20DCS103 - Rushik . Rathod .

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* **Experiment 1(a) : Measurement of self-inductance by Maxwell's bridge.**

→ Objectives : Measurement of self-inductance by Maxwell's bridge.

→ Apparatus : Maxwell's inductance bridge trainer kit. DC supply

→ Procedure :

1. Connect all the components and the air cored coil as shown in the diagram.

2. Set the product of R_2R_3 at a convenient value and obtain the balance by varying R_1 and C_1.

3. Decide the ranges for R_1 and C_1 through which they can vary.

4. Repeat the procedure with different values of the product R_2R_3 and decide upon readings that permit maximum accuracy for the measurement.

→ Precaution :

1. Connections should be tight.

2. Instrument should be handled carefully.

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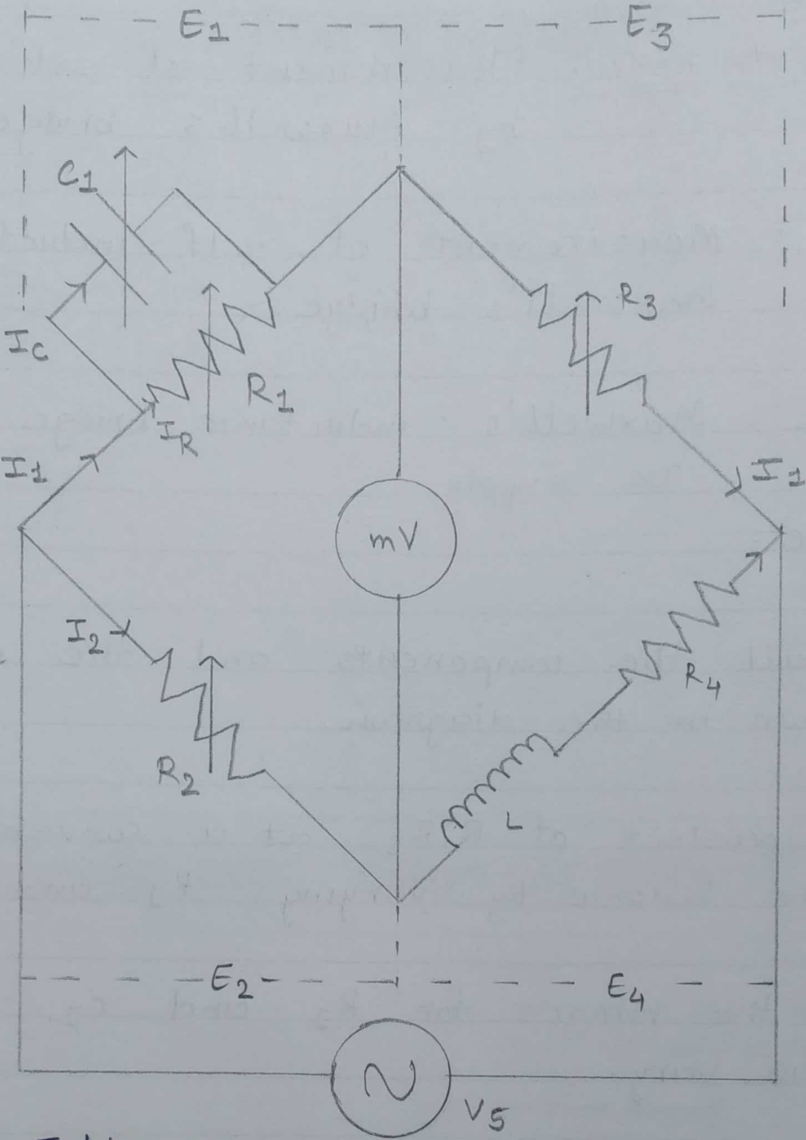
→ Diagram :



Here,

L = Unknown inductance

R_4 = Effective resistance of unknown inductance coil.

R_1, R_2, R_3 = known non-inductive resistance.

C_1 = Standard variable capacitor

→ Observation Table :

Sr. No.	R_2	R_3	C_1	$L_1 = \frac{R_3 L_2}{R_4}$	True value of L_1
1	0.937	0.920	0.1	1.018	1 mH
2	0.938	0.980	0.1	9.56	10 mH
3	0.936	0.978	0.1	95.8	100 mH

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→ Calculations :- From the formula $L_1 = \frac{L_2 R_3}{R_4}$;

1. $L_3 = \frac{R_3 \cdot L_2}{R_4} = \frac{0.920 \times 10^{-1} \times 1.31 \times 10^{-1}}{0.937 \times 10^{-1}}$

$= 1.018$ mH.

2. $L_3 = 95.80$ mH

3. $L_3 = 9.56$ mH.

→ Conclusion :-

→ Actual and practical values of inductances are found to be nearly equal.

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* **Experiment 1(b)** : To determine the capacitance of an unknown capacitor.

→ Objectives : To determine the capacitance of an unknown capacitor by schering bridge.

→ Apparatus :

→ Procedure :

1. Apply supply voltage from the signal generator with arbitrary frequency. ($V = 3V$). Also, set the unknown capacitance value from 'set capacitor value' tab.

2. Then switch on the supply to get millivolt meter deflection.

3. Choose the values of C_2, C_4, C_3 and R_4 from the capacitance and resistance box. Vary the values to some particular values to achieve 'NULL'.

4. Observe the millivolt meter pointer to achieve 'NULL'.

5. If 'NULL' is achieved, switch to 'Measure Capacitor Value' tab and click on 'Simulate'. Observe the calculated values of unknown capacitance (C_1) and it's internal resistance (r_1).

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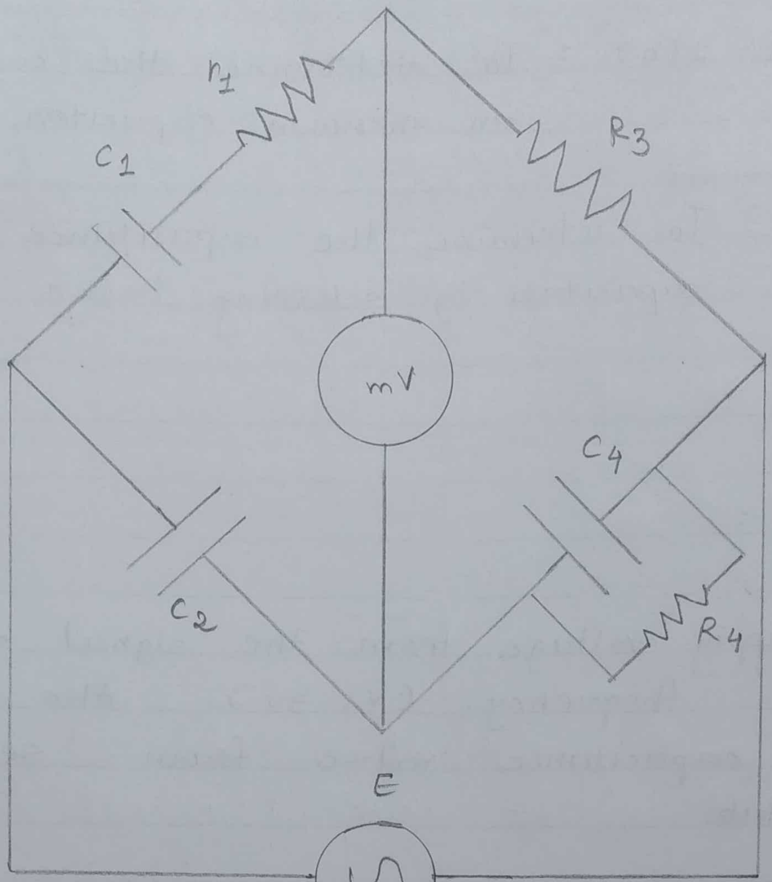
→ Diagram :



C_1 = capacitor whose capacitance is to be measured

r_1 = a series resistance representing the loss in the capacitor C_1.

C_2 = a standard capacitor

R_3 = a non-inductive resistance

C_4 = a variable capacitor

R_4 = a variable non-inductive resistance.

→ Observation Table :

Sr No.	C_4 (μF)	C_1 (μF)	C_2 (μF)	R_3 (kΩ)	R_4 (kΩ)
1	0.005	0.01	0.045	4	8
2	0.018	0.02	0.039	6.5	7
3	0.0244	0.03	0.023	8	10

6. Also observe the dissipation factor of the unknown capacitor which is defined as $\omega C r$. Where, $\omega = 2\pi f$.

→ Precautions :-

1. Connections should be tight.
2. Instrument should be handled carefully.

→ Calculations :-

1). $C_4 = C_1 \cdot \frac{R_3}{R_4} = \frac{0.01 \times 4}{8} = 0.005 \ \mu F.$

2) $C_4 = C_1 \cdot \frac{R_3}{R_4} = \frac{0.02 \times 6.5}{7} = 0.018 \ \mu F.$

3) $C_4 = C_1 \cdot \frac{R_3}{R_4} = \frac{0.03 \times 8}{10} = 0.024 \ \mu F.$

→ Conclusion :-

→ The balanced condition of schering bridge is obtained and unknown value of capacitance is found.

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* Experiment 2 : Study of Resonance in LCR circuit.

→ **Objectives** : To study series and parallel resonance in LCR circuit and damping effect by using resistances and air core inductance with metal.

→ **Apparatus** : LCR circuit kit, connecting wires

→ **Procedure** :

1. To plot the series resonance curve in LCR circuit (air core inductance, two decade condensers and circuit resistance) at fixed frequency by varying condenser (c). Observe the damping by a metal [ferromagnetic] plate along with air core inductance, find out new resonance curve by varying condenser (c).

2. To plot the series resonance curve in LCR circuit by varying frequency. Observe damping by a metal plate along with air core inductance, find out new resonance curve by varying frequency (f).

3. To plot the parallel resonance curve in LCR circuit [air core inductance , two decade

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condensers and circuit resistance] at fixed frequency by varying condenser (c). Observe damping by a metal [ferromagnetic] plate along with air core inductance, find out new resonance curve by varying condenser (c).

4. To plot the parallel resonance curve in LCR circuit by varying frequency. Observe damping by a metal plate along with air core inductance, find out new resonance curve by varying frequency (f).

5. To plot the series resonance curve in LCR circuit by varying frequency. Observe damping effect by using resistance.

→ Observations :

Graph:- A graph is drawn for current against frequency. The frequency corresponding to maximum current is noted and it is resonant frequency f_0. The frequencies f_1 and f_2 corresponding to half power points is noted and from it the bandwidth, $(f_1 - f_2)$ is noted. From the values of f_0, f_1 and f_2, the quality factor, Q is calculated.

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→ Diagram :

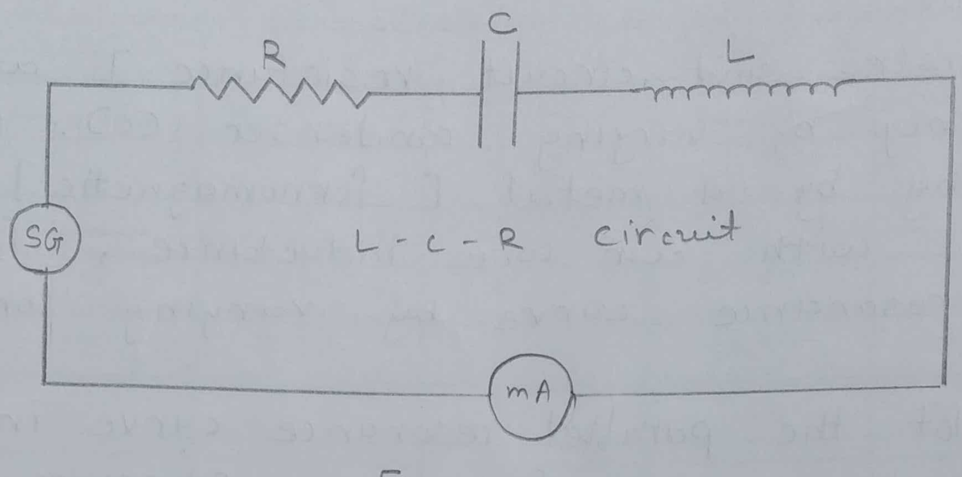

Fig. 1

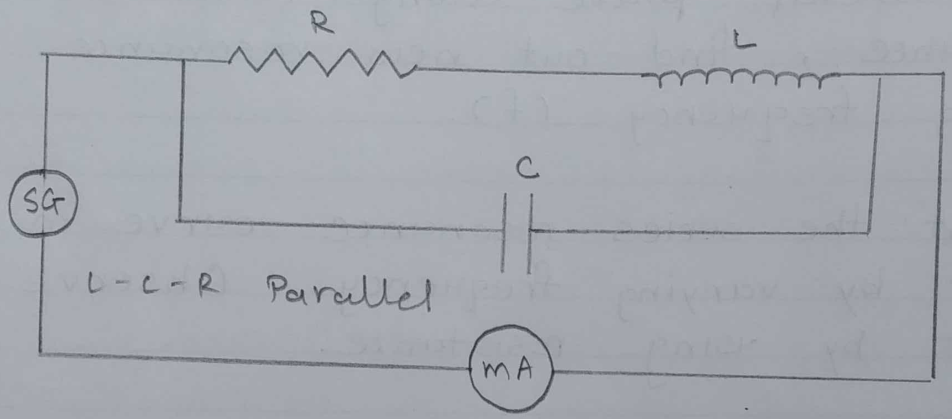

Fig. 2

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→ Observation Table :

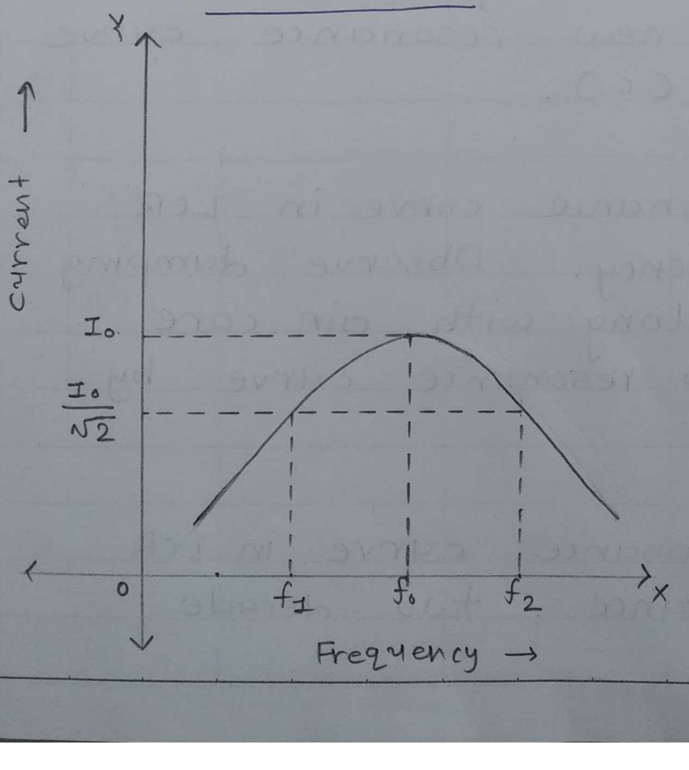
Table : 1

Sr. No.	Frequency (Hz)	Current (mA)
1	29	221
2	30	226
3	31	233
4	32	241
5	33	245

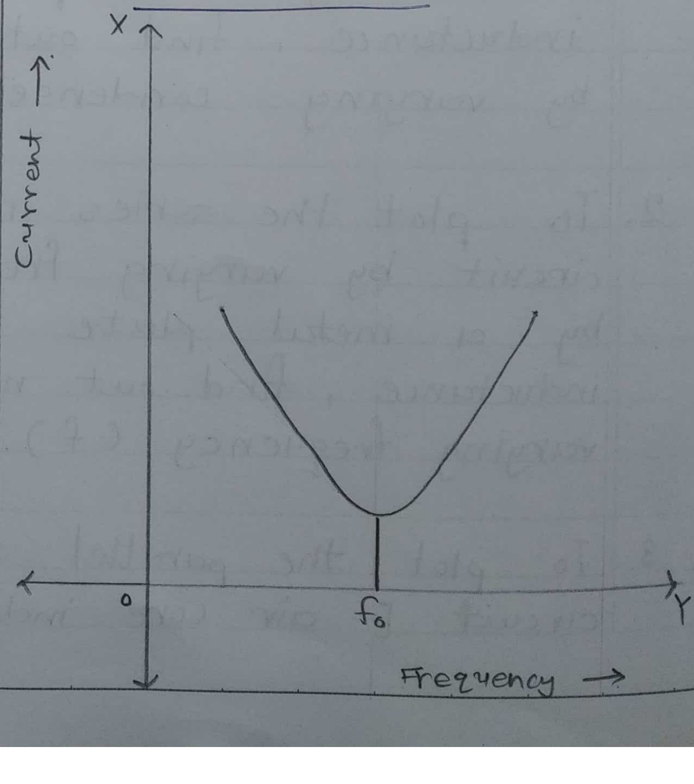
Table : 2

Sr. No.	Frequency (Hz)	Current (mA).
1	1000	11
2	2000	9
3	3000	7.5
4	4000	8.3
5	5000	10.1

LCR series



LCR Parallel



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→ For L-C-R parallel, the circuit is connected as shown in the figure - 2. The frequency of the signal generator is changed in steps and the corresponding current values are noted from the a.c. milli-ammeter. The readings are tabulated. But here, the current values decrease with the increase of frequency up to the anti-resonant frequency, further increase of frequency causes the increase of current. The anti-resonant frequency f_0 is noted corresponding to the minimum current in the circuit.

→ Conclusion :

→ Introducing the resistor increases the decay of oscillations, which is called damping. The resistor also reduces the peak resonant frequency.

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* Experiment 3 : Time constants of an RC circuit.

→ Objectives : To measure the time constant of an RC circuit experimentally and to verify the results againsts the values obtained by theoretical calculations.

→ Apparatus : Digital Multimeter DC power supply alligator [clips] jumper resistor : 20 kΩ capacitor : 2200 μF [rating = 50 V or more]

→ Procedure :

1. Construct the circuit in figure. Let R = 20 kΩ, C = 2,200 μF C rating = 50 V or more), V_S = 35 V. Use an alligator lead jumper as the short circuit across the capacitor.

2. Record the initial current reading of the milliameter, it should be closed to " full-scale " for a digital meter on the 2 mA range [I = (35 V / 20 kΩ)], Express the current in units of mA. Write the value in Table 10-1, for t = 0, columns Trial One and Trial Two.

3. Calculate the values of τ and 5τ. Recall that it takes a time of 5τ for a capacitor to

substantially reach fully charge. You may need to extend your data table to ensure that data is taken for a time of no less than 5τ.

4. Now get ready to collect the data. This is best done with your partner, but can be done successfully by one person. You will need a stopwatch [you can use your phone], or an analog clock with a school hand.

5. The instant you remove the alligator jumper, the current [which had been flowing through the jumper] flows through the capacitor. This is time = 0, and you will begin recording data every 15 seconds after that instant.

6. Every 15 seconds, record the current under the Trial One column in Table 10-1, until you have reached 5τ or beyond.

7. Now repeat steps 4 to 6 under Trial 2. Be sure to replace the alligator jumper before starting Trial Two. There will be a significant spark the moment you put the jumper across the capacitor, resulting from the rapid discharge of the energy stored in the capacitor, which brings its voltage back to 0 volts.

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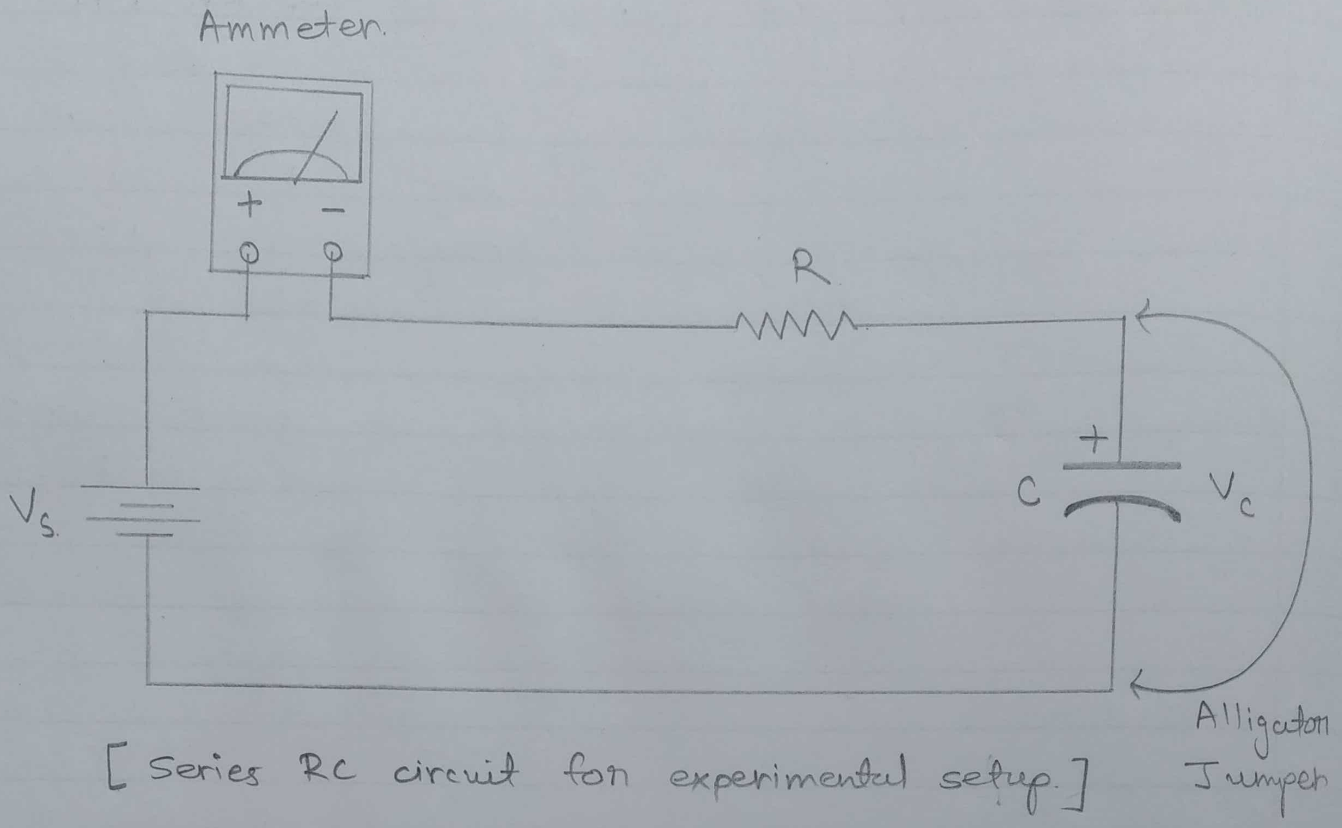
→ Diagram :



[Series RC circuit for experimental setup.]

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→ Observation Table :

τ = 15 second   Initial Current = 2 mA

5τ = 75 second

Time (min : sec)	Current (mA)			Resistor Voltage (V_R)	Capacitor Voltage (V_c)
	Trial : 1	Trial : 2	Average		
0:00	2	4	03	0	6
0:15	1.8	1.9	1.85	2	4
0:30	1	0.5	0.75	4	2
0:45	0.1	0.1	0.1	6	0
1:00	0	0	0	6	0
1:15	0	0	0	6	0
1:30	0	0	0	6	0
1:45	0	0	0	6	0

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8. The results of Trial One and Trial Two will then be averaged, because obtaining accurate repeatable readings when the current is changing is difficult.

9. Average the currents [Trial One and Trial Two] for each row in the data-table, and enter that average current in the table. At each time in the table using the average current at that time, calculate the resistor voltage using $V_R = IR$ [ohm's law]. Be sure to use the measured value of R.

10. Now for each time in the table using the calculated resistor voltage, calculate the capacitor voltage using $V_C = V_S - V_R$. Be sure to use the measured value of R. This is just Kirchoff's voltage law applied: The sum of the resistor voltage and the capacitor voltage must equal the source voltage.

→ Conclusion :-

→ As time constant increases, the voltage reaches the maximum voltage of the capacitor.

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Exp :- 3

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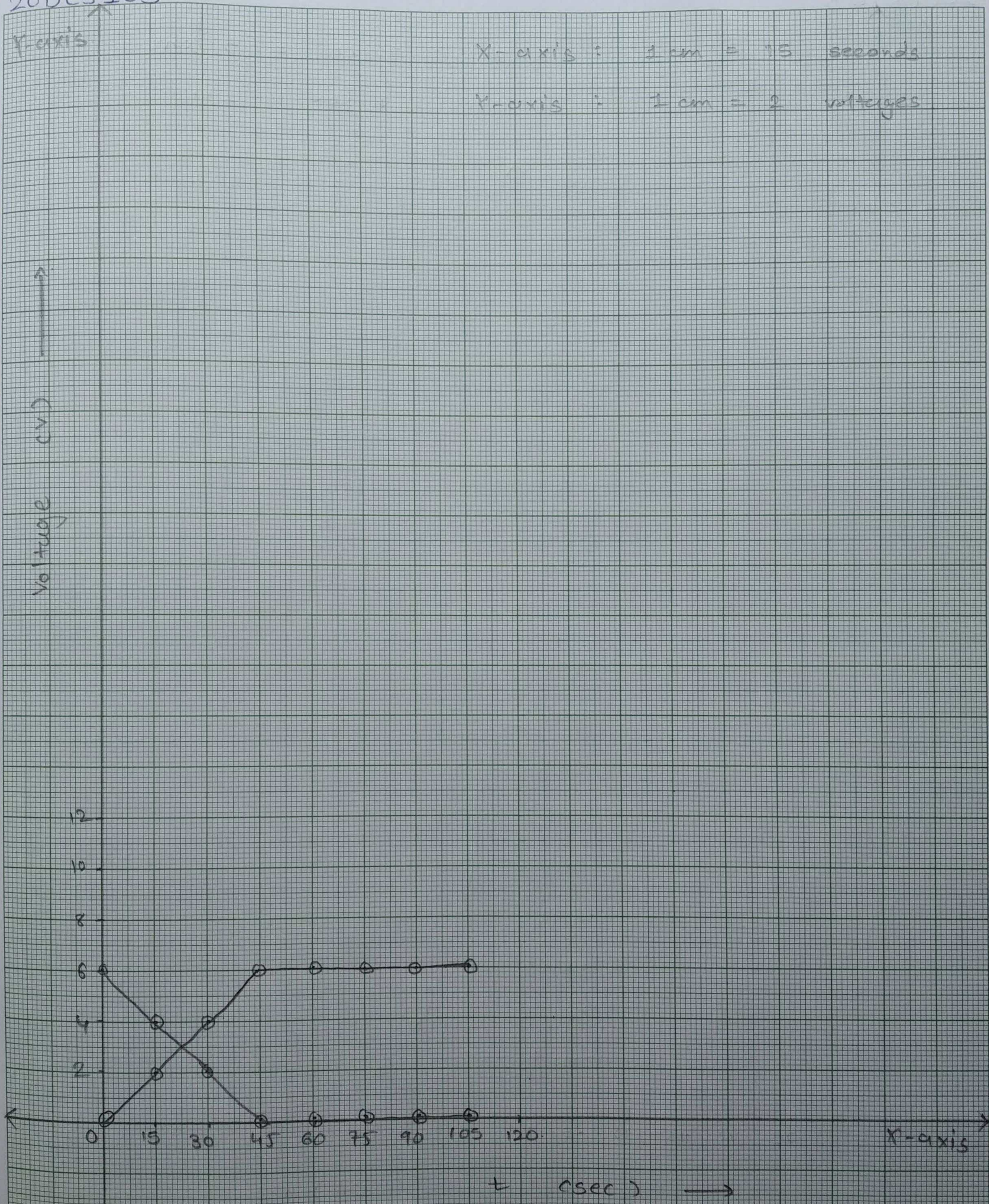
X-axis : 1 cm = 15 seconds

Y-axis : 1 cm = 2 voltages



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* Experiment 4 : Study of the variation of Magnetic Field.

→ Objectives : To study the variation of magnetic field at the centre of circular coils when turns remain same and RADII vary.

→ Apparatus : Variation of magnetic field at the centre of circular coils when turns remain same and radii vary, Battery eliminator, Ammeter, Reversing key, Spirit level.

→ Procedure :

1. To find the magnetic field.

2. The connections are made as shown in the diagram and the initial adjustments of the apparatus are made as follows :

3. First, the coil is fixed at the middle of the platform and the compass box is placed at the centre of the coil.

4. The compass box is rotated till the 90 - 90 line becomes parallel to the plane of the coil.

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5. Then the apparatus as a whole is rotated till the aluminium pointer reads 0-0.

6. Close the circuit.

7. Adjust the rheostat until the deflection lies between 30 and 60 degrees. Note down the deflection of the compass needle and the current.

8. Then current through the coil is reversed using the commutator and again the deflection and current are noted.

9. Average the magnitude of the two deflections and calculate the magnetic field at the centre of the coil from the equation.

10. Without changing the current or the number of turns, place the compass box at a particular distance from the centre of the coil. Note the deflection. Again reverse the current and average the magnitudes of the two deflections. Note the average and the distance.

11. The same procedure is repeated with the compass box at the same distance on the other side of the arm, keeping number of turns and current constant.

12. Take the average of the two values of θ measured on opposite sides of the coil.

13. Then calculate the magnetic field B_x from the coil using equation (3).

14. Repeat for various distances.

15. Draw graph of B_x on the vertical axis vs. distance x on the horizontal axis.

16. To plot the graph between distance and magnetic field intensity:

→ Precautions :-

1. There should be no magnet, magnetic substances and current carrying conductor near the apparatus.

2. The plane of the coil should be set in the magnetic medium.

3. The current should remain constant and should be reversed for each observation.

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→ Observations :

$B_0 = 3.5 \times 10^{-5}$ T

Current $I = 1$ A

No: of turns of the coil, $n = 10$

Radius of the circular coil, $r = 8$ cm

→ Observation Table :

Distance from the centre x (cm)	Deflection with compass box on left side				Deflection with compass box on right side				Mean θ [degrees]	B_x (T) (10^{-5})	$B_0 = \frac{B_x}{\tan\theta}$ (T) (10^{-5})
	Direct		Reversed		Direct		Reversed				
	θ_1	θ_2	θ_3	θ_4	θ_1	θ_2	θ_3	θ_4			
0	67	67	67	67	67	67	67	67	67	8.23	7.85156
5	54	54	54	54	54	54	54	54	54	4.83	4.78786
10	29	29	29	29	29	29	29	29	29	1.93	1.91408
15	14	14	14	14	14	14	14	14	14	0.84	0.818237
20	7	7	7	7	7	7	7	7	7	0.42	0.402206
25	4	4	4	4	4	4	4	4	4	0.245	0.222278
-5	54	54	54	54	54	54	54	54	54	4.83	4.78786
-10	29	29	29	29	29	29	29	29	29	1.93	1.91408
-15	14	14	14	14	14	14	14	14	14	0.84	0.818237
-20	7	7	7	7	7	7	7	7	7	0.42	0.402206
-25	4	4	4	4	4	4	4	4	4	0.245	0.222278

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→ Calculations :-

1. $B_0 = \frac{B_x}{\tan\theta} = \frac{8.23 \times 10^{-5}}{\tan 67^\circ} = 7.85156 \times 10^{-5}$ T.

2. $B_0 = \frac{B_x}{\tan\theta} = \frac{4.83 \times 10^{-5}}{\tan 54^\circ} = 4.78786 \times 10^{-5}$ T.

3. $B_0 = \frac{B_x}{\tan\theta} = \frac{1.93 \times 10^{-5}}{\tan 29^\circ} = 1.91408 \times 10^{-5}$ T

4. $B_0 = \frac{B_x}{\tan\theta} = \frac{0.84 \times 10^{-5}}{\tan 14^\circ} = 0.818237 \times 10^{-5}$ T

5. $B_0 = \frac{B_x}{\tan\theta} = \frac{0.42 \times 10^{-5}}{\tan 7^\circ} = 0.402206 \times 10^{-5}$ T

6. $B_0 = \frac{B_x}{\tan\theta} = \frac{0.245 \times 10^{-5}}{\tan 4^\circ} = 0.222278 \times 10^{-5}$ T.

7. $B_0 = \frac{B_x}{\tan\theta} = \frac{4.83 \times 10^{-5}}{\tan 54^\circ} = 4.78786 \times 10^{-5}$ T

8. $B_0 = \frac{B_x}{\tan\theta} = \frac{1.93 \times 10^{-5}}{\tan 29^\circ} = 1.91408 \times 10^{-5}$ T

9. $B_0 = \frac{B_x}{\tan\theta} = \frac{0.84 \times 10^{-5}}{\tan 14^\circ} = 0.818237 \times 10^{-5}$ T

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10. $B_0 = \frac{B_x}{\tan\theta} = \frac{0.42 \times 10^{-5}}{\tan 7^\circ} = 0.402206 \times 10^{-5}$ T

11. $B_0 = \frac{B_x}{\tan\theta} = \frac{0.245 \times 10^{-5}}{\tan 4^\circ} = 0.2278 \times 10^{-5}$ T.

→ Conclusion :-

1. The intensity of magnetic field is maximum at the centre of magnetic field and goes on decreasing as we move away from the centre of the coil towards right or left.

2. The point on the both side of graph where curve becomes convex to concave are called the point of inflection. The distance between the two points of inflexion is equal to the radius of the circular coil.

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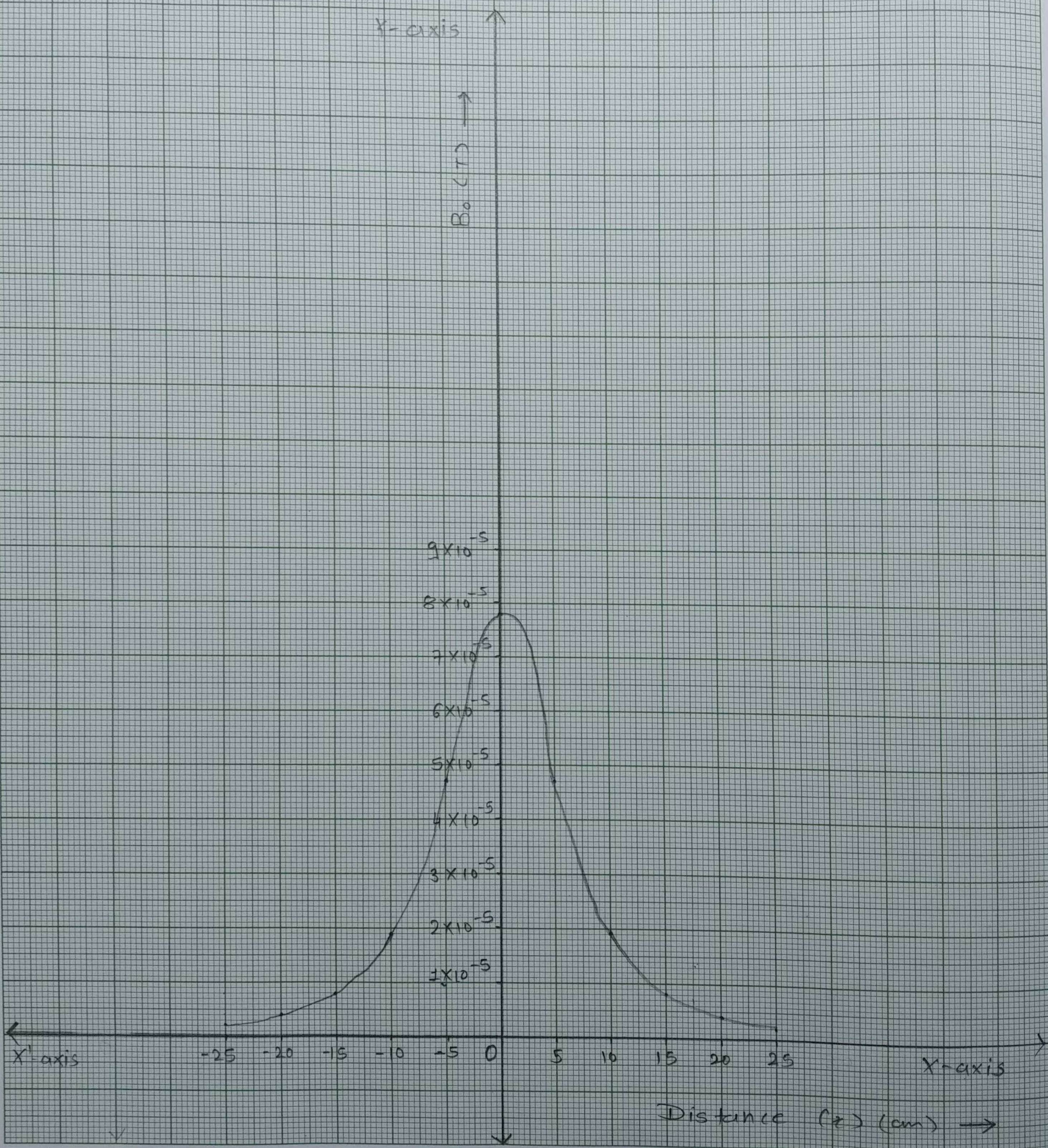
Exp :- 4

X- axis : 1 cm = 5 cm

Y- axis : 1 cm = 1×10^{-5} T



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* Experiment 5 : Quincke's Method

→ Objectives : To determine the mass susceptibility of paramagnetic solution by Quincke's method.

→ Apparatus : Quincke's tube fitted on stand, Electromagnetic capable of producing magnetic field of about 10 K gauss with power supply, Gaussmeter, Travelling microscope and experimental solutions.

→ Procedure :

The experimental solution is placed in a Quincke's tube consisting of a wide and narrow limb. The wide limb is placed outside the field and the narrow limb inside the magnetic field provided by an electromagnet as shown in the figure. The field varies rapidly along the vertical direction due to the wedging of the pole pieces. Thus, the force given by equation below on the specimen will be vertical.

1. Put the tube on stand and fix it with clamp.

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2. Insert the narrow limb of the Quincke's tube vertically between the pole pieces of the electromagnet such that the meniscus is in the central region of the uniform magnetic field or in the centre of the poles and the wide limb is placed outside the field as shown in figure.

3. Illuminate the meniscus level with an ordinary bulb and view it with a travelling microscope.

4. Adjust the horizontal cross wire of the eye piece of microscope on the meniscus and note this reading of the microscope. It will be the initial position of the meniscus. Record this reading in table as shown below.

5. Switch ON the electromagnet power supply and adjust the current say at 0 amp, bring the cross wire again on the meniscus and also record this reading in table by moving the microscope downwards.

6. Increase the power supply current in steps of 0.5 amp i.e. say 0.5, 1.0, 1.5, ..., 3.0 and note the corresponding position of the level of the liquid. Note all these readings in table.

7. Repeat the experiment for different concentration of the solution.

8. Finally, put the magnetic field sensor b/w pole pieces. Switch on gauss meter and read the magnetic field corresponding to each value of current and note it in the table.

→ Precautions :

1. Adjust the microscope to get clearer picture of meniscus.

2. Use lamp and magnifying glass while taking readings.

3. Let the liquid rise and become steady before taking readings of meniscus.

4. Draw best fit straight line while plotting rise in liquid level 'h' vs B1.

→ Calculations :

1. $h = |h_1 - h_2| = |6.624 - 6.652|$

$= 0.028$ cm

→ $\frac{h}{H^2} = \frac{0.028}{(1060)^2} = 2.49 \times 10^{-8} \frac{cm}{(kgauss)^2}$

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→ Observation Table :

Sr No.	Power Supply Current I (Amp)	Initial position of the meniscus h_1 (cm)	Final position of the meniscus h_2 (cm)	Change in height $h = (h_1 - h_2)$ cm	Magnetic Field B1 (k gauss)	B_1^2 (k gauss)^2
1	0.5	6.624	6.652	0.028	1060	2.49
2	1.0	6.624	6.770	0.146	1930	3.92
3	1.5	6.624	6.805	0.181	2760	2.38
4	2.0	6.624	6.972	0.348	3690	2.56
5	2.5	6.624	7.051	0.427	4170	2.46
6	3.0	6.624	7.203	0.579	5290	2.07

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2. $h = |h_1 - h_2| = |6.624 - 6.770|$

$= 0.146 \text{ cm}$

$\rightarrow \dfrac{h}{H^2} = \dfrac{0.146}{(1930)^2} = 3.92 \times 10^{-8} \dfrac{\text{cm}}{(\text{K gauss})^2}$

3. $h = |h_1 - h_2| = |6.624 - 6.805|$

$= 0.181 \text{ cm}$

$\rightarrow \dfrac{h}{H^2} = \dfrac{0.181}{(2760)^2} = \dfrac{0.181}{7617600} = 2.38 \times 10^{-8} \dfrac{\text{cm}}{(\text{K gauss})^2}$

4. $h = |h_1 - h_2| = |6.624 - 6.972|$

$= 0.348 \text{ cm}$

$\rightarrow \dfrac{h}{H^2} = \dfrac{0.348}{(3690)^2} = 2.56 \times 10^{-8} \dfrac{\text{cm}}{(\text{K gauss})^2}$

5. $h = |h_1 - h_2| = |6.624 - 7.051|$

$= 0.427 \text{ cm}$

$\rightarrow \dfrac{h}{H^2} = \dfrac{0.427}{(4170)^2} = 2.46 \times 10^{-8} \dfrac{\text{cm}}{(\text{K gauss})^2}$

6. $h = |h_1 - h_2| = |6.624 - 7.203|$

$= 0.579 \text{ cm}$

$\rightarrow \dfrac{h}{H^2} = \dfrac{0.579}{(5290)^2} = 2.07 \times 10^{-8} \dfrac{\text{cm}}{(\text{K gauss})^2}$

$\rightarrow$ Mean $H^2 = \dfrac{(1123600 + 3724900 + 7617600 + 1361600 + 1738890 + 27984100)}{6}$

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$$= \frac{71455200}{6}$$

$$= 11909200 \quad (K.gauss)^2$$

→ Average $\frac{h}{H^2} = \frac{2.48 \times 10^{-8} + 3.92 \times 10^{-8} + 2.38 \times 10^{-8} + 2.56 \times 10^{-8} + 2.46 \times 10^{-8} + 2.07 \times 10^{-8}}{6}$

$$= \frac{(2.48 + 3.92 + 2.38 + 2.56 + 2.46 + 2.07) \times 10^{-8}}{6}$$

$$= \frac{15.87 \times 10^{-8}}{6}$$

$$= 2.645 \times 10^{-8} \quad \frac{cm}{(Kgauss)^2}$$

→ Mass susceptibility $\chi_m = 2 \mu_0 g \cdot \frac{h}{H^2}$

$$= 2 \times 4\pi \times 10^{-7} \times 980 \times 2.645 \times 10^{-8} \times \frac{10^{-2}}{(10^4)^2}$$

$$= 22364.6388 \times 10^{-9}$$

$$\chi_m = 0.00022365 \quad \frac{m^3}{kg}$$

→ Conclusion :

→ The mass susceptibility of the given solution is 0.00022365 m^3/kg.

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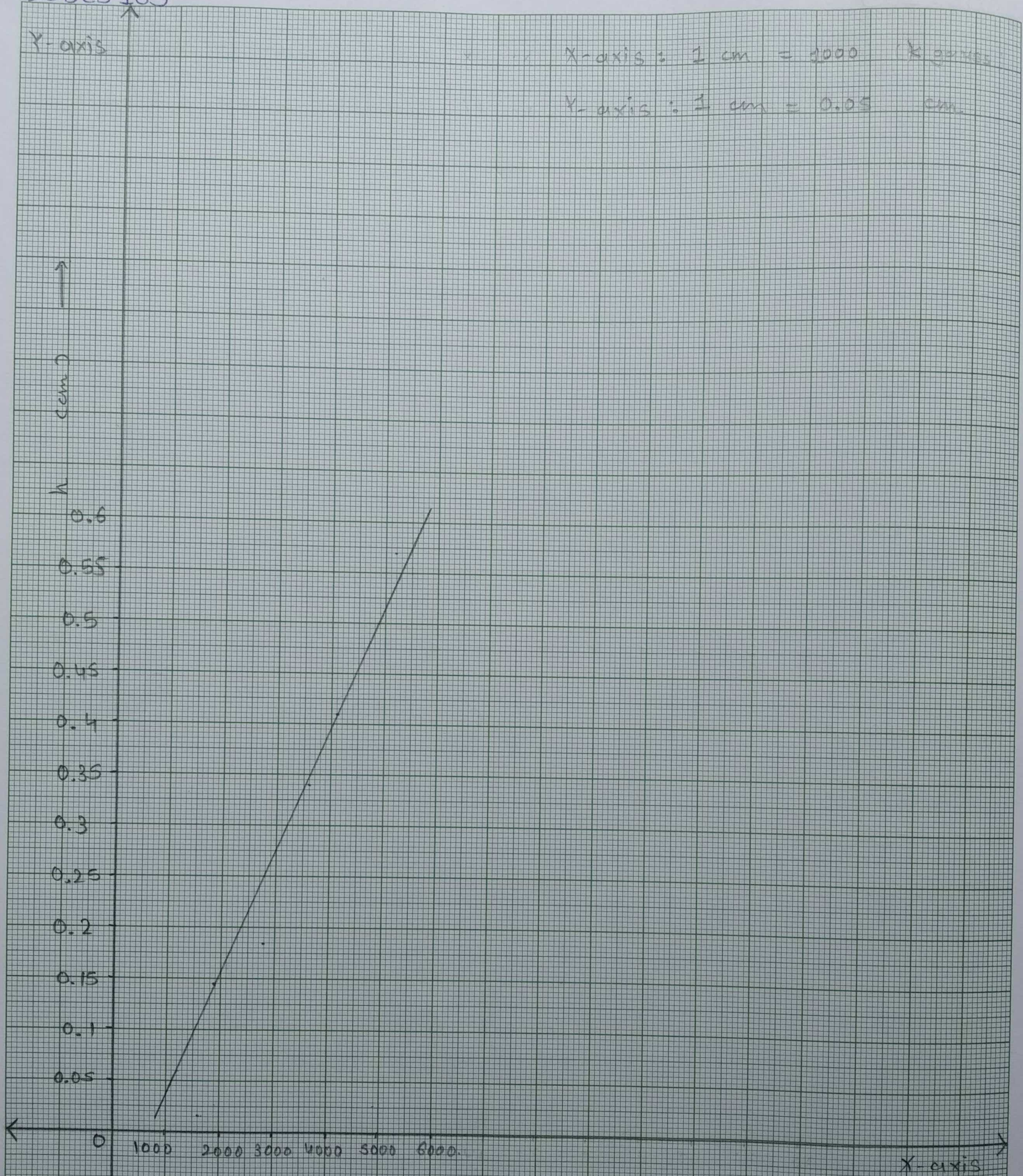
Exp :- 5



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* Experiment 6 : Wavelength of LASER

→ Objectives : To determine the wavelength of semiconductor diode laser.

→ Apparatus : He-Ne Laser source, Optical bench, Transmission type granting [100 lpmm, 200 lpmm, 600 lpmm], Screen, Graph paper, Scale, Binder clips.

→ Procedure :

1. Level the optical bench.

2. Place the laser source on laser holder and mount on the optical bench.

3. Hold the transmission granting [100 lpmm] on the holder between LASER source and screen as shown in the figure.

4. The LASER beam after passing through the granting will split into zero order, first order and second order beam as shown in the figure.

5. Measure the distance between first order spot and zeroth order spot and half of this distance

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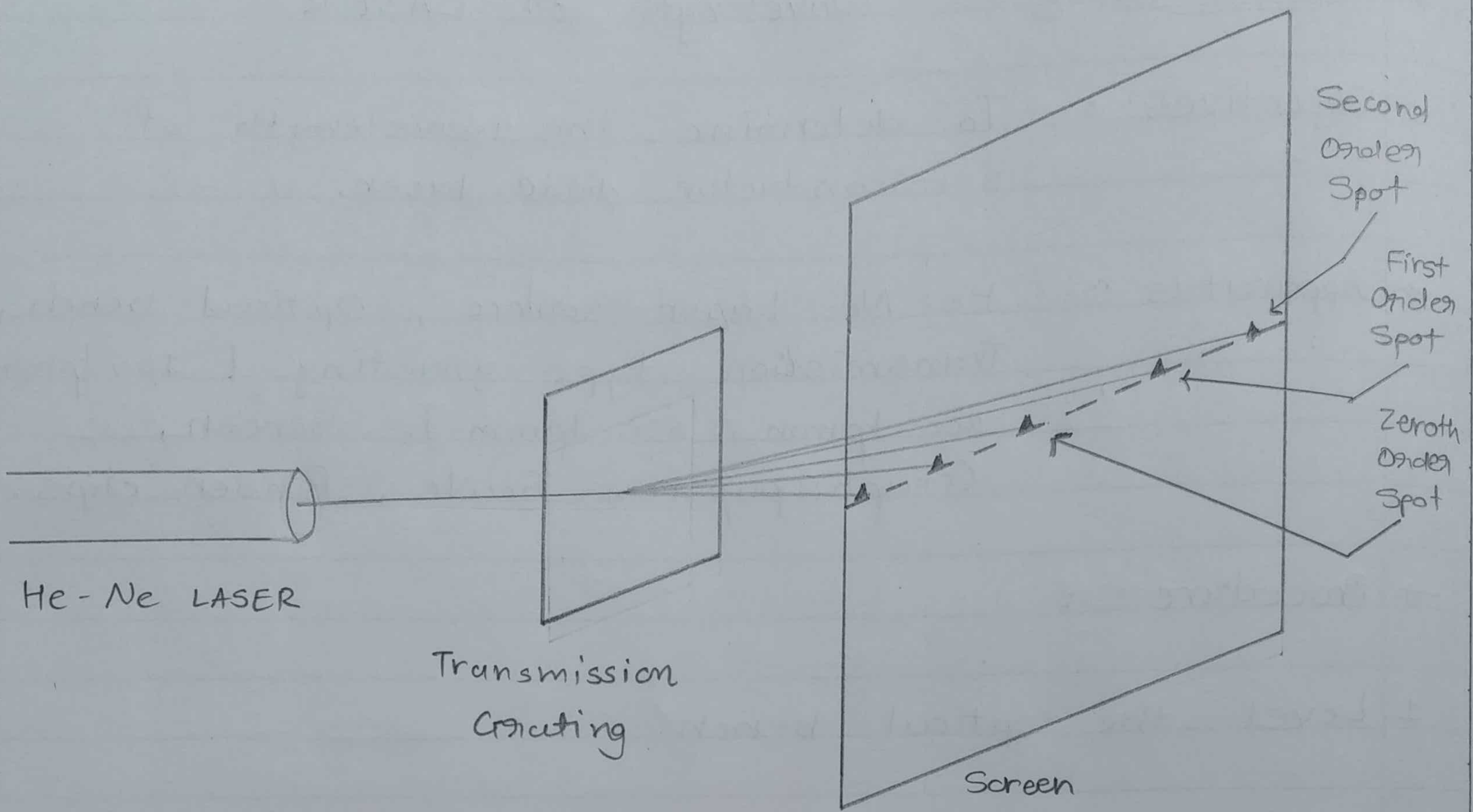
→ Diagram :



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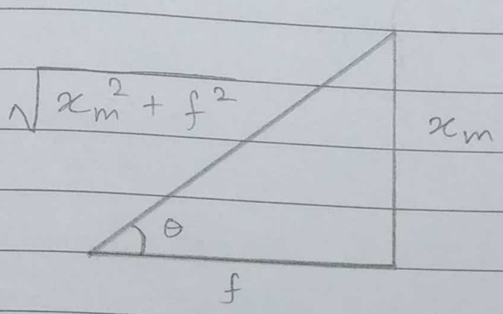
i.e. $$x_m = \left(\frac{x_{ml} + x_{mr}}{2} \right)$$



6. From above figure, $\sin\theta_n = \dfrac{x_m}{\sqrt{x_m^2 + f^2}}$

7. Put $\sin\theta_n$ as below, $n\lambda = d \cdot \sin\theta_n$ ------ (a)

$$\therefore \lambda = \frac{d}{n} \left(\frac{x_m}{\sqrt{x_m^2 + f^2}} \right) \quad \text{----(b)}$$

where,
n = Order of spots.
λ = Wavelength of LASER beam.
d = Resolution of granting (= 1/ granting element)
x_m = Distance between zero order spot and first order spot (mm).
f = Distance between screen and granting element (mm).

8. Write the observations in the observation table and repeat the experiment for the transmission

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gruntings ~~are~~ of 300 lpmm and 600 lpmm.

9. Find the average wavelength of Diode laser.

→ Precautions :

1. Do not ~~u~~see LASER directly, it can harm eyes. Beside this, reflected rays can also be harmful.

2. Handle the apparatus carefully.

→ Calculations :

→ From, $\lambda = \dfrac{d\, x_m}{n\sqrt{x_m^2 + f^2}}$

1. 1) => $\dfrac{1/100 \times 20}{1\sqrt{(20)^2 + (283)^2}}$ = 0.07 nm

2) => $\dfrac{1/100 \times 40}{2\sqrt{(40)^2 + (283)^2}}$ = 0.067 nm

3) => $\dfrac{1/100 \times 61}{3\sqrt{(61)^2 + (283)^2}}$ = 0.07 nm

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2. 1) $\Rightarrow \dfrac{1/300 \times 25.5}{1 \times \sqrt{(25.5)^2 + (115)^2}} = 0.07$ nm

2) $\Rightarrow \dfrac{1/300 \times 55}{2 \times \sqrt{(55)^2 + (115)^2}} = 0.07$ nm

3) $\Rightarrow \dfrac{1/300 \times 95}{3 \times \sqrt{(95)^2 + (115)^2}} = 0.07$ nm

3. 1) $\Rightarrow \dfrac{1/600 \times 34.5}{1 \times \sqrt{(34.5)^2 + (73)^2}} = 0.07$ nm

2) $\Rightarrow \dfrac{1/600 \times 114}{2 \times \sqrt{(114)^2 + (73)^2}} = 0.07$ nm

→ Conclusion :

→ The wavelength of Diode Laser = 0.07 nm

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* Experiment 7 : Optical Fiber

→ Objectives : To determine the value of numerical apparature by optical fiber cable.

→ Apparatus : Diode laser source, Microscope objective, fiber Holders (2 nos), optical fiber, Base with rotational mount, Holders, Bases and Screen.

→ Procedure :

1. Mount Laser source, objective and detector on the respective holders.

2. Mount both the ends of the optical fiber on the fiber holders.

3. Aign the different objects as per the setup shown below.

4. Couple the light from the laser source onto one of the fiber ends using a microscopic objective (provided with the kit).

5. Place the screen [sheet having circular markings] at some distance from the output end of the fiber such that it is

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perpendicular to the axis of the fiber. Now move the screen towards or away from the output end of the fiber such that circular beam emanating from the fiber end covers the [1st or 2nd or 3rd] circle on the screen.

6. Measure the distance between the output end of optical fiber and screen. Let this be L. also measure the diameter of the circular spot formed on the screen. [Diameters are mentioned in mm]. Let it be D.

7. Use the formula

$$NA = \sin\theta = \sin\left[\tan^{-1}\left(\frac{D}{2L}\right)\right]$$

→ Precautions :

1. Mounting and coupling should be carefully done.

2. Care should be taken so that laser light should not directly fall into eyes.

3. As far as possible, experiment should be conducted in dark room environment.

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→ Observations :

Wavelength of given diode laser = 650 nm
(Red laser)

Optical fiber = Multimode optical fiber.

→ Observation Table :

Sr No.	Circle No.	Diameter of Circle D (cm)	Distance Between end of the Fiber and Screen L (mm)	$\frac{D}{2L}$	$\tan^{-1}\left(\frac{D}{2L}\right)$	NA	Average NA
1	1	12	10	$\frac{3}{5}$	$\tan^{-1}(3/5)$	0.75	
2	2	16	12	$\frac{2}{3}$	$\tan^{-1}(2/3)$	0.55	
3	3	20	15	$\frac{2}{3}$	$\tan^{-1}(2/3)$	0.55	0.586
4	4	24	18	$\frac{2}{3}$	$\tan^{-1}(2/3)$	0.55	
5	5	28	22	$\frac{7}{11}$	$\tan^{-1}(7/11)$	0.53	

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→ Calculations :

1. $\frac{D}{2L} = \frac{12}{2 \times 10} = \frac{3}{5}$

→ $\tan^{-1}\left(\frac{D}{2L}\right) = \tan^{-1}\left(\frac{3}{5}\right)$

→ $NA = \sin\theta = \sin\left(\tan^{-1}\left(\frac{3}{5}\right)\right)$

$= \sin\left[\sin^{-1}\left(\frac{3}{4}\right)\right] = 0.75$

2. $\frac{D}{2L} = \frac{16}{2 \times 12} = \frac{2}{3}$

→ $\tan^{-1}\left(\frac{D}{2L}\right) = \tan^{-1}\left(\frac{2}{3}\right)$

→ $NA = \sin\theta = \sin\left(\tan^{-1}\left(\frac{2}{3}\right)\right)$

$= \sin\left[\sin^{-1}\left(\frac{2}{3}\right)\right] = 0.55$

3. $\frac{D}{2L} = \frac{20}{2 \times 15} = \frac{2}{3}$

→ $\tan^{-1}\left(\frac{D}{2L}\right) = \tan^{-1}\left(\frac{2}{3}\right)$

→ $NA = \sin\theta = \sin\left(\tan^{-1}\left(\frac{2}{3}\right)\right)$

$= \sin\left[\sin^{-1}\left(\frac{2}{\sqrt{13}}\right)\right] = 0.55$

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4. $\frac{D}{2L} = \frac{24}{2 \times 18} = \frac{2}{3}$

$\rightarrow \tan^{-1}\left(\frac{D}{2L}\right) = \tan^{-1}\left(\frac{2}{3}\right)$

$\rightarrow \sin\theta = \sin\left(\tan^{-1}\left(\frac{2}{3}\right)\right)$

$= \sin\left[\sin^{-1}\left(\frac{2}{\sqrt{13}}\right)\right] = 0.55$

5. $\frac{D}{2L} = \frac{28}{2 \times 22} = \frac{7}{11}$

$\rightarrow \tan^{-1}\left(\frac{D}{2L}\right) = \tan^{-1}\left(\frac{7}{11}\right)$

$\rightarrow \sin\theta = \sin\left(\tan^{-1}\left(\frac{7}{11}\right)\right]$

$= \sin\left[\sin^{-1}\left(\frac{7}{\sqrt{170}}\right)\right] = 0.53$

$\rightarrow$ Average NA $= \frac{(NA)_1 + (NA)_2 + (NA)_3 + (NA)_4 + (NA)_5}{5}$

$\therefore$ Average NA $= 0.586$

$\rightarrow$ Conclusion :

NA of given optical fiber = 0.586

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* **Experiment 8 : Photoelectric Effect.**

→ **Objectives** : To determine the electronic charge and the work function of a photo metal using photo electric cell.

→ **Apparatus** : Light source, Digital voltmeter and ammeter, vaccuum photo tube, filters of different colors.

→ **Procedure** :

1. Insert the red color filter (635 nm), set light intensity switch (12) at strong light, voltage direction switch (16) at '-', display mode switch (10) at current display.

2. Adjust to de-accelerating voltage to 0 V and set current multiplier (4) at X 0.001.

3. Increase the de-accelerating to decrease the photo current to zero.

4. Take down the de-accelerating voltage (V_s) corresponding to zero current of 635 nm wavelength.

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5. Get the V_s of other wave lengths, the same way.

6. Repeat for at least 2 distances say 40 cm and 30 cm.

→ Precautions :

1. This instrument should be operated in a dry, cool indoor space.

2. Phototube particularly should not be exposed to direct light, particularly at the time of installation of phototube; the room should be dimly lit.

3. The instrument should be kept in dust proof and moisture proof environment, if there is dust on the phototube, color filters, lens etc. clean it by using absorbent cotton with a few drops of alcohol.

4. The color filter should be stored in dry and dust proof environment.

5. After finishing the experiment remember to switch off power and cover the drawtube (4) with the lens cover (15) provided. Phototube is light

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→ Observation Table :

Sr No.	Filters	$\nu\ [sec^{-1} \times 10^{14}]$	Stopping Voltage V_s in volt	
			d = 40 cm	d = 30 cm
1	Red [635 nm]	403	1.80	1.80
2	Yellow [585 nm]	446	1.60	1.60
3	Green [500 nm]	569	1.90	1.90
4	Blue [460 nm]	611	0.75	0.75

→ $e = 1.6 \times 10^{-19}$ C [electron charge] sensitive device and its sensitivity with exposure to light and due to ageing.

→ Calculations :

→ From the graph ΔE_K vs Δf

$$h = e \times \text{slope of the graph}$$
$$= e \times \frac{\Delta E_K}{\Delta f}$$
$$= \frac{[1.60 \times 10^{-19}\ J]}{1\ eV} \times \frac{[1.80\ eV - 0.40\ eV]}{7.44 \times 10^{14}\ Hz - 4.06 \times 10^{14}\ Hz}$$

$\therefore h = 6.63 \times 10^{-34}$ J·s.

→ The standard value of $h = 6.62 \times 10^{-34}$ J·s.

Again, from graph (1) intercept at $V = 0$.

$\therefore$ Work function ϕ = intercept on y axis = 1.28 volt

→ Conclusion :

1) Planck's constant 'h' is found to be work function $h = 6.62 \times 10^{-34}$ J.sec.

2) $\phi = 1.28$ V.

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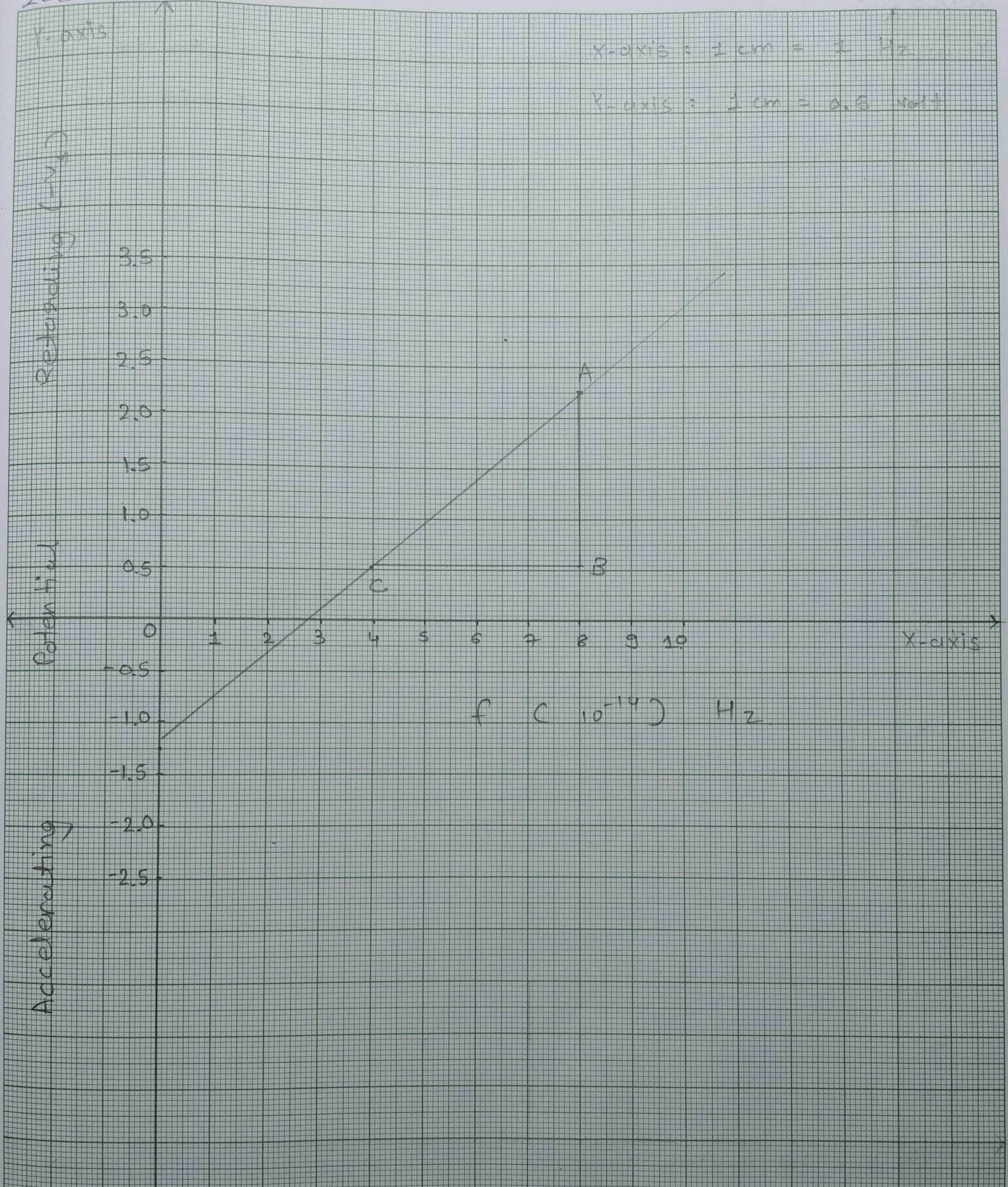

* Experiment 9 : Planck's Constant by LED.

→ Objective : To determine planck's constant using emitting diodes [LED's].

→ Apparatus : Planck's Constant kit and LED's.

→ Procedure :

1. Make the connection in the kit.

2. Take the current measurement of each LED by varying the voltage as given in the table.

3. Plot the curve on the graph paper between Voltage on X-axis and current on Y-axis.

4. The linear portion of the I/V curve is extra plotted back to the X-axis.

5. The intercept is the point at which the voltage equals to the barrier potential. Put this value in the table.

→ Precautions :

1. This instrument should be operated in a dry, cool indoor space.

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2. Phototube particularly should not be exposed to direct light, particularly at the time of installation of phototube ; the room should be only dimly lit.

3. The instrument should be kept in dust proof and moisture proof environment, if there is dust on the phototube, color filters, lens etc. clean it by using absorbent cotton with a few drops of alcohol.

4. The color filter should be stored in dry and dust proof environment.

5. After finishing the experiment remember to switch off power and cover the drawtube (4) with the lens cover (15) provided. Phototube is light sensitive device and its sensitivity decreases with exposure to light and due to ageing.

→ Calculations :

1. Red :- $h_1 = \frac{e \lambda V_0}{c}$

$$= \frac{1.6 \times 10^{-19} \times 635 \times 10^{-9} \times 2.24}{3 \times 10^{8}}$$

$$= 7.58 \times 10^{-34} \text{ J.s}$$

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→ Observation Table :-

Sr No.	Voltage (Volts)	Current I_{red} (μA)	Current I_{yellow} (μA)	Current I_{green} (μA)	Current I_{Blue} (μA)
1	0	0	0	0	0
2	0.25	0	0	0	0
3	0.50	0	0	0	0
4	0.75	0	0	0	0
5	1.0	0	0	0	0
6	1.25	0	0	0	0
7	1.50	0	0	0	0
8	1.75	112	219	100	0
9	2.0	840	968	796	0
10	2.25	1842	1903	1719	0
11	2.50	Max	Max	Max	44
12	2.75	Max	Max	Max	480
13	3.0	Max	Max	Max	1226

→ $c = 3 \times 10^{8}$ m/s [speed of light]

→ $e = 1.6 \times 10^{-19}$ C [electron charge]

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→ Observation Table (2) :-

Sr. No.	L.E.D. Colour	Voltage V [volts]	Wavelength λ [nm]	Frequency [Hz] $fc = \lambda$	Energy [J] E.eV
1.	Blue	2.76	500	7.36×10^{-34}	
2.	Green	3.26	460	5.52×10^{-34}	6.685×10^{-34}
3.	Yellow	2.24	585	6.29×10^{-34}	
4.	Red	2.24	635	7.58×10^{-34}	

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2. Yellow :- $h_2 = \frac{e\lambda V_0}{c}$

$= \frac{1.6\times10^{-19} \times 585 \times 2.24\times10^{-9}}{3\times10^{8}}$

$= 6.29\times10^{-34}$ J.s

3. Green :- $h_3 = \frac{e\lambda V_0}{c}$

$= \frac{1.6\times10^{-19} \times 460\times10^{-9} \times 3.26}{3\times10^{8}}$

$= 5.52\times10^{-34}$ J.s

4. Blue :- $h_4 = \frac{e\lambda V_0}{c}$

$= \frac{1.6\times10^{-19} \times 500\times10^{-9} \times 2.76}{3\times10^{8}}$

$= 7.36\times10^{-34}$ J.s

$\therefore$ Average $h = \frac{h_1 + h_2 + h_3 + h_4}{4}$

$= \frac{7.58\times10^{-34} + 6.29\times10^{-34} + 5.52\times10^{-34} + 7.36\times10^{-34}}{4}$

$= \frac{[7.58 + 6.29 + 5.52 + 7.36]\times10^{-34}}{4}$

$= 6.685\times10^{-34}$ J.s

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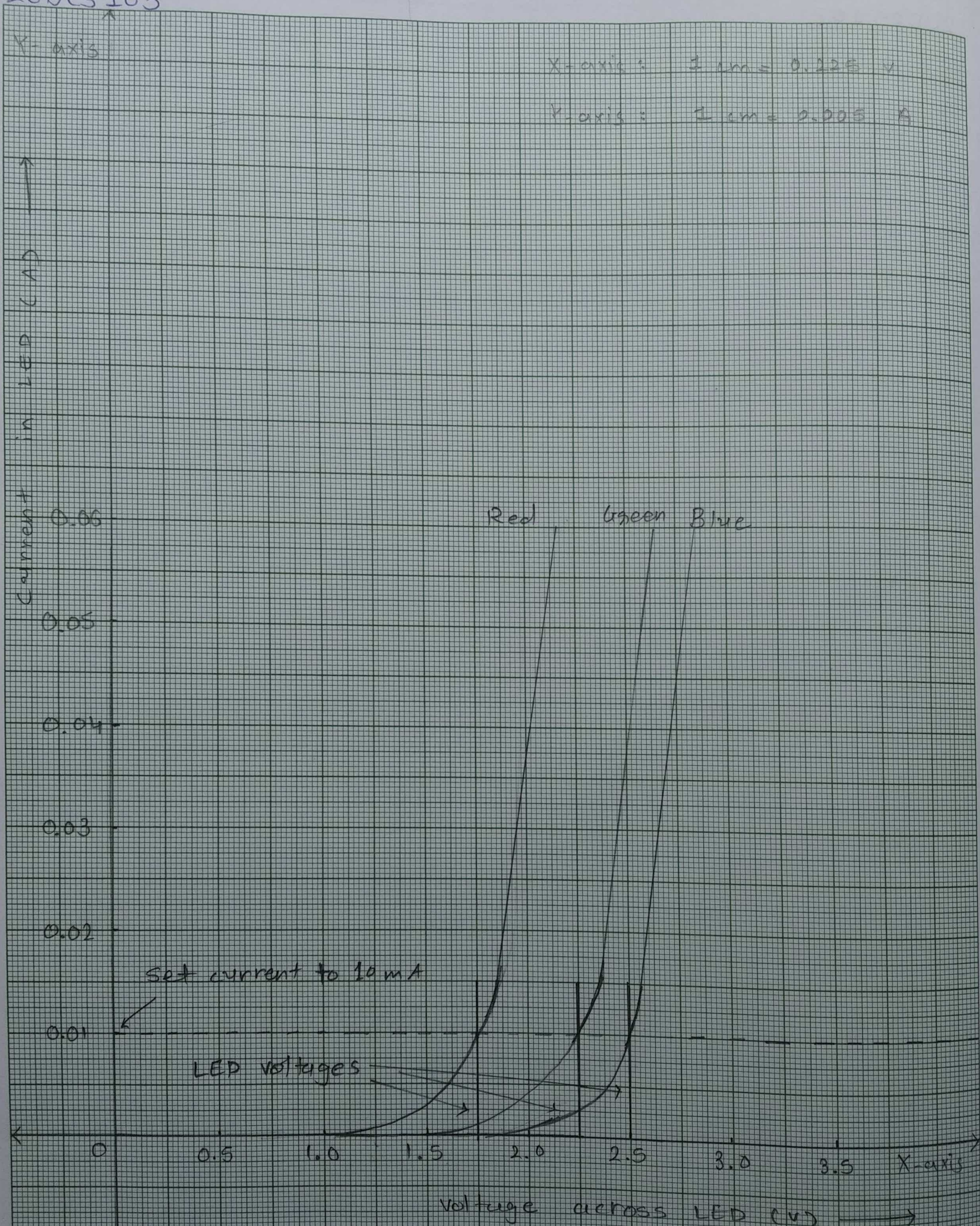
Exp : 9



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→ Conclusion :

1. Observed value of planck's constant is
$h = 6.685 \times 10^{-34}$ J·s

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* Experiment 10 : Bandgap of Semiconductor.

→ Objective : To determine the energy band-gap in semiconductor diode.

→ Apparatus : Omega type ETB 58 Experimental training board, and Thermometer. [The board consists of the following built in parts, 3V D.C. at 15 mA, regulated power supply, D.C. Microammeter, 65 mm rectangular dial to read 0-50 mA, Semiconductor diode, Oven, electrical heater to heat the semi conductor diode.]

→ Procedure :

1. Insert the thermometer and the diode inside the holes of the oven, where the pn junction diode is kept.

2. Plug the two leads to the diode inside the socket.

3. Now, put the power ON/OFF switch to ON position and see that the jewel light is glowing.

4. Put the oven switch to ON position and allow the oven temperature to increase upto 90° C. Please

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→ Observation Table :

Sr. No.	Temp. °C	Current I_s (μA)	Temp. K	$10^3/T$	$\log_{10} I_s$
1	85	36	350	2.80	1.5563
2	80	23	353	2.832	1.3617
3	75	17	348	2.873	1.2304
4	70	14	343	2.915	1.1461
5	65	11	338	2.958	1.0414
6	60	9	333	3.003	0.9542
7	55	8	328	3.049	0.9031
8	50	6	323	3.096	0.7781
9	45	5	318	3.145	0.6990
10	40	4	313	3.195	0.6020

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note that as soon as the temperature reaches above 90° c switch off the oven so that the temperature raises little further and become stable while cooling.

→ Precautions :

1. The Germanium or Silicon crystal is very brittle ; as such only minimum pressure was applied on it for proper electrical contact.

2. The oven should not be over heated. The maximum temperature should not exceed 95 °c.

3. The bulk of the thermometer and the diode should be inserted well in the oven.

4. The current through the sample was adjusted to the most bearable minimum, because if large, it will amount to overheating.

5. The instrument should be operated in a dry, cool indoor space.

→ Calculations :

→ Taking $10^3/T$ along X-axis and $\log_{10} I_s$ along Y-axis, plot a graph between $\log_{10} I_s$ and

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$10^3/T$ for three different voltages. The graph will be a straight line as shown in the graph. Determine the slope of straight line from this graph and then calculate band gap using formula.

→ Band gap $E_g = \dfrac{\text{Slope}}{5.036}$

where, slope $= \dfrac{AB}{BC}$

$= \dfrac{1.5563 - 1.0414}{2.958 - 2.80}$

$= \dfrac{0.5149}{0.158}$

$= 3.26$

$\therefore E_g = \dfrac{3.26}{5.036} = 0.65$ eV.

→ Conclusion:

1. The band gap E_g of the given semiconductor is found to be 0.65 eV.

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Exp. 10.

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