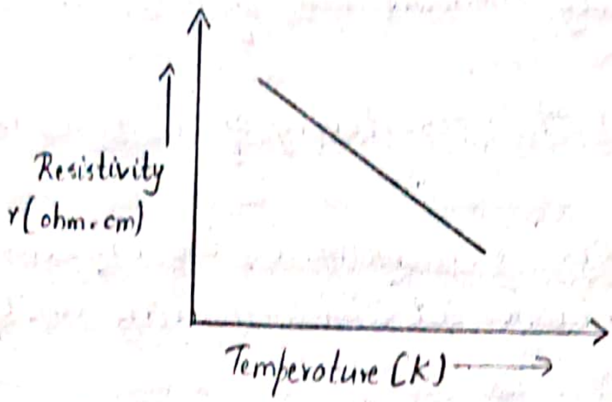
Model Graph:



Calculations:

Formula used $\rho = \frac{V}{I} 2\pi S$

1. $\frac{47.1 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 276.32$

2. $\frac{46.9 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 294.53$

3. $\frac{50.4 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 316.51$

4. $\frac{54.3 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 339.74$

5. $\frac{57.8 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 362.98$

6. $\frac{61.6 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 386.84$

7. $\frac{65.2 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 409.45$

8. $\frac{69.8 \times 10^{-3}}{2 \times 10^{-3}} \times 2 \times 3.14 \times 2 \times 10^{-3} = 438.34$

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Result:

Resistivity of the given semiconductor decreases with increase in temperature

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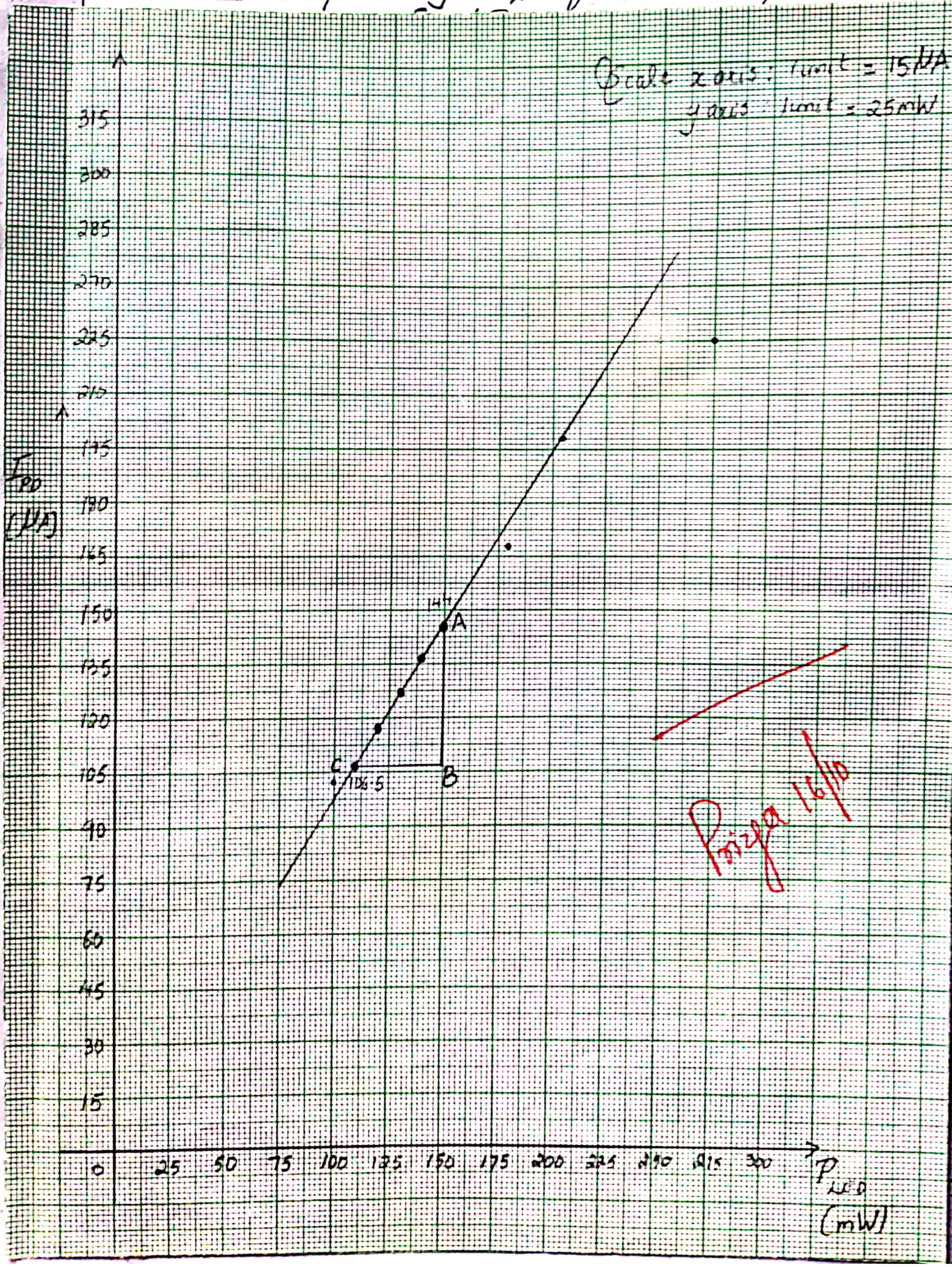
Formula: Responsivity (R_λ) of a silicon photodiode



P_LED

(mW)

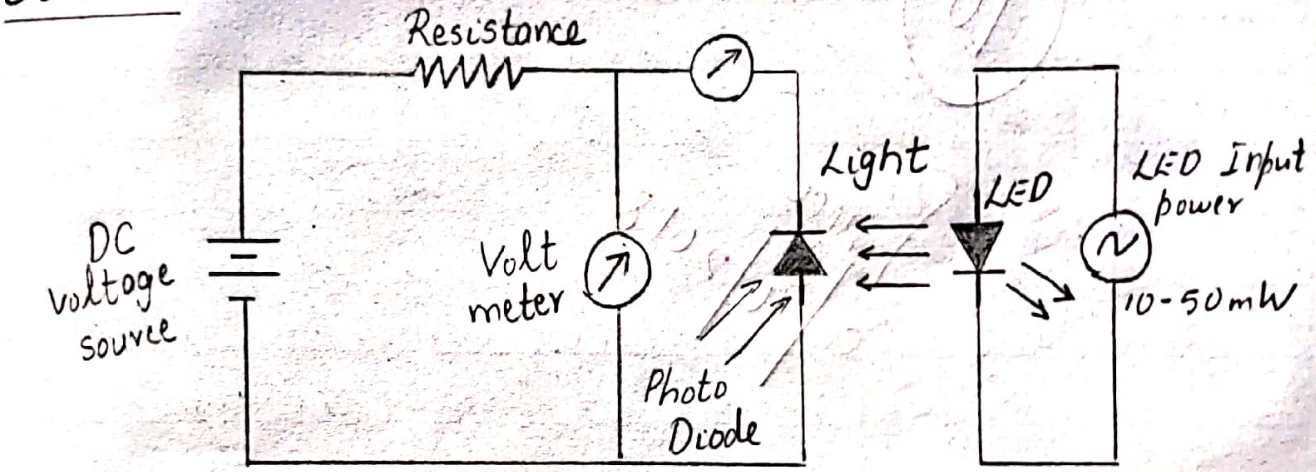
LR

Formula: Responsivity (R_λ) of a silicon photodiode

$= I_{pd} / P$

where I_{pd} is the photodiode current and P is the light input power.

Circuit:

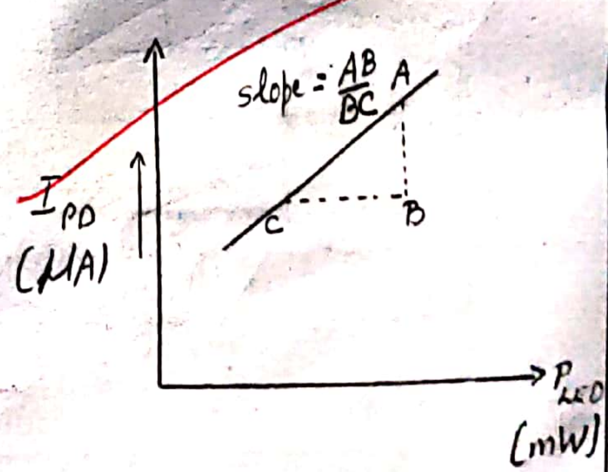


Observation:

Table-1: PD current variation with LED power

P_{LED} (mW)	I_{PD} (µA)
10	101
11	106
12	117
13	127
14	136
15	144
18	169
21	197
24	216
30	255
38	313

Model graph:



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7. I-V Characteristics of a PHOTO DIODE

Aim: To determine the IV characteristics of photo diode and to find the variation of photo current as a function of light intensity

Apparatus used: Photodiode experimental setup consisting of 0-3 V regulated power supply, 0-2mA digital dc current meter, 0-20V digital dc volt meter, white LED module and photo diode LED type. A transistor drive for LED is used. The LED power ($P_{LED} = V_{LED} I_{LED}$) is directly read from the dial marked on the LED power supply.

Procedure:

1. Determination of Responsivity:

- The LED is switched on and LED power is set to 10mW by positining the knob to its minimum position. After confirming that the LED is glowing and PD current in the meter, the cover is placed so that external light will not affect the readings. Positive of the PD is connected to the negative of the power supply and Negative of the PD is connected to the positive of the power supply. This reverse biases the photo diode.
- The voltage across P.D is set to 1-V by varying 0-3V power supply. The P.D current I_{PD} is noted
- The LED power is increased to 11mW and V_{PD} is again set to 1V and the corresponding PD current is

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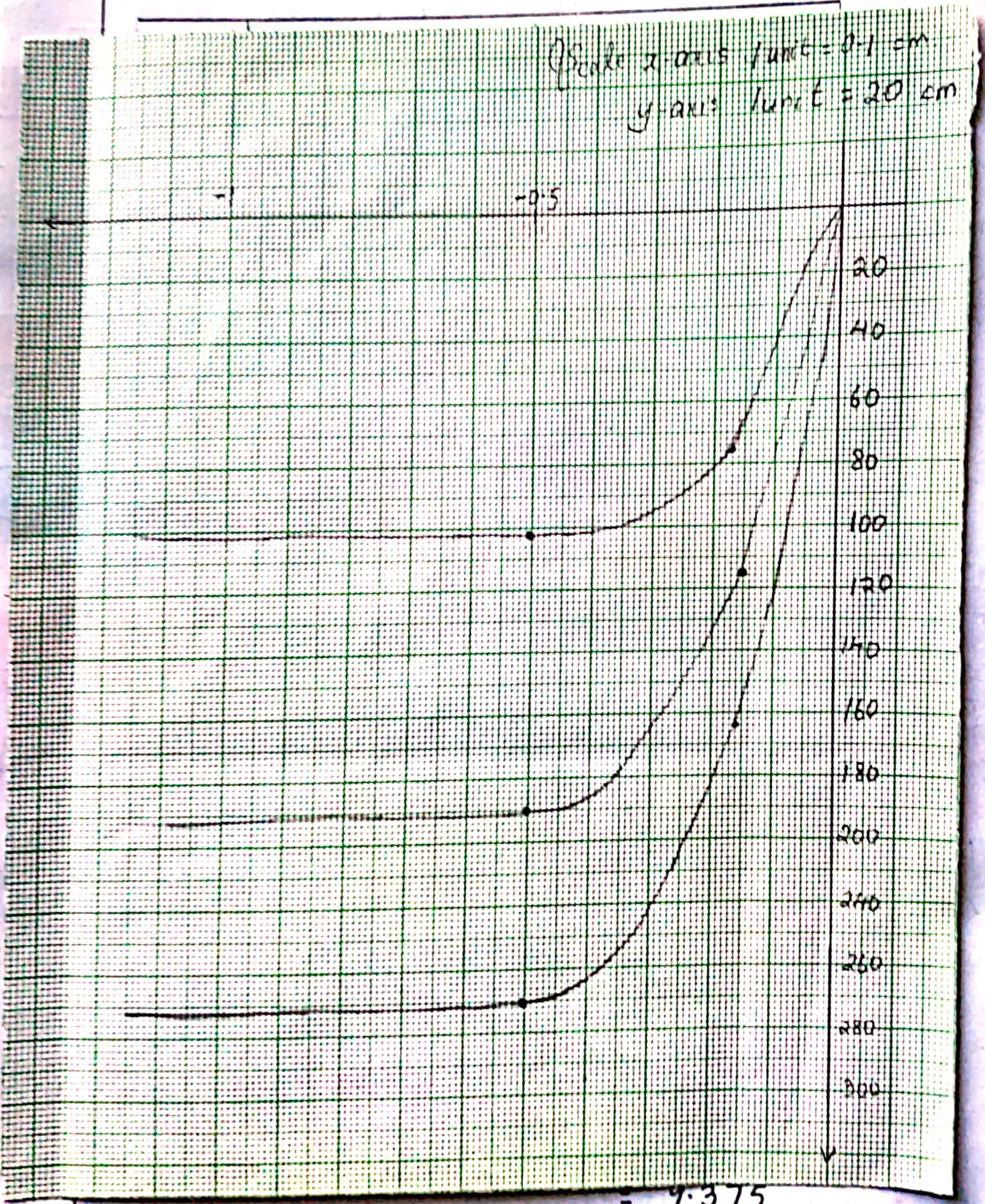
Table-2: Variation of PD voltage with current



= 1.375

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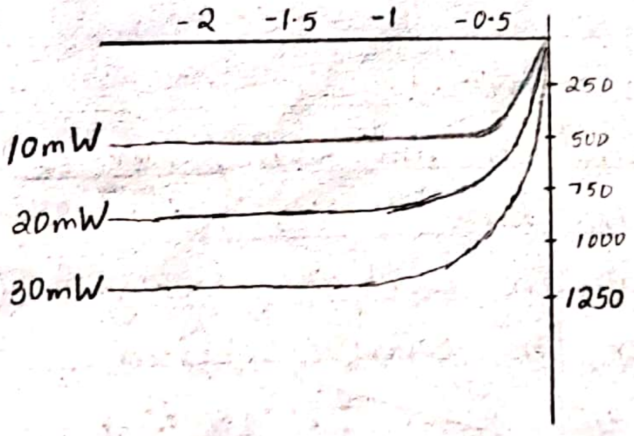
Table-2: Variation of PD voltage with current

V_{PD} (V)	I_{PD} (μA)		
	P_{LED} = 10mW	P_{LED} = 20mW	P_{LED} = 30mW
0	0	0	0
-0.1	0.3	5	14
-0.2	77	126	164
-0.3	98	182	249
-0.4	100	185	256
-0.5	101	188	257
-1.0	103	190	263
-2.0	106	196	271

Model Graph:



Calculation: Slope $= \frac{y_2 - y_1}{x_2 - x_1} = \frac{144 - 106.5}{15 - 11}$

$= 9.375$

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noted in Table - 1

- Trial is repeated for input power 12, 13mW etc up 50mW. In each case V_{PD} is set to -1V and I_{PD} is noted in Table - 1
- A graph showing the variation of LED power on X-axis and PD current on Y axis is drawn. A straight line graph is obtained, slope of which gives Responsivity

  Responsivity (R_λ) of a silicon photodiode = slope (from the graph).

2. I-V Characteristics of PD:

In this part of the experiment, PD current and voltage are recorded for different LED input power.

- The LED power is set to 10mW on the dial and V_{PD} is set to -0.10 V and the I_{PD} is noted
- Trial is repeated by increasing V_{PD} in suitable steps up to a maximum of -2V. The corresponding I_{PD} is noted in Table - 2
- Experiment is repeated by increasing the LED power to 20, 30, 40 and 50mW. In each case variation in V_{PD} and corresponding I_{PD} are noted in Table - 2
- A graph is drawn taking V_{PD} along X-axis and I_{PD} along Y-axis. The equal spacing between characteristic curves indicates linearity of photo current with light intensity.

Result: The Responsivity of the photodiode = 9.3 mA/W and IV characteristics is drawn for the photo diode in the third quadrant

Priya 16/10

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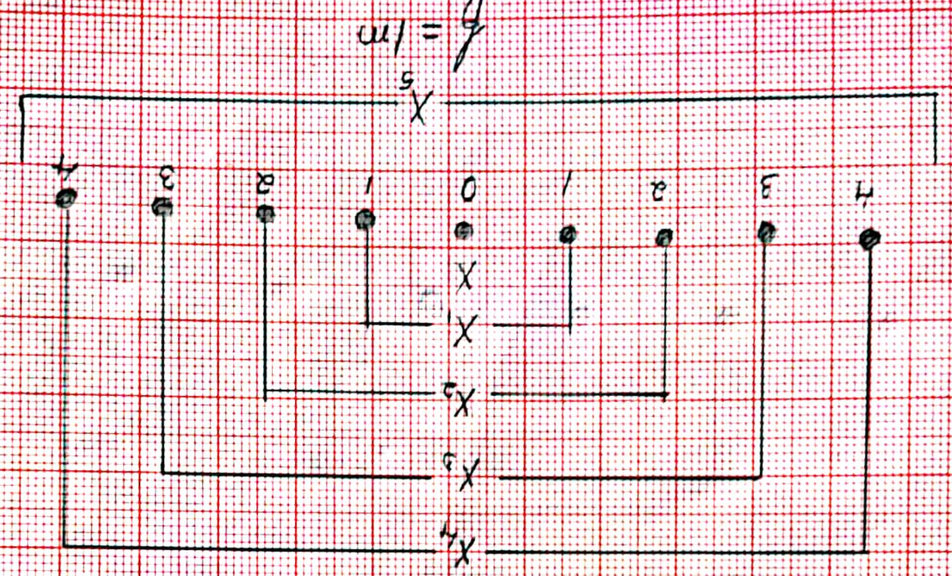
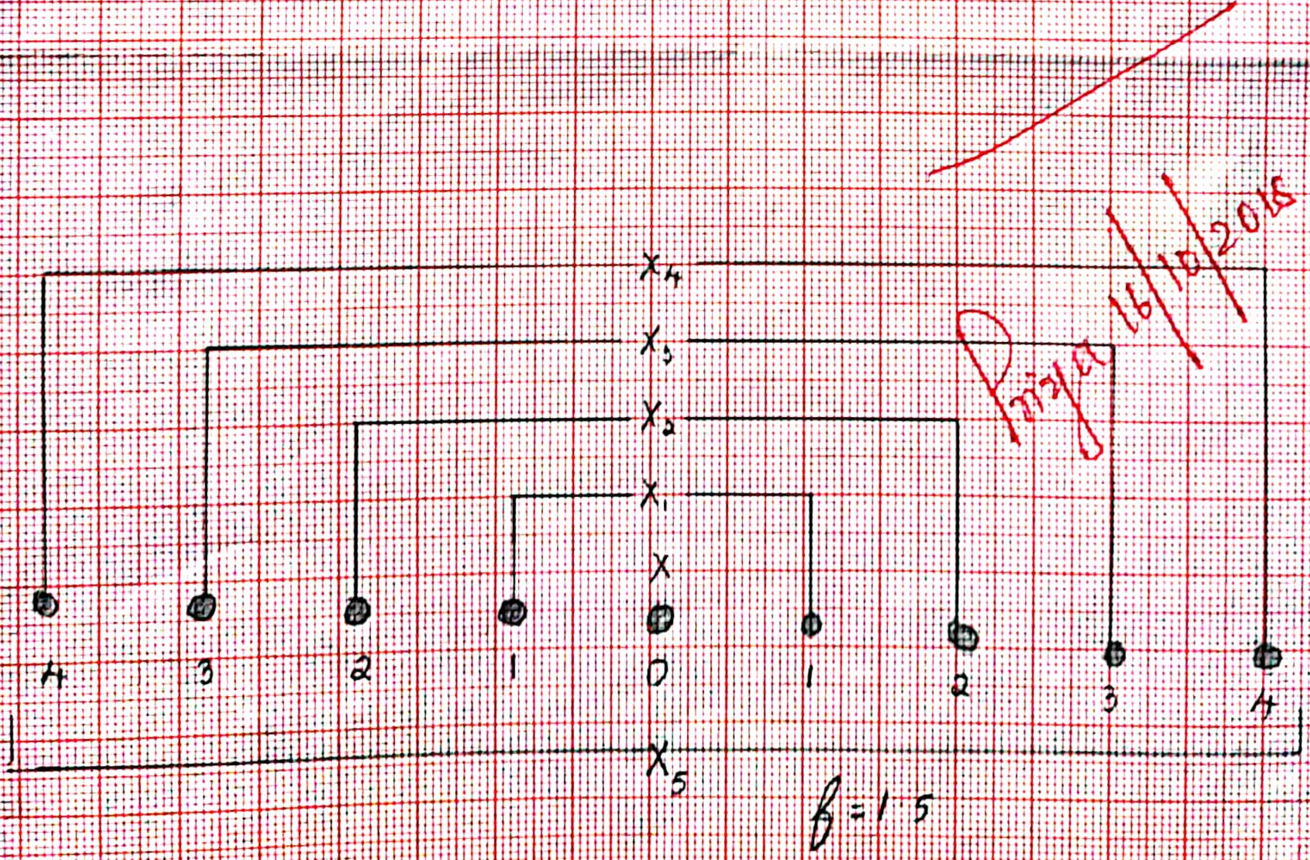
Formula used: $\theta_n = \tan^{-1}\left(\frac{x_n}{f}\right)$





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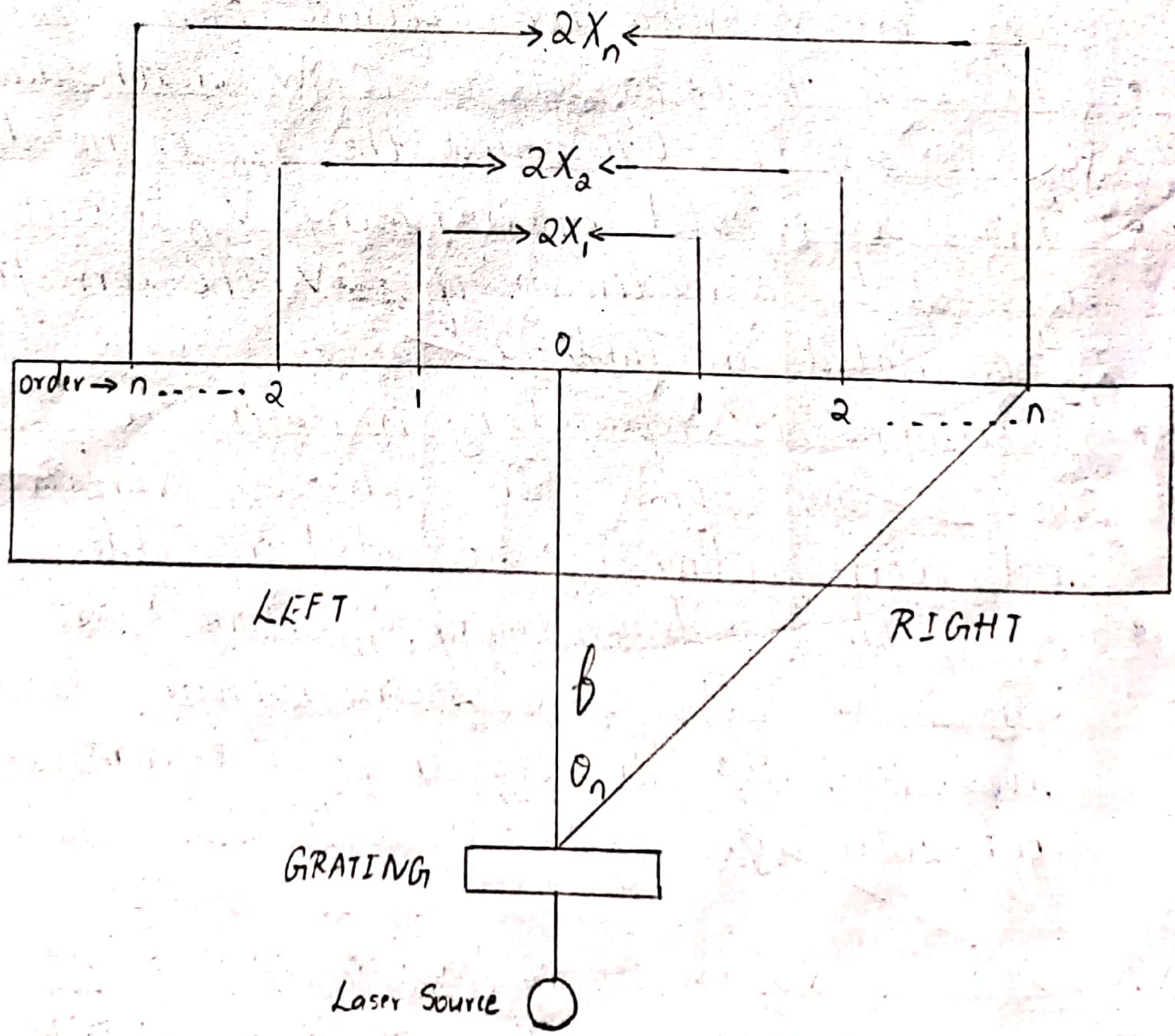
Formula used: $\theta_n = \tan^{-1}\left[\frac{X_n}{f}\right]$

$$\lambda = \frac{d \sin \theta_n}{n}$$

Grating constant d (Reciprocal of no. of lines/inch,
d = 1/no. of lines per inch)

1. For 200 lines
$= 2.54 \times 10^{-2} / 200 = 1.27 \times 10^{-4}$ meters
2. For 500 lines
$= 2.54 \times 10^{-2} / 500 = 5.08 \times 10^{-5}$ meters

Diagram: Process of Diffraction using Grating



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8. Determination of the Wavelength of a Given Laser Source using a Diffraction Grating

Aim: To determine the wave length of the given laser light using diffraction grating of known grating constant.

Apparatus and Components needed:

Laser source (a laser pointer), Mount and stand for the laser, grating, scale and a screen.

Theory: A plane diffraction grating is an optical glass plate containing a large number of parallel equidistant slits of the same width. If the width of each transparent portion be 'a' and each opaque portion be 'b', then $d = a+b$ is called grating constant. It is the reciprocal of the number of lines per unit length (N) of grating.

When a beam of monochromatic light falls normally on the grating surface, its wavelength λ is calculated using the formula,

$$d \sin\theta = n\lambda \quad \text{----- (1)}$$

where $d = [1/N]$ is the grating constant, θ is the angle of diffraction and n is the order of spectrum.

In this equation all the terms except θ are constant. The angle θ can be measured by measuring the distance between source and image and distance between the consecutive maximums. Different orders

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Observations:

Trial 1: The distance between the screen and the grating, f = 1 m

Diffraction order, n	Distance, $2X_n$ (m)	Distance, X_n (m)	Diffraction angle $\theta_n = \tan^{-1}(X_n/f)$	Wavelength λ (nm)
1	2.6×10^{-2}	0.013	0.744	659
2	6.3×10^{-2}	0.0265	1.517	672
3	7.9×10^{-2}	0.0395	2.262	668
4	10.4×10^{-2}	0.052	2.976	659

Mean value of λ = 665.4 nm

Trial 2: The distance between the screen and the grating, f = 1.5 m

Diffraction order, n	Distance $2X_n$ (m)	Distance, X_n (m)	Diffraction angle $\theta_n = \tan^{-1}(X_n/f)$	Wavelength λ (nm)
1	3.8×10^{-2}	0.019	0.725	642
2	6.3×10^{-2}	0.039	1.489	660
3	11.8×10^{-2}	0.059	2.252	665
4	15.5×10^{-2}	0.0775	2.957	655

Mean value of λ : 655.5 nm

Mean value of λ of trial 1 and trial 2 : $\frac{665.4 + 655.5}{2}$ = 660.45 nm

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of diffraction are the results of different incident angles θ. Hence, to specify order θ has been rewritten as θ_n, which indicate the diffraction angle for n-th order. Fig 1. indicates process of diffraction, using laser light and grating. The n^{th} order diffraction angle is given by

$$\theta_n = \tan^{-1}\left(\frac{X_n}{f}\right) \quad \text{----} \quad (2)$$

where X_n is the distance of n^{th} order diffraction pattern from the centre of the diffraction pattern and f is the distance between the screen and the grating. Substituting θ_n in eq (1), the wavelength λ can be calculated using the formula

$$\lambda = \frac{d \sin\theta_n}{n} \quad \text{----} \quad (3)$$

Procedure: The laser source is placed on a table and switched on. At about 1 to 2 meters away on the path of laser a white screen is placed. The laser beam is made to fall exactly at the centre of the screen.

The grating is placed on the grating stand close to the laser source and the diffraction pattern is observed. The distance between the grating and the screen is measured. Equally spaced diffracted laser light spots will be observed. The total number of spots are counted. The distance between consecutive orders of diffraction is measured using a scale and tabulated. Using eq (2) diffraction angles are calculated for each order of diffraction.

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Calculation: Trial 1 : $\theta_n = \tan^{-1}(X_n/f)$

$\theta_1 = \tan^{-1}\left(\frac{0.013}{1}\right) = 0.744$ $\theta_3 = \tan^{-1}\left(\frac{0.0395}{1}\right) = 2.262$

$\theta_2 = \tan^{-1}\left(\frac{0.0265}{1}\right) = 1.517$ $\theta_4 = \tan^{-1}\left(\frac{0.052}{1}\right) = 2.976$

$$\lambda_n = \frac{d \sin\theta_n}{n}$$

$\lambda_1 = 5.08 \times 10^{-5} \sin(0.744)/1 = 6.59 \times 10^{-7}$ m
$\lambda_2 = 5.08 \times 10^{-5} \sin(1.517)/2 = 6.72 \times 10^{-7}$ m
$\lambda_3 = 5.08 \times 10^{-5} \sin(2.262)/3 = 6.68 \times 10^{-7}$ m
$\lambda_4 = 5.08 \times 10^{-5} \sin(2.976)/4 = 6.69 \times 10^{-7}$ m

Mean value : $\lambda = 6.654 \times 10^{-7}$ m

Trial 2 : $\theta_n = \tan^{-1}(X_n/f)$

$\theta_1 = \tan^{-1}\left(\frac{0.019}{1.5}\right) = 0.725$ $\theta_3 = \tan^{-1}\left(\frac{0.059}{1.5}\right) = 2.252$

$\theta_2 = \tan^{-1}\left(\frac{0.039}{1.5}\right) = 1.489$ $\theta_4 = \tan^{-1}\left(\frac{0.0775}{1.5}\right) = 2.957$

$$\lambda_n = \frac{d \sin\theta_n}{n}$$

$\lambda_1 = 5.08 \times 10^{-5} \sin(0.725)/1 = 6.42 \times 10^{-7}$ m
$\lambda_2 = 5.08 \times 10^{-5} \sin(1.489)/2 = 6.60 \times 10^{-7}$ m
$\lambda_3 = 5.08 \times 10^{-5} \sin(2.252)/3 = 6.65 \times 10^{-7}$ m
$\lambda_4 = 5.08 \times 10^{-5} \sin(2.957)/4 = 6.55 \times 10^{-7}$ m

Mean value : $\lambda = 6.555 \times 10^{-7}$ m

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The wavelength is calculated in each case using eq(3). The average value of wavelength is calculated The experiminent is repeated for another distance between the screen and grating.

Result: The wavelength of the given laser source = 660.45 nm

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16/10/2018

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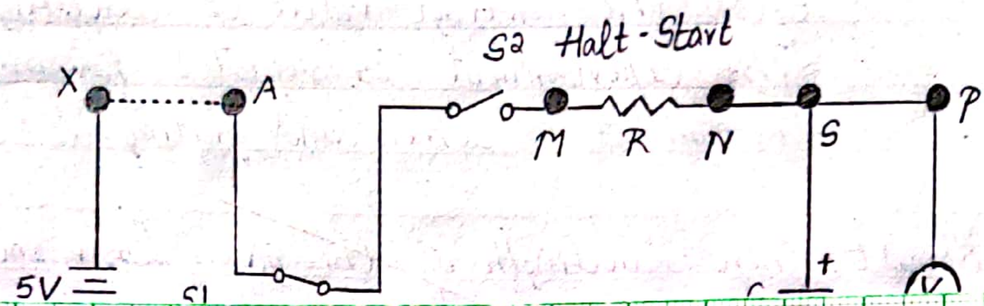
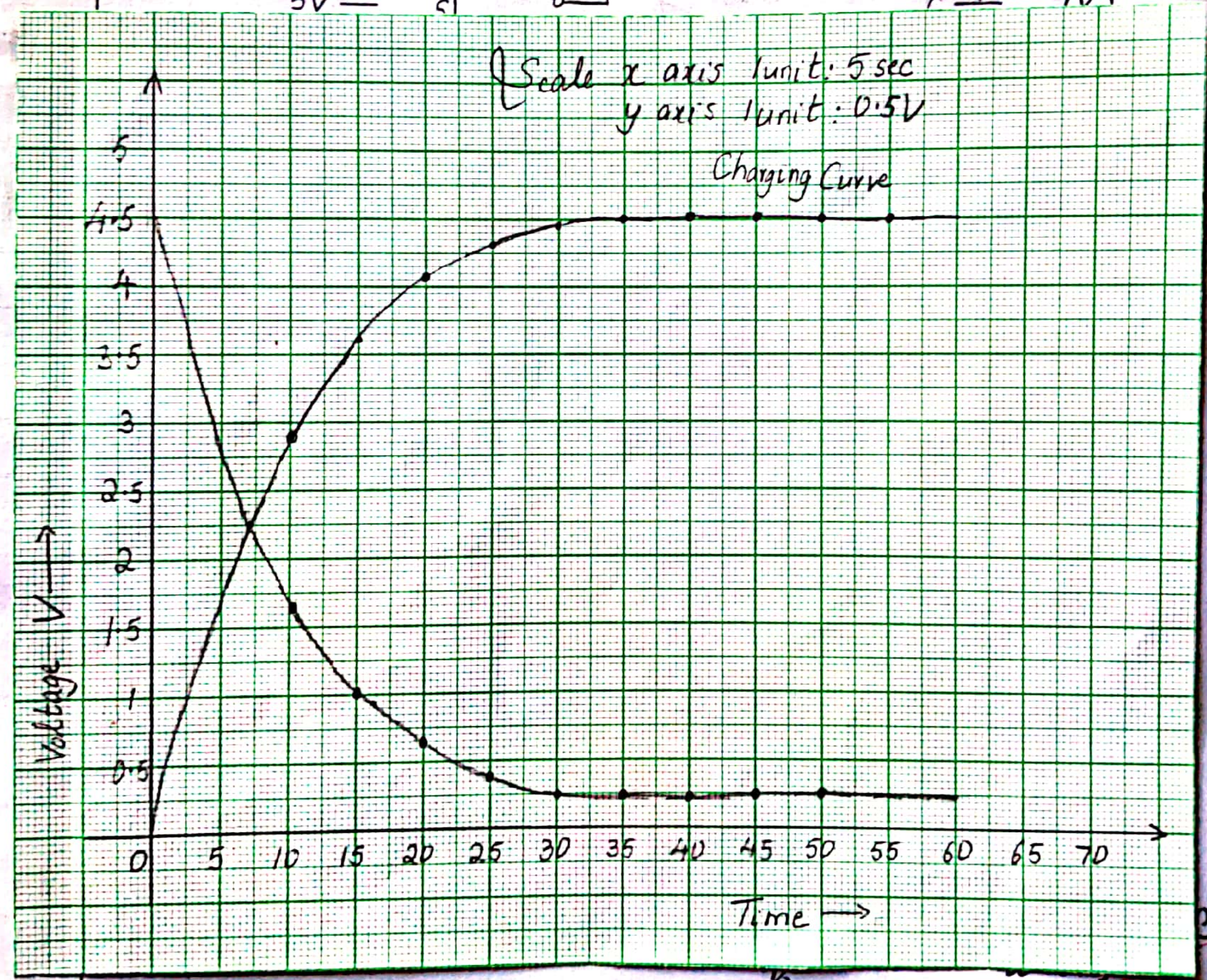
Circuit diagram:





$$\frac{{}_{1/2}}{\varepsilon_0 AR}$$

d is distance between the plates, A is the area of the plates $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m is the permittivity of free space, R is the resistance of the resistor used in the circuit in Ω and $T_{\frac{1}{2}}$ is time in seconds.

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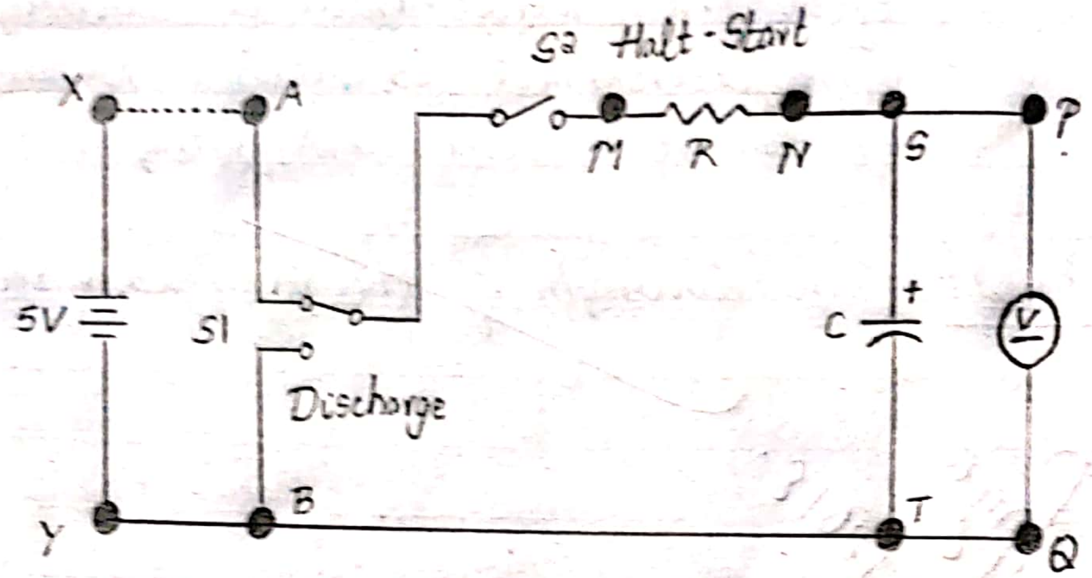
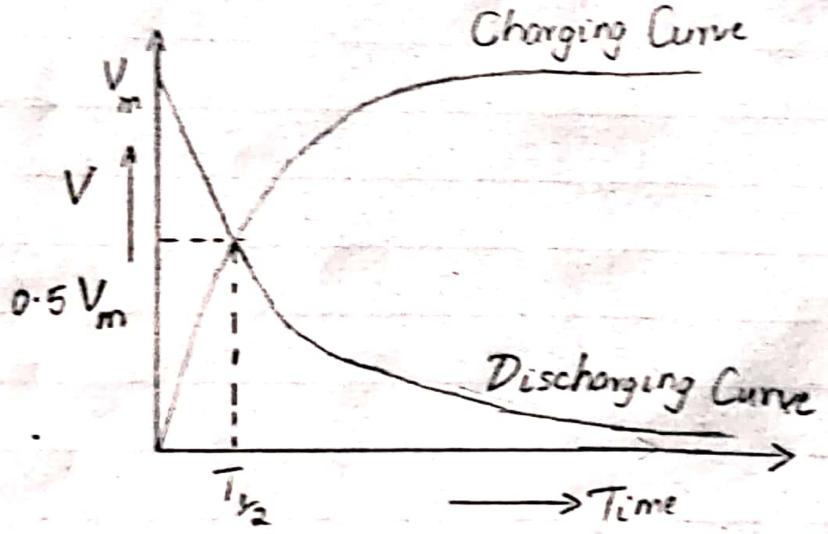
Circuit diagram:



Nature of Graph:



Formula: The dielectric constant (k) of the material of the dielectric used in the capacitor is determined using the relation $k = \frac{1.44\, T_{1/2} \times d\, 10^{-6}}{\varepsilon_0 A R}$ where,

d is distance between the plates, A is the area of the plates $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m is the permittivity of free space, R is the resistance of the resistor used in the circuit in Ω and $T_{1/2}$ is time in seconds.

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Observations: Table 1 - Physical dimensions of capacitor

Capacitor	C1	C2	C3
Length (mm)	47	114	183
Breadth (mm)	5	5	6
Separation (mm)	0.075	0.075	0.075

Table 2:

Time (sec)	Voltage (volts)					
	C_1 = R=100k Ω		C_2 = R=100kΩ		C_3 = R=100kΩ	
	Charging	Discharging	Charging	Discharging	Charging	Discharging
0	0	4.59	0	4.31	0	3.33
5	1.92	2.72	0.88	3.68	0.45	2.93
10	2.97	1.65	1.62	2.94	0.87	2.64
15	3.6	1.01	2.34	2.23	1.23	2.38
20	4.05	0.55	2.79	1.78	1.63	2.09
25	4.26	0.33	3.14	1.43	1.92	1.89
30	4.39	0.21	3.43	1.09	2.18	1.71
35	4.47	0.11	3.70	0.87	2.41	1.54
40	4.52	0.07	3.87	0.70	2.66	1.36
45	4.65	0.04	4.01	0.53	2.85	1.22
50	4.57	0.02	4.15	0.43	3.01	1.11
55	4.58	0.02	4.23	0.34	3.20	0.98
60	4.59	0.01	4.31	0.28	3.33	0.86

Calculation: K for C_1: $K = \dfrac{1.44 \times 7 \times 0.075 \times 10^{-3} \times 10^{-6}}{8.854 \times 10^{-12} \times 47 \times 10^{-3} \times 5 \times 10^{-3}}$

$= \dfrac{0.756 \times 10^{-9}}{2080.69 \times 10^{-16}} = 0.000363 \times 10^{7} = \underline{3.63}$

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Observations: Table 1 - Physical dimensions of capacitor

Capacitor	C1	C2	C3
Length (mm)	47	114	183
Breadth (mm)	5	5	6
Separation (mm)	0·075	0·075	0·075

Table 2:

Time (sec)	Voltage (volts)					
	C_1 = R=100k Ω		C_2 = R=100k Ω		C_3 = R=100k Ω	
	Charging	Discharging	Charging	Discharging	Charging	Discharging
0	0	4·59	0	4·31	0	3·33
5	1·92	2·72	0·88	3·68	0·45	2·93
10	2·97	1·65	1·62	2·94	0·87	2·64
15	3·6	1·01	2·34	2·23	1·23	2·38
20	4·05	0·55	2·79	1·78	1·63	2·09
25	4·26	0·33	3·14	1·43	1·92	1·89
30	4·39	0·21	3·43	1·09	2·18	1·71
35	4·47	0·11	3·70	0·87	2·41	1·54
40	4·52	0·07	3·87	0·70	2·66	1·36
45	4·65	0·04	4·01	0·53	2·85	1·22
50	4·57	0·02	4·15	0·43	3·01	1·11
55	4·58	0·02	4·23	0·34	3·20	0·98
60	4·59	0·01	4·31	0·28	3·35	0·86

Calculation: K for C_1 : $K = \dfrac{1{\cdot}44 \times 7 \times 0{\cdot}075 \times 10^{-3} \times 10^{-6}}{8{\cdot}854 \times 10^{-12} \times 47 \times 10^{-3} \times 5 \times 10^{-3}}$

$= \dfrac{0{\cdot}756 \times 10^{-9}}{2080{\cdot}69 \times 10^{-16}} = 0{\cdot}000363 \times 10^{7} = \underline{3{\cdot}63}$

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voltage across the capacitor. The readings obtained are noted in Table-2.

7. Trial is repeated until the capacitor is charged to 4.5 Volts. In each case the capacitor voltage is noted at an interval of 5 seconds and noted in Table 2

8. When the capacitor is charged to maximum voltage, the charging is stopped and the charge discharge switch is thrown to discharge position and clock is reset.

9. The voltage across the discharging capacitor is noted after 5 seconds interval by stopping clock after five seconds. This is done until the capacitor is discharged fully

10. Experiment is repeated for different capacitance values. And the corresponding readings are noted in Table 2

11. A graph is drawn taking time on X-axis and voltage along the Y-axis as shown. The charging and discharging curve intersects at a point P, where the voltage across the capacitor during charging and discharging remains the same. The time at which voltage across the capacitor during charging and discharging is noted..

Result :

Parameters	C_1
$T_{1/2}$ (sec)	
$C_1 = 7.5$	7.5
Capacitance (μF)	
$C_1 = 27$	27
k ($k_1 = 3.2$)	3.63

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Formula: Young's Modulus of the given material of the beam.

$$Y = \frac{3mgxl^2}{2bd^3\delta} \ Nm^{-2}$$ where,

Y = Young's Modulus of the material of the beam (N/m^2).

m = Mass kept either side of the scale pans

x = is the distance between knife edge and the point of suspension of the nearer scale pan

b = Breadth of the beam (m)

d = Thickness of the beam (m)

δ = Mean value

Observations:

Thickness of the beam (d) = 0.535 cm (given).

Breadth of the beam (b) = 2.55 cm (given)

Least Count of the Travelling Microscope =

$$LC = \frac{\text{Smallest division the main scale}}{\text{Total number of divisions on the vernier scale}}$$

$$= \frac{0.5}{50} \text{ cm} = 0.001 \text{ cm}$$

Distance between two knife edges (l) = 50×10^{-2} m

Distance between the weight hanger and any one of the adjacent knife edge $x = 15 \times 10^{-2}$ m

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10. Young's Modulus By Uniform Bending

Aim: To determine the Young's modulus of the material (wooden scale) of the given beam by uniform bending

Apparatus and Components needed:
Travelling microscope, Two knife edge supports, two weight hangers, slotted weights, Pin, Screw gauge, Vernier Calipers.

Theory: Young's modulus is named after Thomas Young, a British scientist. Young's modulus is defined as the ratio of the longitudinal stress over longitudinal strain, in the range of elasticity the Hook's law holds. It is measure of stiffness of elastic material. If a wire of length 'L' and area of cross section 'a' be stretched by a force 'F' and if a change of length 'l' is produced then,

Young's Modulus = Normal Stress / Longitudinal strain

$= F/a \quad l/L$

Procedure: The given beam is placed over the two knife edges at a distance of 50 cm (l). Two weight hangers are suspended, one each on either side of the knife edge at equal distance (x = 15 cm) from the knife edge. Since the load is applied at both paints of the beam, the bending is uniform throughout the beam and the bending of the beam is called Uniform Bending. A pin is fixed vertically exactly at the centre of the beam.

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Tabular Column:

Load m_1 (gm)	Reading of T.M: Load Increasing MSR (cm)	CVD	TR (cm) I	Load Decreasing MSR (cm)	CVD	T.R (cm) D	Mean (I+D)/2 (cm) R_1	Load m_2 (gm)	Reading of T.M: Load Increasing MSR (cm)	CVD	TR (cm) I	Load Decreasing MSR (cm)	CVD	TR (cm) D	Mean (I+D)/2 (cm) R_2	Elevation $S = R_1 \sim R_2$ (cm)
00	7.65	30	7.653	7.6	46	7.654	7.655	150	7.9	46	7.904	7.9	32	7.903	7.903	0.248
50	7.8	35	7.803	7.8	37	7.803	7.803	200	8.0	48	8.00	8.0	20	8.003	8.003	0.200
100	7.85	42	7.854	7.85	30	7.853	7.853	250	8.15	49	8.154	8.15	49	8.154	8.154	0.32

Mean $S = 0.249 \times 10^{-2}$ meters

Calculations:

$$Y = \frac{3mgxl^2}{2bd^3S} \ Nm^{-2}$$

$$= \frac{3 \times 10 \times 1}{2 \times 2.55 \times 10^{-2} \times (0.535 \times 10^{-2})^3 \times 0.2497}$$

$$= 0.8506 \times 10^{10} \ N/m^2$$

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DD MM YYYY

A travelling microscope is placed in front of this arrangement. Taking the weight hangers alone as the dead load, the tip of the pin is focused by the microscope and is adjusted in such a way that the tip of the pin just touches the horizontal cross wire. The reading on the vertical scale of the travelling microscope is noted.

Now equal weights are added on both weight hangers in steps of 50gms. Each time the position of the pin is focused and the readings are noted from the microscope. The procedure is followed until the maximum load is reached. The same procedure is repeated by unloading the weight from both the weight hangers in steps of same 50grams and the readings are tabulated in the tabular column. The thickness and the breadth of the beam are measured using screw gauge and vernier calipers respectively and are tabulated. By substituting all the values in the given formula, the Young's modulus of the given material of the beam can be calculated.

Result: The Young's modulus of the material (wood) of the given beam by uniform bending method is

$Y = 0.8506 \times 10^{10}\ N/m^2$

Priya

4/12

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