MEERUT INSTITUTE ON ENGINEERING & TECHNOLOGY

EXPERIMENT NO: 01

CAREY FOSTER'S BRIDGE

OBJECT: To determine the specific resistance of a given wire using Carey Foster's bridge.

APPARATUS USED: Carey foster's bridge, laclanche cell, galvanometer, fractional resistance box, two resistances box (each of 1-10 Ω), thick copper strip, one way key, connecting wires.

FORMULA USED: The specific resistance of the material of a given wire is given by

$$\rho = A \frac{X}{l_2 - l_1}$$

Where X = fractional resistance

A = cross-sectional area of the wire

l_1, l_2 = positions of null points

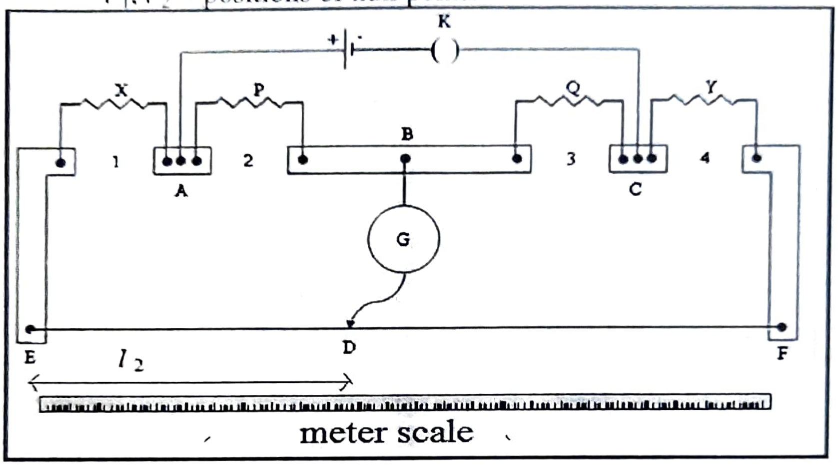

Figure: Carey foster's bridge

PROCEDURE:

1. Make the connections as shown in figure.
2. Place two equal small resistances P and Q (between 1Ω to 10 Ω) in gaps 2 and 3.
3. Connect fractional resistance X in the fractional resistance box in gap 1 and the metal strip in gap 4.
4. Introduce the some resistance (say X = 0.1 Ω) in the fractional resistance box by opening the plug.

$$P_1 = \frac{X_1}{L_2 - L_1} = \frac{0.1\ \Omega}{(54.6 - 49.5)\ cm} = 0.019\ \Omega\ cm^{-1}$$

$$P_2 = \frac{X_2}{L_2 - L_1} = \frac{0.2\ \Omega}{(55.5 - 46.5)\ cm} = 0.022\ \Omega\ cm^{-1}$$

$$P_3 = \frac{X_3}{L_2 - L_1} = \frac{0.3\ \Omega}{(57 - 46)\ cm} = 0.027\ \Omega\ cm^{-1}$$

$$P_4 = \frac{X_4}{L_2 - L_1} = \frac{0.4\ \Omega}{(58.5 - 45)\ cm} = 0.022\ \Omega\ cm^{-1}$$

$$P_5 = \frac{X_5}{L_2 - L_1} = \frac{0.5\ \Omega}{(60 - 43.5)\ cm} = 0.030\ \Omega\ cm^{-1}$$

* Mean $P_l = \frac{P_1 + P_2 + P_3 + P_4 + P_5}{5}$

$$= \left(\frac{0.99 + 0.22 + 0.027 + 0.029 + 0.03}{5}\right)\ \Omega\ cm^{-1}$$

$$= 0.025\ \Omega\ cm^{-1}$$

* Specific Resistance:-

$$P_l = P_l(\pi r^2)$$

$$= 0.025 \times 3.14 \times (0.0225)^2$$

$$= 39.74 \times 10^{-6}\ \Omega\ cm^{-1}$$

* Error:- $\left|\frac{(49.1 \times 10^{-6})\ \Omega\ cm^{-1} - (39.74 \times 10^{-6})\ \Omega\ cm^{-1}}{49.1 \times 10^{-6}\ \Omega\ cm^{-1}}\right| \times 10$

$= 14.06\ \%$

5. Find the null position in the galvanometer G by sliding the jockey J.

6. Measure the distance of the null point l_1 from the left end.

7. Now interchange the position of metal strip and fractional resistance box.

8. Find the new null position and measure the distance of the null point l_2 from the right end.

9. Repeat the process for different values of the fractional resistance X.

OBSERVATIONS:

1. Radius of the constantan wire (r) = ...0.0225...cm.

2. P = Q = ...10...Ω

3. Determination of ρ:

S.No.	Resistance (X) introduced in fractional box (Ω)	Position of null point Left gap l_1 (cm)	Right gap l_2 (cm)	$l_2 - l_1$ (cm)	$\rho = \frac{X}{l_2 - l_1}$ (Ω / cm)
1.	0.1	49.5	54.6	5.1	0.019 Ω cm⁻¹
2.	0.2	46.5	55.5	9	0.022 Ω cm⁻¹
3.	0.3	46	57	11	0.027 Ω cm⁻¹
4.	0.4	45	58.5	13.5	0.029 Ω cm⁻¹
5.	0.5	43.5	60	16.5	0.030 Ω cm⁻¹

CALCULATIONS:

1. Resistance per unit length, ρ

$\rho_1 = \frac{X}{l_2 - l_1}$ = 0.019 Ω/cm

$\rho_2 = \frac{X}{l_2 - l_1}$ = 0.022 Ω/cm

$\rho_3 = \frac{X}{l_2 - l_1}$ = 0.027 Ω/cm

$\rho_4 = \frac{X}{l_2 - l_1}$ = 0.022 Ω/cm

$\rho 5 = \frac{X}{l_2 - l_1}$ = 0.030 Ω cm⁻¹

Mean ρ_l = ...0.025...Ω / cm

2. Specific resistance: $\rho_s = \rho_l (\pi r^2)$ = ..39.7×10⁻⁶..Ω-cm

RESULT:

1. Specific resistance of the wire is 39.74×10⁻⁶...Ω-cm.
2. Standard result = 49.1×10^{-6} Ω-cm.
3. $$Percentage\ error = \frac{Standard\ value - calculated\ value}{standard\ value} \times 100 = 14.06\%$$

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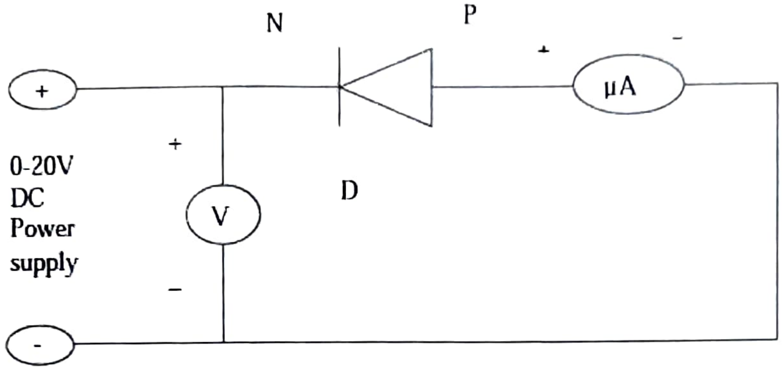
EXPERIMENT NO:02...

ENERGY BAND GAP OF A SEMICONDUCTOR

OBJECT: To determine the energy band gap of a given semiconductor material using a reversed biased p-n junction diode.

APPARATUS USED: DC power supply, electrically heated oven, voltmeter, micro ammeter, thermometer and semiconductor diode.

DIAGRAM:



FORMULA USED: Energy band gap of a semiconductor material is given by

$$E_g = 2.303 \times 10^3 \times K_B \times \text{Slope of line}$$

Where K_B = Boltzmann's constant=8.6 x 10^{-5} eV/Kelvin

PROCEDURE:

(1) Connect p and n sides of junction diode to micro ammeter and battery in reverse bias configuration, as shown in fig.

(2) Set a fix voltage at any value(preferably less than 10V)

(3) Vary the heater current so that the temperature of the oven slowly. For convenience fast heating may be done up to 60^0C and then slowly heat up to 90^0C.

(4) Switch off the heater and note the current with decreasing temperature starting from 80^0C to 45^0C with a step of 5^0C.

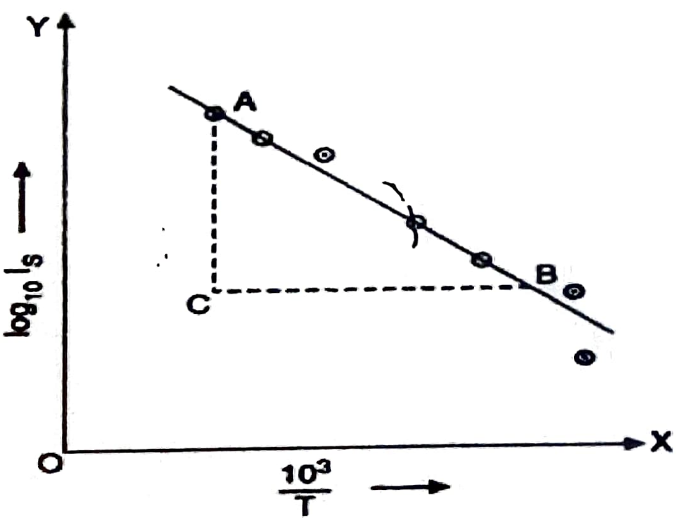
(5) Set another voltage and repeat the steps (3) and (4).

OBSERVATION TABLE:

S.No.	Temperature		Voltage V = 5 volts			Voltage V = 7.5 volts		
	T°C	T(K)	Current I(amp)	log I	$\frac{10^3}{T(K)}$	Current I(amp)	log I	$\frac{10^3}{T(K)}$
1	80	353	0.000176	-3.75	2.83	0.000186	-3.73	2.83
2	75	348	0.000134	-3.87	2.87	0.000138	-3.80	2.83
3	70	343	0.0001	-4	2.92	0.000105	-3.78	2.92
4	65	348	0.000073	-4.14	2.96	0.00079	-4.1	2.96
5	60	333	0.000053	-4.28	3	0.000059	-4.23	3.05
6	55	328	0.000413	-4.39	3.05	0.00044	-4.36	3.05
7	50	323	0.0003	-4.52	3.1	0.000033	-4.48	3.1
8	45	318	0.000021	-4.62	3.14	0.000024	-4.62	3.14

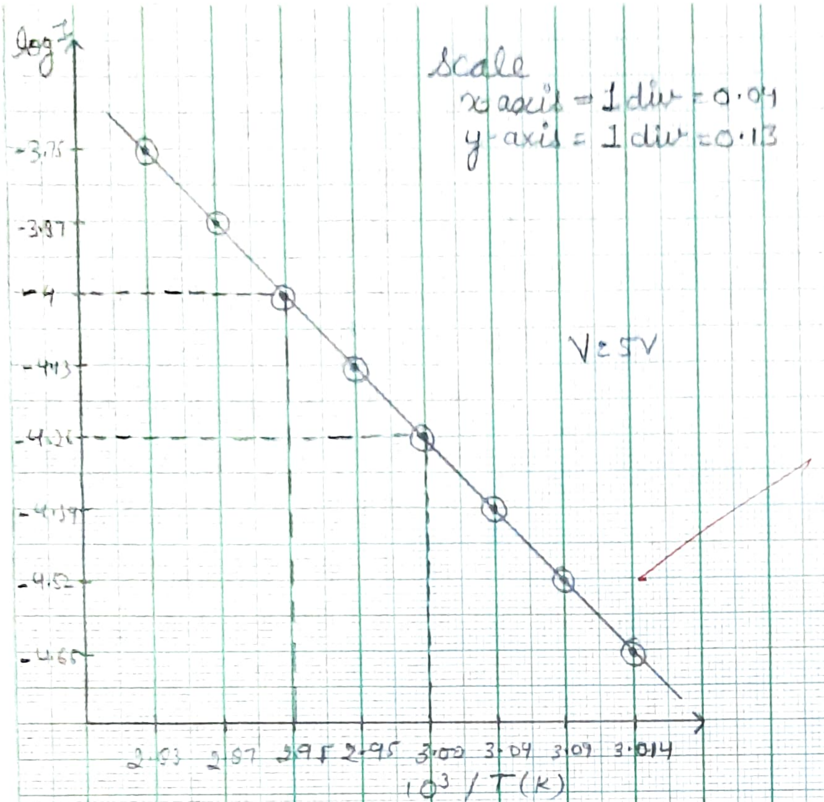
CALCULATION: Plot a curve between log I and $\left(\frac{10^3}{T}\right)$ gives a straight line with a

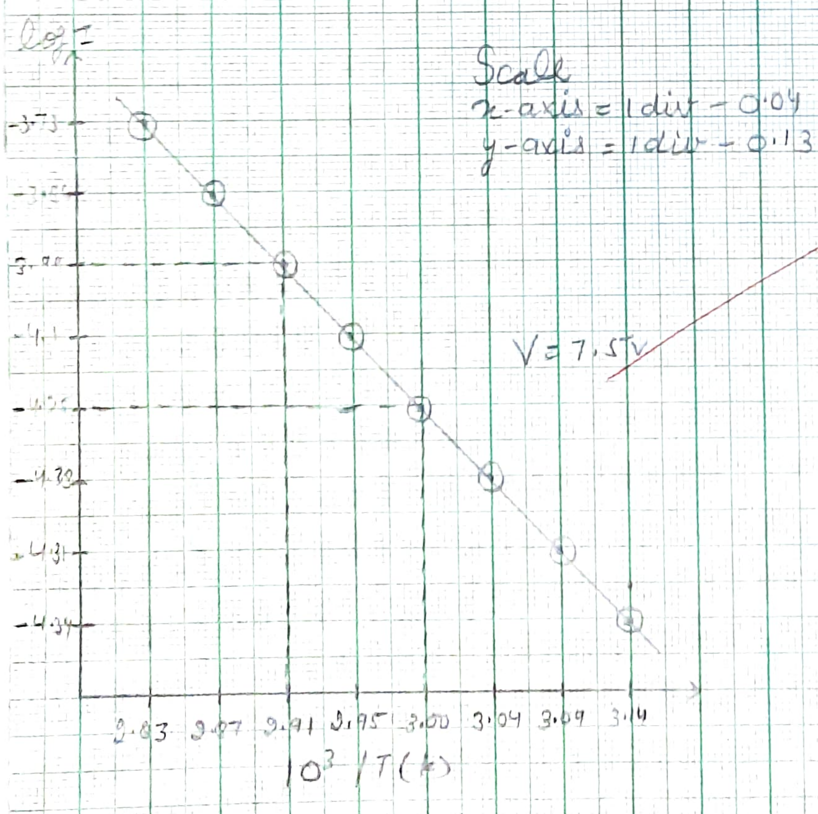
Similarly find the energy band gap on finding the slope of line taken from the set of voltage. Finally determine the mean value of them.



$$\text{Slope of line} = \frac{AC}{BC}$$

Use $$E_g = 2.303 \times K_B \times 10^3 \times Slope\ of\ line$$


log I
Scale
x axis = 1 div = 0.04
y axis = 1 div = 0.13
V = 5V
-3.75
-3.87
-4
-4.13
-4.26
-4.39
-4.52
-4.65
2.83
2.87
2.95
3.00
3.04
3.09
3.014
10³ / T(K)


log I
Scale
x-axis = 1 div - 0.04
y-axis = 1 div - 0.13
V = 7.5V
-3.73
2.83
2.87
2.91
2.95
3.00
3.04
3.09
3.14
10³ / T(K)

Paste graph 1. Slope for …….Volt

$$Slope = \left|\frac{y_2 - y_1}{x_2 - x_1}\right|$$

$$= \left|\frac{-4.68 + 4.37}{3.14 - 2.87}\right|$$

$$= \left|\frac{-0.81}{0.27}\right|$$

$$= 3$$

Paste graph 2. Slope for …….Volt

$$Slope = \left|\frac{1.38 - 1.778}{3.774 - 3.003}\right| = 2.81$$

$$\% = \left| \frac{0.67eV - 0.58eV}{0.67eV} \right| \times 100 = 0.1343 \times 100$$

$$= 13.43\%$$

Energy band gap for 5.0 Volt

$$E_g = 2.303 \times K_B \times 10^3 \times Slope\ of\ line$$

$$E_g = 2.303 \times 8.6 \times 10^{-5} \times 10^3 \times 3 = 0.594 eV$$

Energy band gap for 7.5 Volt

$$E_g = 2.303 \times K_B \times 10^3 \times Slope\ of\ line$$

$$E_g = 2.303 \times 8.6 \times 10^{-5} \times 10^3 \times 2.81 = 0.56 eV$$

RESULT:

(a) Energy band gap of a given semiconductor material = 0.58 eV

(b) Given semiconductor is Ge (Ge or Si)

STANDARD RESULT: Band gap of Ge and Si are as

= 0.67 eV(for Ge)

= 1.12eV (for Si)

%ERROR:

$$= \frac{\text{Experimental Value} - \text{Calculated Value}}{\textit{Experminal Value}} \times 100 = 13.43\%$$

$$= \frac{\ldots\ldots - \ldots\ldots}{\ldots\ldots} \times 100 = \text{------------------}\%$$

PRECAUTIONS:

(1)Diode should be in reverse biased.

(2)Do not heat more than 100^0C.

(3)Reading must be taken during cooling.

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EXPERIMENT NO:..4...

STEFAN'S LAW

OBJECT: To verify Stefan's law by electrical method.

APPARATUS: 6V battery, D.C. Voltmeter (0-10 V), D.C. Ammeter (0-1 Amp.), Electric bulb having tungsten filament, Rheostat (100 ohm).

FORMULA USED:

Stefan's law states that the total radiant energy emitted per second from the unit surface area of a perfectly black body is proportional to the fourth power of its absolute temperature.

$$E = \sigma T^4$$

where σ is called Stefan's constant.

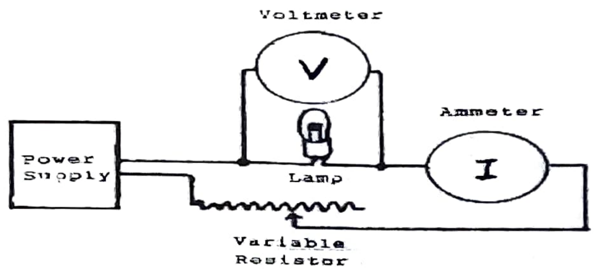

Figure: Circuit diagram

PROCEDURE: (A) For table (a)

1). Make the connections as shown in figure.
2). Set the voltage in voltmeter to just glow the filament of the bulb and note down the corresponding values of current.
3). Take at least 3 readings in just glow condition in increasing order of current.

(B) For table (b)

1). Now increase the voltage enough to get brightness in bulb's filament.
2). Increase the voltage in small step and cover the whole range of voltage and note down the corresponding value of current.

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OBSERVATION:

Table (a) Determination of Rg

S.No.	Current Increasing		
	Voltage V (Volt)	Current I (Amp)	$R_g = \frac{V}{I}$ Ohm
1.	0.8 V	70 mA = 70×10^{-3} A	11.42 Ω
2.	1.0 V	75 mA = 75×10^{-3} A	13.33
3.	1.2 V	80×10^{-3} A	15

Table (b) Determination of Power dissipated at different temperature T.

S. No.	Voltage V (Volt)	Current I (Amp)	Power P = VI	$\log_{10} P$	Resistance $R_t = \frac{V}{I}$ (Ohm)	$\frac{R_t}{R_o}$	Temp T (K) From graph	$\log_{10} T$
1.	0.8	0.07	0.056	-1.251	11.42	3.361	703	2.846
2.	1.0	0.075	0.075	-1.125	13.33	3.923	793	2.899
3.	1.2	0.08	0.096	-1.017	15	4.415	873	2.94
4.	1.4	0.085	0.119	-0.924	16.47	4.847	953	2.979
5.	1.6	0.095	0.152	-0.818	16.84	4.956	973	2.988
6.	1.8	0.1	0.18	-0.744	18	5.298	983	2.992
7.	2.0	0.105	0.21	-0.677	19.04	5.604	1073	3.030
8.	2.2	0.110	0.242	-0.616	22	5.886	1113	3.046
9.	2.4	0.115	0.276	-0.56	20.86	6.139	1133	3.054
10.	2.6	0.120	0.312	-0.505	21.66	6.375	1193	3.076
11.	2.8	0.125	0.35	-0.455	22.4	6.593	1223	3.087
12.	3.0	0.130	0.39	-0.408	23.076	6.792	1253	3.097
13.	3.2	0.135	0.432	-0.364	23.70	6.975	1283	3.100
14.	3.4	0.140	0.476	-0.322	24.28	7.146	1293	3.111
15.	3.6	0.145	0.522	-0.202	24.82	7.305	1333	3.124

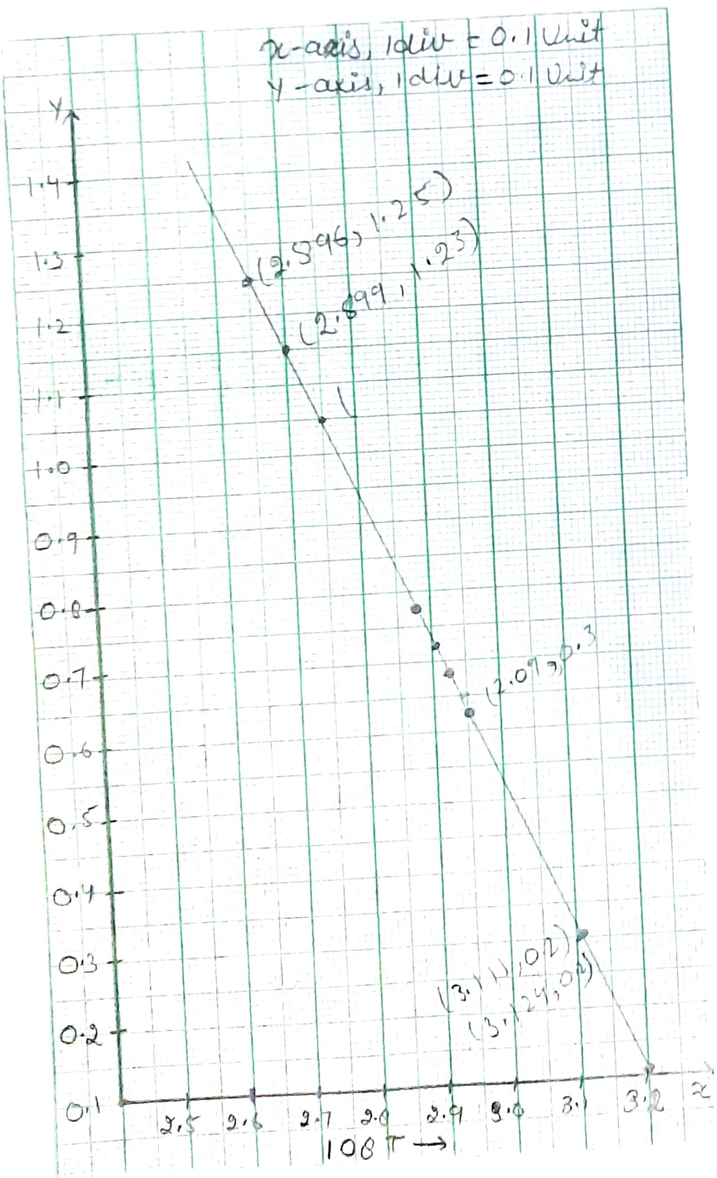

x-axis, 1div = 0.1 Unit
Y-axis, 1div = 0.1 Unit
Y
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
x
108 T →

Table (c) Table for plotting temperature T versus $\frac{R_t}{R_o}$

Temprature T(°C)	$\frac{R_t}{R_o}$	Temprature T(°C)	$\frac{R_t}{R_o}$
0	1.00	1100	7.60
100	1.53	1200	8.26
200	2.07	1300	8.90
300	2.13	1400	9.70
400	3.22	1500	10.43
500	3.80	1600	11.17
600	4.40	1700	11.42
700	5.00	1800	12.67
800	5.64	1900	13.50
900	6.37	2000	14.30
1000	6.94		

CALCULATIONS:

1. Determine the mean value of filament resistance R_g of bulb at just glow condition. Further calculate $R_o = \frac{R_g}{3.9}$ Ohm.
2. Plot the curve between temperature T(K) versus $\frac{R_t}{R_o}$ using data from table.
3. Find the experimental value of temperature T from the projected value of $\frac{R_t}{R_o}$ calculated from table (b).
4. Plot the curve between log P versus log T which comes out to be a straight line. Find the slope α of the line that comes out around 4 to verify Stefan's Law of radiation.

RESULT:

1. The graph of logP versus logT comes out to be a straight line having slope α. Hence $P = C\,T^{\alpha}$, Law is verified. Further the slope of the line α = 4 and therefore the law is verified as a fourth power law.

2. **Standard Result**

The value of slope α = 4.

3. **Experimental Result**

The value of slope α obtained from experimental data = ...3.94...

4. **Percentage Error**

$$\% \text{ Error} = \frac{(\textbf{Standard Value} - \textbf{Calculated Value})}{(\textbf{Standard Value})} \times 100 = \left|\frac{4-3.94}{4}\right| \times 100$$

$$= 1.50\%$$

PRECAUTION:

1. All connections should be tight.
2. Use the bulb having tungsten filament.
3. Increase the current in steps.
4. Note down the voltage reading carefully after every change in current.
5. Reading should be taken only when the system is stable.

EXPERIMENT NO:..04...

HALL EFFECT

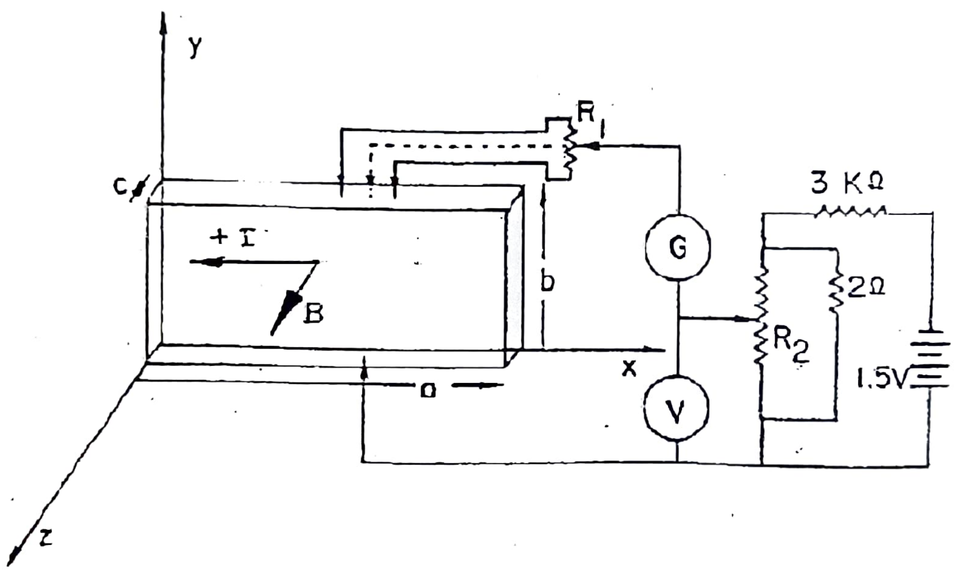
OBJECT:

To study the Hall Effect and determine Hall Coefficient and carrier density of a given semiconductor material using Hall Effect set–up.

APPARATUS USED:

A rectangular slab of semiconductor crystal, electromagnet, flux meter, constant current source with ammeter and milli voltmeter, connecting leads, etc.

DIAGRAM:



FORMULA USED:

i) Hall Coefficient of a semiconductor is given by

$$R_H = \frac{V_H\ t}{I_x\ B_z}\ \text{m}^3/\text{C}$$

Where V_H = Hall Voltage in Volts

I_x = Current in the specimen in Amperes

t = Thickness of the specimen in meter

B_z= Magnetic field in Gauss

ii) Carrier Density

The number of charge carriers per unit volume in a semiconductor (n-electron concentration in n-type and p-hole concentration in p-type semiconductor) is

$$p = \frac{1}{R_H\, e}$$

PROCEDURE:

(A) Calibration of the Electromagnet

1. Allow some current I in the electromagnet from the constant current source.

2. Note the corresponding magnetic field B_z using Gauss probe and flux meter.

3. Measure the magnetic field for different values of current.

(B) Measurement of Hall Voltage

1. Place the specimen between the pole pieces of the electromagnet and set a suitable current.

2. Allow some current (mA) through the semiconductor and note the corresponding Hall voltage (mV).

3. Measure Hall voltage for different value of Hall Voltage.

4. Repeat the steps (2) and (3) for different values of current in the electromagnet.

LEAST COUNT:

It can be calculated by dividing the one division of main scale by total no. of divisions on Vernier scale.

Calculation :-

For 1A = slope $= \left|\frac{61-32}{4-2.10}\right| = 15.26$

$R_H = \frac{slope}{B_z} \times 1\ m^3/C$

$B_z = 2.40$ gauss

$R_H = \frac{15.26}{2.40} \times 10^{-3} = 6.35 \times 10^{-3}\ m^3/C$

For 2A = slope $= \left|\frac{60.5-31.6}{4-2.10}\right| = 15.21$

$R_H = \frac{15.21 \times 10^{-3}}{4.60} = 3.30 \times 10^{-3}\ m^3/C$

For 3A = slope $= \left|\frac{60-30.32}{4-2.10}\right| = 15.15$

$R_H = \frac{15.15 \times 10^{-3}}{6.14} = 2.48 \times 10^{-3}\ m^3/C$

Mean $R_H = \frac{6.35 + 3.30 + 2.48}{3} \times 10^{-3}$

$= 4.043 \times 10^{-3}\ m^3/C$

OBSERVATIONS:

(A) Calibration of the Electromagnet

S.No.	CURRENT (in Ampere)	MAGNETIC FIELD (in Gauss)
1.	1 A	2.40
2.	2 A	4.60
3.	3A	6.14

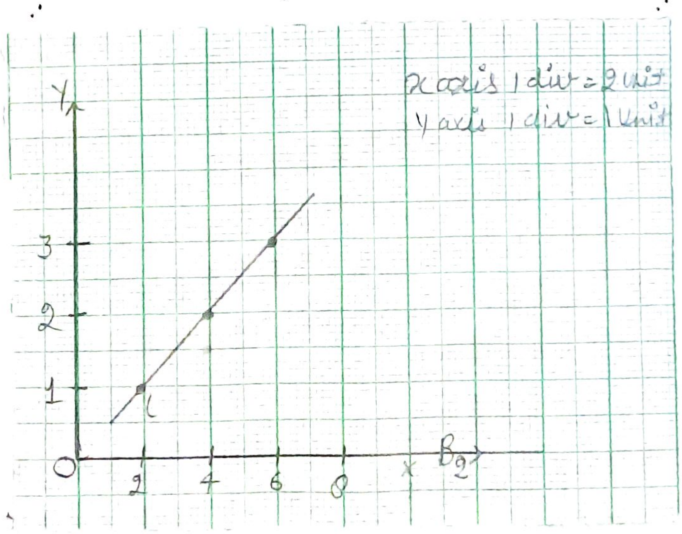
(B) Measurement of Hall Voltage

S.No.	For I = 1 Amp		For I = 2 Amp		For I = 3 Amp	
	Current through specimen I_x (mA)	Hall Voltage V_H (mV)	Current through specimen I_x (mA)	Hall Voltage V_H (mV)	Current through specimen I_x (mA)	Hall Voltage V_H (mV)
1.	1.02	15.6	1.02	15.5	1.02	15.6
2.	2.10	32.0	2.10	31.6	2.10	30.0
3.	3.00	45.6	3.00	45.3	3.00	45.5
4.	4.00	61.0	4.00	60.5	4.00	60.8
5.	5.00	76.6	5.00	76.8	5.00	76.0

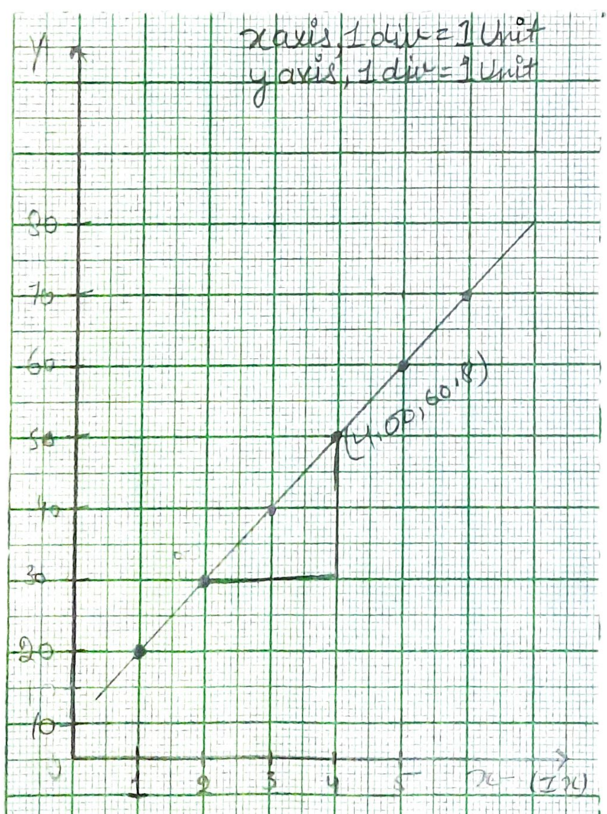
CALCULATIONS:

(A) Calibration of the Electromagnet

Plot a graph between I (current) and B_z (Magnetic Field).



For 3A:-

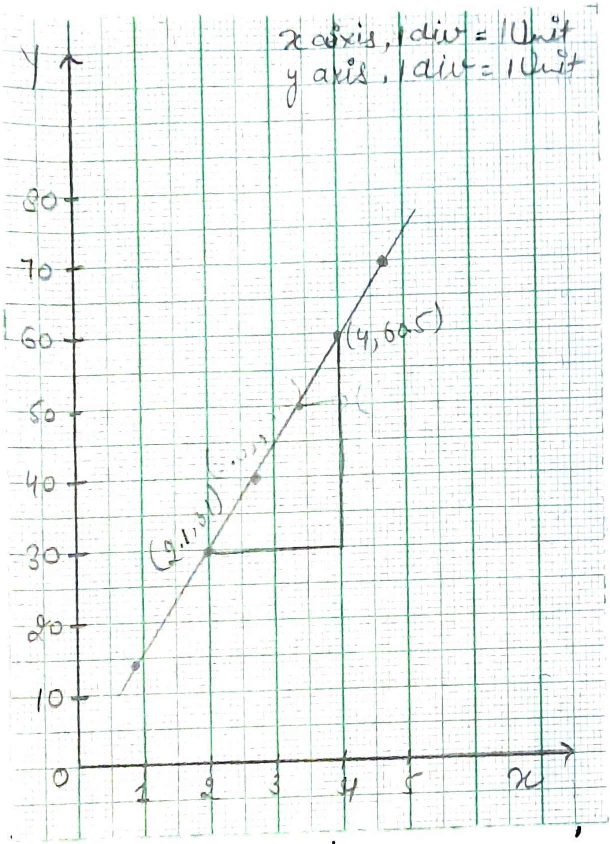


$$\text{Slope} = \left| \frac{60-30.0}{4-2.10} \right| = 15.15$$

(B) Measurement of Hall Voltage

i) Plot a graph between V_H and I_x for different values of I and calculate the slope of each line $\frac{V_H}{I_x}$ and the Hall coefficient.

$$R_H = \frac{V_H\, t}{I_x\, B_z}$$



For 1A :-

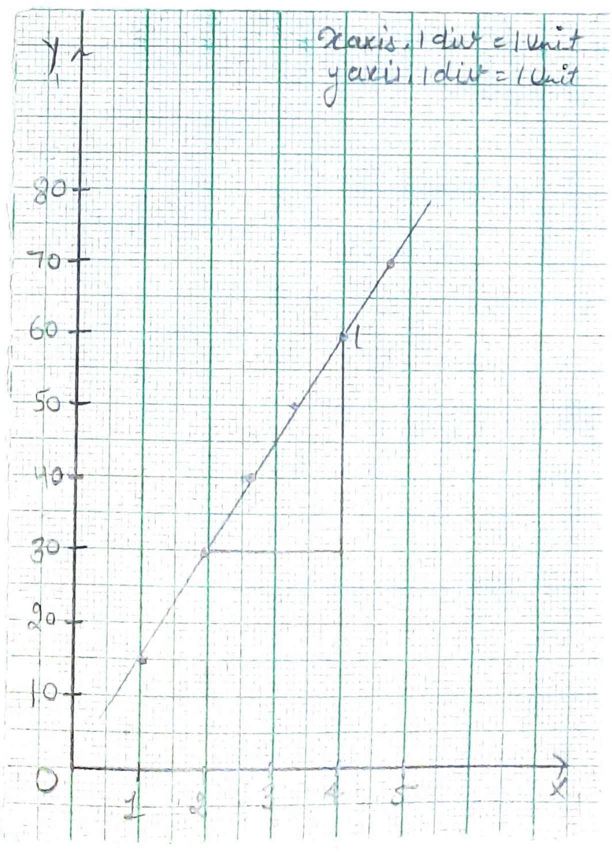
Slope = $\left|\frac{61-32}{4-2.10}\right|$

= 15.26

For 2A :-

Slope = $\left|\frac{60.15-31.6}{4-2.10}\right|$

= 15.21



The no. of charge carriers in the specimen –

$$\frac{1}{eR_H} = \frac{1}{1.6 \times 10^{-19} \times 4.04 \times 10^{-3}}$$

$$= 1.547 \times 10^{21}$$

Or

$$R_H = slope \times \frac{t}{B_z} \; m^3/C$$

$$R_H = \cdots \ldots\ldots \times \frac{\ldots\ldots}{\ldots\ldots\ldots} \; m^3/C = 4.04 \times 10^{-3}$$

ii) The number of charge carriers in the specimen

$$n\ (\text{or } p) = \frac{1}{eR_H}$$

$$n\ (\text{or } p) = \frac{1}{1.6\times10^{-19}\times 4.04\times10^{-3}} = 1.57\times10^{21}$$

RESULT:

1. The Hall coefficient R_H = 4.043×10^{-3} m^3/C.
2. The number of charge carriers = 1.54×10^{21}.
3. The nature of given semiconductor material is P type.

PRECAUTIONS:

1. Hall voltage developed is very small and should be measure accurately.
2. The specimen should be kept properly in the magnetic field of electromagnet.
3. Current through the semi-conducting crystal should be strictly by 10 mA.
4. Electromagnet should not be touched during flow of current through it.
5. Current through electromagnet should not reach more than 3 Ampere.
6. Switch off the current through electromagnet after completion of readings.

EXPERIMENT NO:05...

NEWTON'S RING

OBJECT: To determine the wavelength of monochromatic (sodium) light by Newton's rings method.

APPARATUS USED: A plano-convex lens, a plane glass plate, sodium lamp, a travelling microscope, a convex lens, a reading lens, a partly reflecting glass plate inclined at 45° and a table lamp.

FORMULA USED: The wavelength (λ) of monochromatic light is determined by the formula

$$\lambda = (D^2_{n+p} - D^2_{n})/ 4pR$$

Where D_{n+p} = Diameter of $(n+p)^{th}$ ring

D_n = Diameter of n^{th} ring

p = An integer number

R = Radius of curvature of the curved face of the plano- convex lens.

APPARATUS ARRANGEMENT:

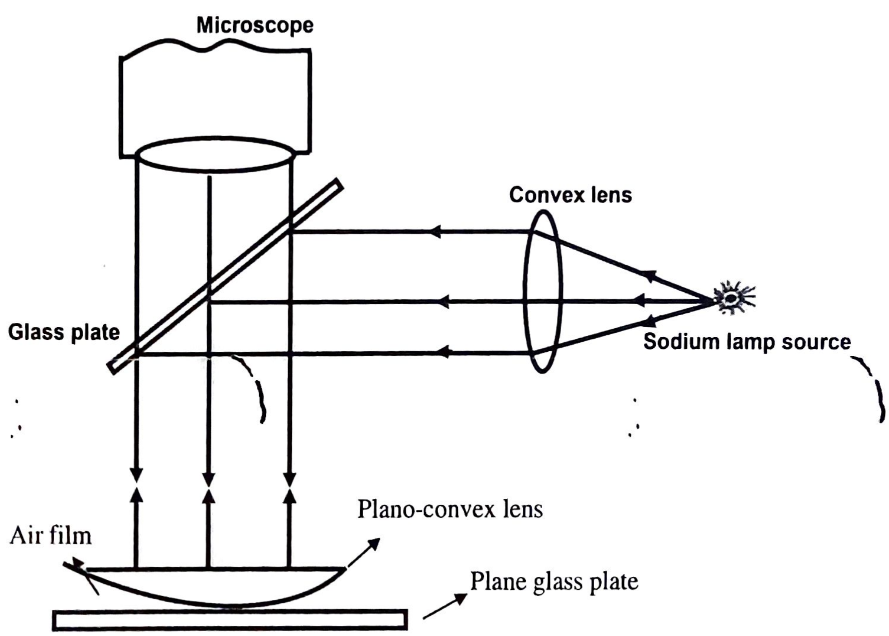


Figure: Newton's Rings in apparatus

PROCEDURE:

1. Make the experimental arrangement as shown if figure (1) and allow the beam of light to pass through the convex lens L.
2. Adjust the partially silvered glass plate at 45^0 so that beam of light gets reflected and falls normally on the plano-convex lens.
3. Focus the microscope till sharp circular dark and bright rings are observed. If the rings are not in field of view, adjust the microscope horizontally/vertically to view the rings. If the rings are not well illuminated, adjust the inclination of the glass plate.
4. Bring the cross wire at central ring and move it slowly towards left (or right) with help of knob provided at right hand side of the base of microscope till you reach at 20^{th} ring, and set the cross wire tangential to the 20^{th} ring.
5. Take the reading of microscope on the main scale (MS) and circular scale (CS).
6. Similarly move further and take observations when the cross wire is tangential to the 19^{th}, 18^{th}, 17^{th},...........,5^{th} ring.
7. Move the cross wire further along the same direction so that it becomes tangential to the 5^{th} bright ring on the other side of the central ring.
8. Take the observation up to 20^{th} bright ring.

OBSERVATIONS:

Value of one division of the main scale of the microscope = ...cm 1mm

Number of divisions on the vernier scale = ... division 100

$$\text{Least count of the microscope (LC)} = \frac{\text{Value of one division of the main scale}}{\text{Total number of divisions on the vernier scale}}$$

$$LC = \frac{....}{......} = \frac{1\,mm}{100} = 0.01\,mm.$$

* Calculation :-

Mean $D^2_{n+p} - D^2_n = 10.345 \text{ mm}^2$

$$\frac{D^2_{n+p} - D^2_n}{4pR} = \frac{10.345 \text{ mm}^2}{4 \times 5 \times 1000 \text{ mm}^2}$$

$= 5172.5 \times 10^{-10}$ m

$= 5172.5$ A°

* Percentage Error :- $\left| \frac{5893 \text{A}^\circ - 5172.5 \text{A}^\circ}{5893 \text{A}^\circ} \right| \times 100$

$= 12.22\%$

Table: For the measurement of $D^2_{n+p} - D^2_n$

Number of rings	Left end of the rings: Main Scale reading (mm) (a)	Vernier Scale readin (LC x n) (b)	Total reading (L) (mm) (a+b)	Right end of the rings: Main Scale reading (mm) (a')	Vernier Scale reading (LC x n) (b')	Total reading (R) (mm) (a + b')	Diameter of the ring (L-R) (mm) D	Square of the diameter $(L-R)^2$ $(mm)^2$ D^2	$D^2_{n+p} - D^2_n$ $(mm)^2$
20	49	0·68	49·68	43	0·38	43·38	6·30	39·69	11·92
19	49	0·54	49·54	43	0·46	43·46	6·08	39·76	11·16
18	49	0·32	49·32	43	0·52	43·52	5·80	33·64	9·93
17	49	0·22	49·21	43	0·60	43·60	5·62	31·58	9·68
16	49	0·12	49·12	43	0·69	43·69	5·43	29·48	9·50
15	49	0·05	49·05	43	0·78	43·78	5·27	27·77	9·71
14	48	0·94	48·94	43	0·86	43·86	5·08	25·80	10·52
13	48	0·84	48·84	43	0·97	43·97	4·87	23·71	10·71
12	48	0·73	48·73	44	0·05	44·05	4·68	21·90	10·20
11	48	0·62	48·63	44	0·15	44·15	4·47	19·88	10·37
10	48	0·51	48·62	44	0·26	44·26	4·25	10·06	10·10
9	48	0·39	48·51	44	0·48	44·48	3·91	15·28	10·40
8	48	0·27	48·39	44	0·58	44·59	3·68	15·24	
7	48	0·12	48·27	44	0·71	44·71	3·41	11·69	
6	47	0·96	48·12	44	0·86	44·86	3·10	9·61	
5	47	0·78	47·78	45	0·03	45·03	2·75	7·56	
4	47	0·56	47·56	45	0·35	45·38	2·21	4·88	

CALCULATIONS:

1. Radius of the curvature R of the convex surface of the plano convex lens R = --- 1000 mm
2. The wavelength of sodium light λ is calculated by substituting value of R and measured value of $D^2_{n+p} - D^2_n / 4pR$ = ...cm = ...A^0 5172.5 A

RESULT: The wavelength of sodium light = ...A^0 5172.5 A^0

STANDARD RESULT: The standard value of wavelength of sodium light = 5893 A^0

PERCENTAGE ERROR:

$$Percentage\ error = \frac{Standard\ value - calculated\ value}{standard\ value} \times 100 = \ldots.\%$$

$$= \frac{5893Å - 5172.5Å}{5893Å} \times 100 = 12.22\%$$

PRECAUTIONS AND SOURCES OF ERROR:

(i) Glass plates and lens should be cleaned thoroughly.

(ii) Before measuring the diameter of rings, the range of the microscope should be properly adjusted.

(iii) Cross wire should be focused on a bright ring tangentially.

(iv) Radius of curvature should be measured accurately.

EXPERIMENT NO: ..06..

DIFFRACTION GRATING

OBJECT: To determine the wavelength of spectral lines using plane transmission grating.

APPARATUS USED:

A spectrometer, a diffraction grating of known grating element, mercury lamp (white light source), spirit level, an electric lamp and reading lens.

FORMULA USED:

The wavelength of any spectral line is given by

$$\lambda = \frac{(e + d)sin\theta}{n}$$

where (e+d) = grating element

θ = angle of diffraction

n = order of the spectrum

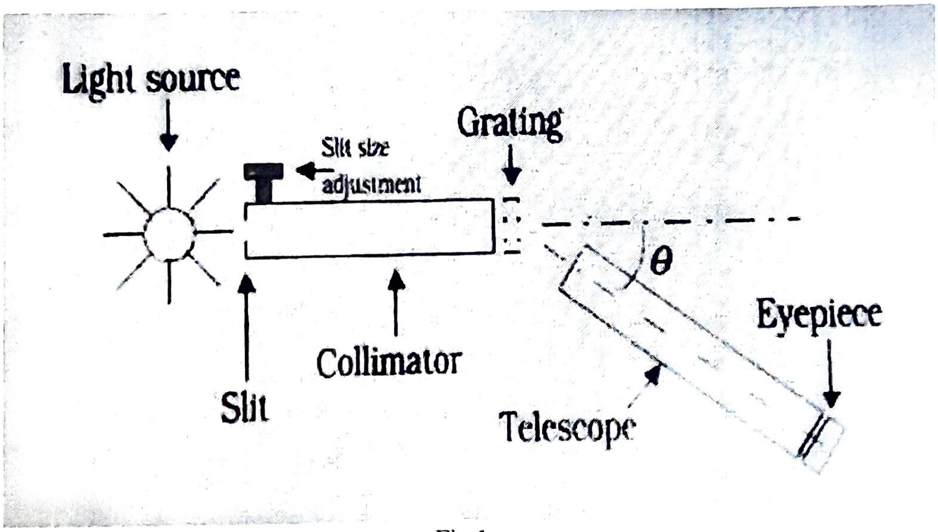


Fig.1s

PROCEDURE:

This experiment is performed in the following two parts :

1. Adjustments 2. Measurements

1. Adjustments

a) Spectrometer should be adjusted for parallel rays.
b) Prism table must be optically leveled using sprit level.
c) The grating is mounted on the prism table such that it is made approximately normal to the axis of the collimator by rotating the prism table.
d) The direct image of the slit is then made to coincide with the vertical cross wire of the telescope.

2. Measurements for angle of Diffraction

a) Place the grating in its holder normal to the surface of the turn table.

b) Rotate the telescope (without disturbing the above adjustment) to the left side of the white light.

c) Set the cross-wire on different spectral lines one by one and note down the reading of both the verniers.

d) Now rotate the telescope to the right side of the white light and note down the reading of both the verniers keeping cross-wire on the corresponding spectral lines.

OBSERVATIONS:

1. Least count of Spectrometer: 1/60
   Value of one division of main scale = ...1..
   Total number of divisions on vernier scale = 60

$$Least\ count\ of\ spectrometer = \frac{value\ of\ one\ division\ on\ main\ scale}{\text{Total number of divisions on vernier scale}}$$

$$= \frac{\dots\dots}{\dots\dots} \quad = 1/60 \text{ degree}$$

2. Determination of grating element:

$$(e+d) = \frac{1\ inch}{Total\ number\ of\ lines\ per\ ich\ on\ the\ grating}$$

$$(e+d) = \frac{2.54\ cm}{N} = \frac{2.54\ cm}{\dots\dots} \dots\dots cm = 1.69 \times 10^{-4} cm$$

$$= 1.69 \times 10^{-6}\ m$$

3. Measurement of the angle of diffraction:

Order of the spectrum	Colour of the spectral line	Vernier	Reading of the telescope when set on the spectrum						2θ = a~b	θ degrees
			Left side			Right side				
			M.S. Reading	V.S. Reading	Total [MS+ (VS× LC)]	M.S. Reading	V.S. Reading	Total [MS+ (VS× LC)]		
I order	Violet	V_1	163	0.3	163.3	186.25	0.25	188.5	25.2	11.67
		V_2	342.75	0.316	343.06	366.25	0.26	366.7	23.4	
	Green	V_1	158.75	0.166	158.91	190.5	0.25	190.75	31.64	15.9
		V_2	330.75	0.233	338.72	370.25	0.25	370.5	31.76	
	Yellow	V_1	157.5	0.25	157.75	11.5	0.28	191.78	34.03	16.07
		V_2	333.75	0.266	338.01	371.25	0.25	371.5	33.49	

CALCULATIONS:

1. The wavelength of spectral lines is determined using

$$\lambda = \frac{(e+d)sin\theta}{n}$$

Violet............ λ(voilet) = (e+d) Sin t
= (1·69 × 10⁻⁶ × 0·202) = 0·34138 × 10⁻⁶ m
= 3413·8 A°

Green............ λ(Green) = (1·69 × 10⁻⁶ × 0·273)
= 0·46137 × 10⁻⁶ m
= 4613·7 A°

Yellow............ λ(Yellow) = (1·69 × 10⁻⁶ × 0·290)
= 0·4901 × 10⁻⁶ m
= 4901 A°

2. The percentage error is calculated by the formula

$$\% \, error = \frac{standard \ value - calculated \ value}{standard \ value} \times 100$$

for voilet = |(4097A° − 3413·8) / 4347| × 100 = 15·6%

For Green = |(4916 − 4613·7) / 4916| × 100 = 6·1%

For Yellow = |(5770 − 4901) / 5770| × 100 = 15·06%

RESULT:

The experimental and standard values of wavelength foe spectral lines of various along with the percentage error are given below:

Colour	Standard value	Experimental value	Percentage error
Violet	4047Å	3413·8 A°	15·6 %
Green	4916 Å	4613·7 A°	6·1%
Yello	5770 Å	4901 A°	15·06 %

PRECAUTIONS AND SOURCES OF ERROR:

1. The mechanical & optical adjustments of the telescope must be made carefully and correctly.
2. The slit should be made as narrow as possible.
3. Grating should be properly normal to the axis of the collimator.
4. The prism table must be levelled optically.
5. While taking observations, the prism table and telescope must be clamped.
6. To set the cross-wires on spectral lines of various colours tangent screw must be read.

EXPERIMENT NO07..

WAVELENGTH OF He-Ne LASER LIGHT BY DIFFRACTION

OBJECT: To determine the wavelength of He-Ne laser light by diffraction at a single slit.

APPARATUS USED: He-Ne laser, a single slit, a long optical bench, meter stick and mounting devices.

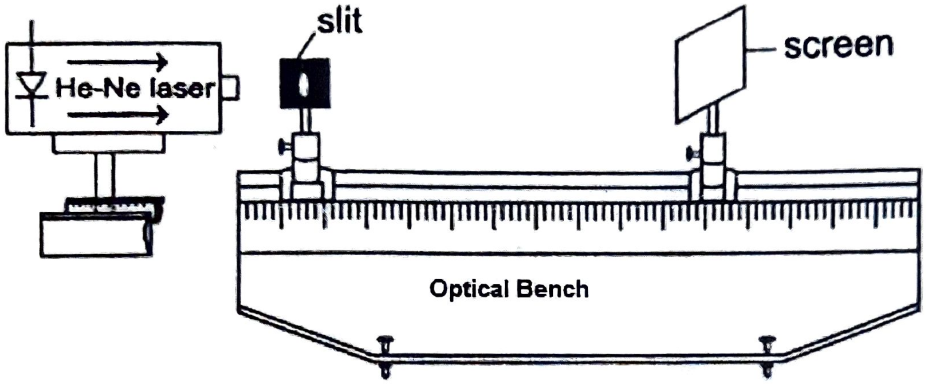


Figure: Helium Neon Laser Apparatus

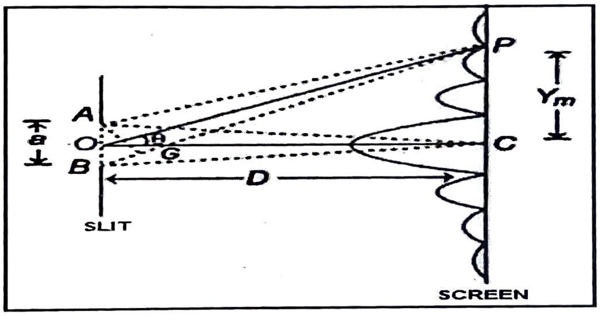


Figure: Diffraction Pattern

FORMULA USED: The wavelength of laser light is given by

$$\lambda = \frac{aY_m}{mD}$$

Where

a = width of single slit.

Y_m= distance of m^{th} dark ring.

m = 1, 2, 3.......order of the dark fringe.

D= distance between slit and screen.

PROCEDURE:

1. First of all mount the He-Ne laser source at one end and the screen at the opposite end of the optical bench. Now adjust the distance between the laser source and screen in such a way that a tiny circular patch of light is observed in the middle of the screen.
2. Mount the single slit near the laser source on the optical bench.
3. Now, adjust the direction of the laser and the position of the slit to give the clearest possible diffraction pattern on the screen.
4. Measure the distance D from the slit to the screen.
5. Now, measure the distance between the central maximum and the first, second, third........minima on either side of central maximum.
6. Repeat this procedure for the different distance D.

OBSERVATIONS:

S.No.	Slit width (a) mm	The distance of slit from screen (D) m	Half distance between nth dark fringe on the left/right and that of central maximum					Mean separation between adjacent dark fringe (Y/m)
			Between dark bright fringe (y_1)	Between dark bright fringe (y_2)	Between dark bright fringe (y_3)	Between dark bright fringe (y_4)	Between dark bright fringe (y_5)	
1.								
2.	0.15	1.035	4.8	9	13.3	16.5	20.5	4.331

CALCULATIONS: The wavelength of the He-Ne laser light is given by

$$\lambda = \frac{aY_m}{mD} = \frac{0.15 \times 4.331}{1035} = 0.0006276011$$

$$= 6.276011 \times 10^{-4} mm$$

$$\Rightarrow 6.276011 \times 10^{-7} m$$

$$\boxed{\lambda \Rightarrow 6276.0 A^\circ}$$

RESULT: The wavelength of the He-Ne laser is 6276.0 A°

STANDARD RESULT: The wavelengthof the He-Ne laser in visible region is

632.8 nm (6328A^0).

PERCENTAGE ERROR: $= \frac{Standard\ Value - Calculated\ Value}{Standard\ Value} \times 100 =$ 0.8%

$$= \frac{6328 - 6276.0}{6328} \times 100 = 0.809\%$$

PRECAUTIONS AND SOURCES OF ERROR:

1. Do not look into the laser beam; even low power laser will cause permanent damage to your vision.
2. The slit width must be measured quite accurately.
3. All the measurements must be made very carefully otherwise error will appear in result.

EXPERIMENT NO:08...

NODAL SLIDE

OBJECT: - To determine the focal length of the combination of two thin convergent lenses separated by a distance with the help of a Nodal Slide and verify to the formula.

APPARATUS: - Nodal – Slide assembly (consisting of an optical bench, plane mirror, cross slit and lamp) and the two given lenses.

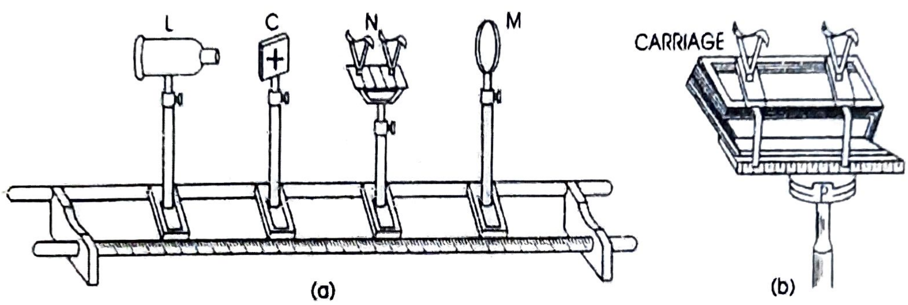
FORMULA USED :- the focal length of the combination of two thin convergent lenses

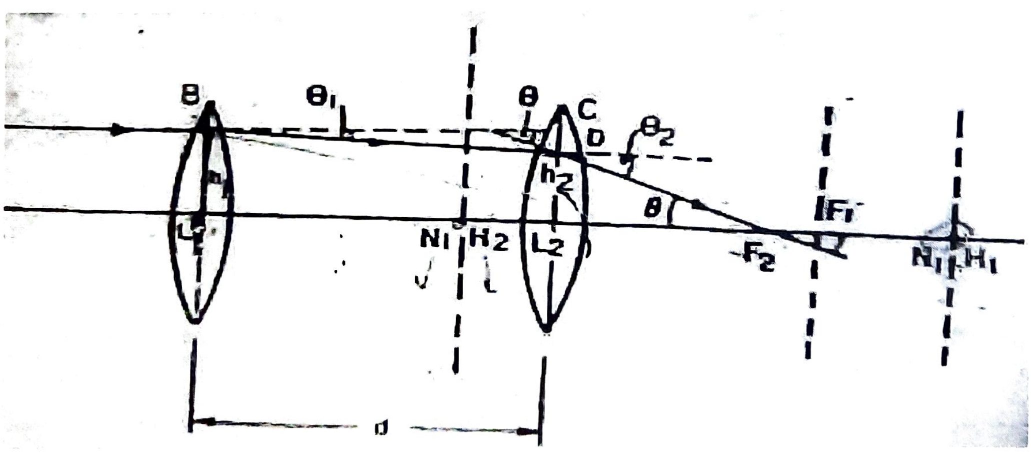
$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Where, F = focal length of the combination

f_1, f_2 = focal length of the two lenses

and d = distance between the two lenses.





METHOD: -

(1) First the focal length f_1 and f_2 of the two given lenses are determined. . For this one of the lenses is mounted on the nodal – slide such that its optical center lies on the axis of rotation of nodal slide. The source of light, screen having the cross slit and plane- mirror are mounted on the proper uprights and the heights of uprights are adjusted in such a manner that the line joining the center of each part is parallel to the bed of the bench.

(2) The cross- slit is illuminated and the plane of the mirror is adjusted till the image of the cross slit is formed close to the cross slit itself. If the image is blurred and not well defined then the upright carrying the nodal slides moved towards or away from the slit till the image becomes sharp and well defined. (In this position light diverging from the cross-slit emerges as a parallel beam of light after passing through the lens. This parallel beam of light is reflected as a parallel beam from the plane–mirror and brought to focus on the plane of the cross- slit by the lens. In other words, the screen having the cross -slit serves as the second focal plane for the parallel beam of light coming from the plane mirror.)

(3) The slide is rotated slightly about the vertical axis and lateral shift of the image is observed. If there is any shift, the position of the axis of rotation with respect to the lens is slightly changed by moving the nodal slide on the upright by means of the screw provided for this purpose. The sharpness of the image is disturbed. The image is refocused by moving the upright (carrying the nodal slide) on the optical bench. Lateral shift of the image is again observed. The same process is repeated till the image of the slit is in sharp focus and does not show any lateral shift when the nodal slide is slightly rotated about its vertical axis. The distance between the plane of the cross slit and the axis of rotation now gives the focal length of the lens.

(4) The lens is rotated through 180^0 and the whole process is repeated. The mean of the two distances, thus obtained, will give the exact focal length "f" of the lens.

(5) The first lens is removed and the second lens is mounted on the nodal- side. Its focal length "f" is determined in the same manner as described.

(6) To determine the focal length of the combination, the two lenses are mounted on the nodal slide at some distance apart (the lenses are being placed equidistance and on opposite sides of the axis of rotation). By adjusting the inclination of the plane mirror and the position of the nodal slide the image of the cross slit is made to lie on the side of the slit itself. The shift in the image due to a slight rotation of the nodal slide is observed. If there is any lateral shift, with the simultaneous focusing of image a suitable position of the nodal slide is determined for which no lateral shift of the image occurs due to a slight rotation of the nodal slide. The distance between the plane of the screen and the axis of the rotation of the nodal slide now gives the focal length of the combination.

(7) Different sets of reading are to be taken by turning the faces of the lens through $180^0$and inter–changing the position of the component lenses.

(8) The experiment is repeated for different values of x- the distance between the lenses

(9) The focal length of the combination is also obtained theoretically for each value of x by the formula

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$$

$$F=\frac{f_1 f_2}{f_1+f_2-d}$$

It will be found that the experimental and theoretically values of the focal length of the combination for given separation agree fairy well thus verifying the truth of the formula.

OBSERVATIONS: -

(A) Observation for the focal length of the first lens:

S.No.	Light Incident on	Position of the cross-slit (a) cm.	Position of the axis of rotation of the nodal slide (b) cm.	focal length =(a-b) cm.	Mean focal length
Lens 1	One face	10	30	20	f_1 = 20.5
	Other face	10	31	21	
Lens 2	One face	10	31	21	f_2 = 20.5
	Other face	10	30	20	

(B) Observations for the focal length of the combination:

S.No.	Distance between lenses (d) cm	Light Incident on	Position of cross slit (a) cm	Position of the axis of rotation of the nodal slide (b) cm.	Focal length of the system F (a-b) cm.	Focal length of the system F Mean cm.
1.	6	One lens	10	21	11	11.1
	6	Other lens	10	21.2	11.2	
2.	6	One lens	10	21.5	11.5	12
	6	Other lens	10	22.5	12.5	

CALCULATION:

(A) Focal length of the coaxially convergent system is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$F = \frac{f_1 f_2}{f_1 + f_2 - d}$$

$$F = \frac{20.5 \times 20.5}{20.5 + 20.5 - 6}$$

$\Rightarrow$ 12.0071 CM

(a) For d = 6 cm.

F = 12.0071 cm.

(b) For d = ---------------------cm.

$f = \frac{20.05 \times 20.5}{20.05 + 20.05 - 8}$

$\Rightarrow$ 12.734 cm

F = 12.734 cm.

f_1 = 20.05 cm.

f_2 = 20.05 cm.

(B) Location of cardinal points is determined as

a) First principal point $L_1H_1 = \frac{Fd}{f_2} =$

b) Second principal point $L_2H_2 = -\frac{Fd}{f_1} =$

c) First focal point $L_1F_1 = -F\left(1 - \frac{d}{f_2}\right) =$

d) Second focal point $L_2F_2 = +F\left(1 - \frac{d}{f_1}\right) =$

RESULTS:

From the above table it is obvious that the experimental and theoretical values of the focal length of the system are nearly the same for each value of x separately. Hence the formula

$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$ is verified

Percentage Error: -

$$= \frac{\text{Experimental Value} - \text{Calculated Value}}{\text{Experminal Value}} \times 100 = 0.0591\ \%$$

$$= \frac{12\text{cm} - 12.0071}{12\text{cm}} \times 100 = 0.0591\ \%$$

PRECAUTIONS

1. False images formed by partial reflection from the faces of the lenses should not be confused with the true image of the cross-slit.

2. While determining the focal length of a single lens, its optical centre must lie on the axis of rotation of the nodal slide. (for easy and quick setting)

3. The nodal slide should be rotated slightly about the axis of rotation.

4. In order to get a bright image of the slit the plane mirror should be placed as close to the combination as possible.

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EXPERIMENT NO:09..

VARIATION OF MAGNETIC FIELD

OBJECT: To study the variation of magnetic field along the axis of a current carrying circular coil and then to estimate the radius of the coil.

APPARATUS USED: Stewart and Gee type galvanometer, battery eliminator (power supply), connecting wires and spirit level.

FORMULA USED: The magnetic field B due to a current carrying coil at a distance x from the center of the coil is given by:

$$B = \frac{2\pi n i a^2}{10(a^2 + x^2)^{3/2}}$$

Where,

n = number of turns in the coil
a = radius of coil
i = current flowing through the coil

DIAGRAM:

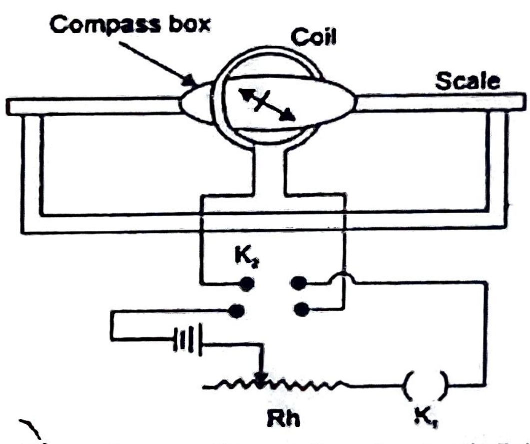


Figure: Appratus for variation of magnetic field

PROCEDURE:

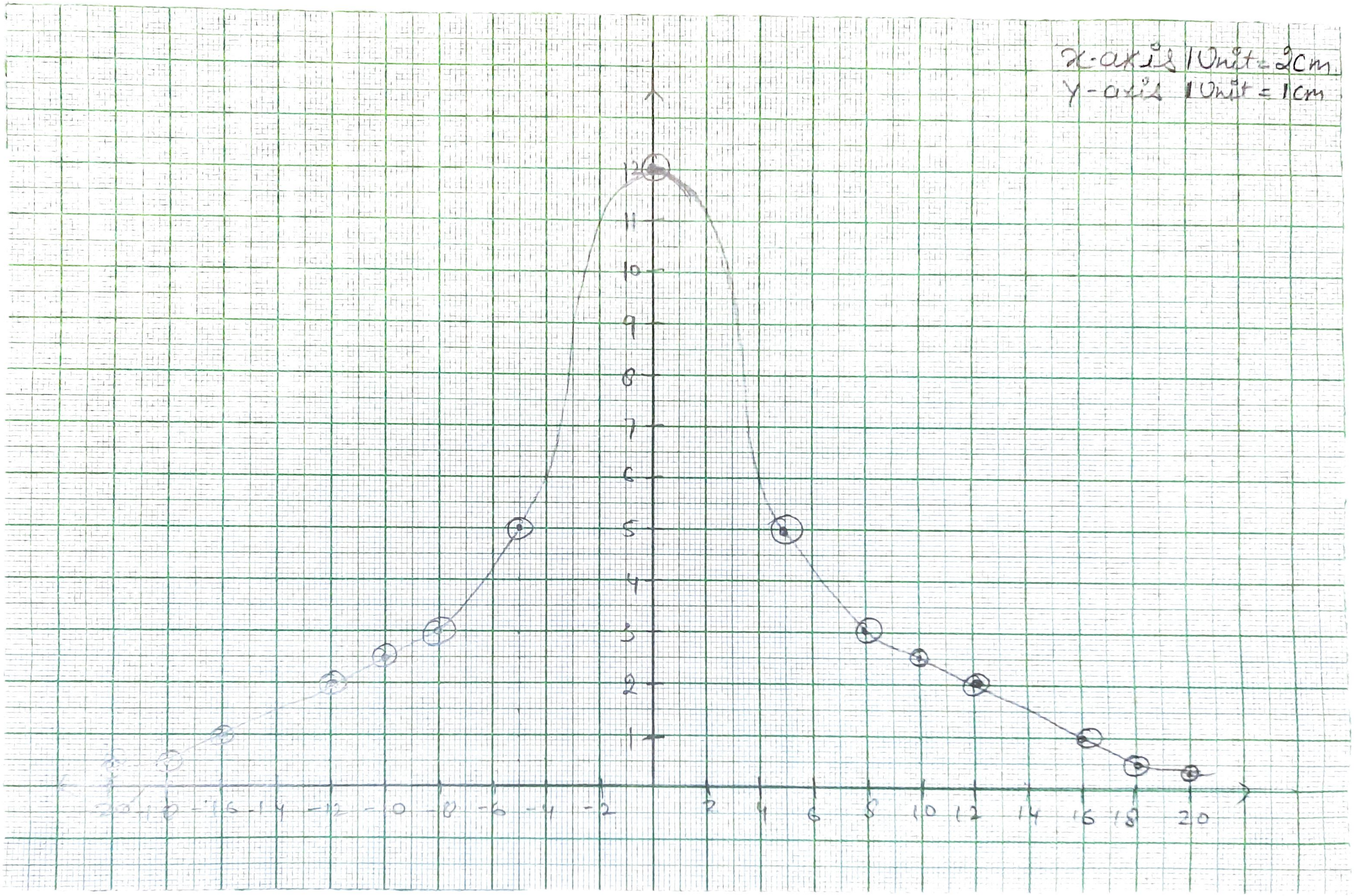
1. Set the compass into Magnetic meridian at the center of the coil.
2. Set the current in the coil such that the deflection is almost 60° & note down the value of θ_1 & θ_2 at $x = 0$. (At constant current)
3. Now, move the compass towards LHS for different value of x according to observations table.
4. After completing the observations of LHS take similar observations for RHS for the same value of x.

OBSERVATION:

S.No.	Distance of the needle (x) from the center of coil. (cm)	Deflection in the coil East Direction (L.H.S.)				Deflection in the coil West Direction (R.H.S.)			
		θ_1	θ_2	Mean θ	tan θ	θ_1	θ_2	Mean θ	tan θ
1	0	85	85	85	11.43	85	85	85	11.43
2	1	79	79	79	5.14	80	80	86	5.67
3	2	77	77	77	9.33	78	78	78	4.07
4	3	72	72	72	3.07	74	74	74	3.48
5	4	69	69	69	2.60	70	70	70	2.74
6	5	61	60	60.5	1.76	62	61	61.5	1.84
7	6	53	52	52.5	1.30	55	55	55	1.42
8	7	48	48	48	1.11	50	50	50	1.19
9	8	40	42	41	0.86	42	42	40	0.90
10	10	35	36	35.5	0.71	36	37	36.5	0.73
11	12	29	29	29	0.55	30	30	30	0.57
12	14								
13	16								
14	18								
15	20								

CALCULATION & RESULT:

1. The radius of the coil as measured from the points of inflexion using the graph = ……... cm.
2. The radius of the coil as determined by the measurement of the circumference of the coil = ……cm


x-axis 1 Unit = 2cm
Y-axis 1 Unit = 1cm

GRAPH: (Between x and $\tan\theta$)

STANDARD RESULT: Radius of coil is 10 cm.

PERCENTAGE ERROR:

% error in the determination of radius of current carrying coil

$$= \frac{\text{Standard Value} - \text{Calculated Value}}{\text{Standard Value}} \times 100$$

$$= \frac{10 - 9.6}{10} \times 100 = 4\,\%$$

PRECAUTIONS & ERROR:

1. There should be no magnetic material or current carrying conductor in the neighborhood of the apparatus.
2. The coil should be adjusted in the magnetic meridian carefully.
3. Initial reading of the pointer must be set as zero. If there is any error, it must be taken into account while recording the deflection.

B H CURVE (HYSTERESIS CURVE)

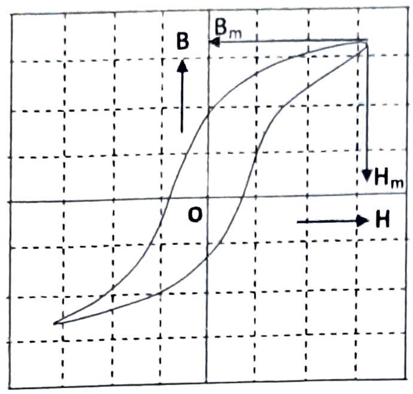
OBJECT: To draw the hysteresis curve of the given ferromagnetic material by C.R.O.

APPARATUS USED: A step down transformer, specimen transformer hysteresis loss of which is to be calculated, resistor (50 kΩ potentiometer), capacitor, a c voltmeter, a c milliammeter, Rheostat (10 ohm).

CIRCUIT DIAGRAM : Circuit is shown in figure. Step down transformer converts 220 volt a.c. to 12 volt a.c.. A-A points are connected to X – plates of C.R.O. and B-B points to Y-plates of C.R.O.

PROCEDURE:

1. Plug in A. C. Mains and switch ON the instrument. Short the A sockets with lead provided with the kit.
2. Connect C. R. O. leads in **X** and **ground** terminals of the kit.
3. Also connect **Y** terminals to C. R. O.'s Y connector and **ground** to ground terminal.
4. Switch on the C. R. O. and by putting the time switch at X-Y Mode.
5. Trace the curve by adjusting X and Y control of C. R. O. and that of B.H. curve set up mark potentiometer and select.
6. Adjust the shape of curve by inserting the iron rods in the coil.



B – H Curve

RESULT: The hysteresis curve of the specimen transformer is shown on the trace paper.

PRECAUTIONS:

1. Attenuator of C.R.O. should be kept at a suitable position.The positions of X and Y amplifiers should not be disturbed after adjusting it once in the whole experiment.
2. Variations in the supply voltage will affect the tracing of the curve on the paper.
3. Handle C.R.O. carefully.

hysteresis curve of the specimen