APPLIED PHYSICS
PH-122
PRACTICAL WORKBOOK

FOR

First Year

Batch : 2020-2021

NAME OF STUDENT: Nashra Ghaffar

CLASS ROLL NO.: 32 SECTION: G1

DISCIPLINE: BCIT

SEMESTER: 1st Semester.

DEPARTMENT OF PHYSICS
NED UNIVERSITY OF ENGINEERING & TECHNOLOGY,
KARACHI, PAKISTAN.

Applied Physics PH-122

CERTIFICATE

Certified that ~~Mr.~~/ Ms Nashra Ghaffar of class **First year Engineering** Bearing Seat No. CT-032 Department BCIT has completed the course in **Applied Physics Practical** as prescribed by the NED University of Engineering & Technology, Karachi for the Academic Session 2020-2021.

Date: 24-Jun-2021

Lab. Teacher

Applied Physics PH-122

Applied Physics Practical

Name of Student: Nashra Ghaffar
Class Roll No.: CT-032 **DISCIPLINE:** BCIT

S. No.	Description	Page #	Remarks	Signature & Date
1.	To determine the Horizontal component of Earth magnetic field strength "H" by Tangent Galvanometer.	07		
2.	To study the characteristics of an acceptor circuit and determine unknown inductance.	12		
3.	To study the characteristics of a rejecter circuit and determine unknown inductance.	18		
4.	To determine the Mechanical equivalent of heat "J" by Calendar and Barne's apparatus.	25	1.5	Marium 9/11/2020
5.	To study the spectral characteristics of photocell and determine the Planck's constant.	29		3
6.	To determine the charge to mass ratio (e/m) of electron.	35		Marium 23/11/2020
7.	To determine the refractive index of the material of a prism using spectrometer.	40		
8.	To determine the velocity of wave propagation in stretched string by using sonometer.	45		
9.	To determine the unknown high resistance by Neon Flash Bulb Apparatus.	50		
10.	To determine the coefficient of viscosity of given liquid (Glycerin) by Stoke's method.	55		
11.	To determine the ionization potential of mercury using a gas filled diode.	60		
12.	To draw a Hysteresis curve for a given ferromagnetic material (Iron) and determine retentivity and coercivity of given material.	66		

PRODEDURE:

1. Connect the circuit as shown in figure.
2. Using leveling screw adjust dial of magnetometer, so that needle could not strike the dial.
3. Adjust the needle of tangent galvanometer so that, the needle is perpendicular to the circular coil.
4. Set rheostat for minimum current (i-e Max resistance), turn on the circuit and give 10°, 15°, 20°, 25° and 30° clockwise deflection to magnetometer needle by increasing the current with rheostat.
5. Reverse the keys of reversing switch and repeat the step 4 in anticlockwise direction.
6. Note down the corresponding current for each deflection.
7. Plot a graph between I and tanθ, which will be a straight line of slope I/tanθ.
8. Knowing also N and r, H_e can be calculated.

OBSERVATIONS:

No. of turns in the coil = n = 50 turns

Radius of the coil = r = 0.0715 m

S.No.	Angle θ deg	Current in mA			
		Clock Wise Reading I_1 mA	Anti-Clock Wise Reading I_2 mA	MEAN $I=(I_1+I_2)/2$ mA	$\tan\theta$
01	5	6.5	7.7	7.1	0.087
02	10	13.6	15.5	14.55	0.176
03	15	20.9	22.2	21.55	0.267
04	20	28	30.9	29.45	0.363
05	25	37.2	37.8	37.5	0.466

CALCULATION:

$$H_{ex} = \frac{nI}{2r\tan\theta} \text{ amp per meter}$$

1 amp per meter = 0.01256 oersted.

$$H_{ex} = \frac{(50)(24\times10^{-3})}{(2)(0.0715)(0.3)}$$

$$\boxed{H_{ex} = 27.972\ A/m}$$

$$H_{ex} = 27.972 \times 0.01256 \text{ oersted}$$

$$\boxed{H_{ex} = 0.3513 \text{ oersted}}$$

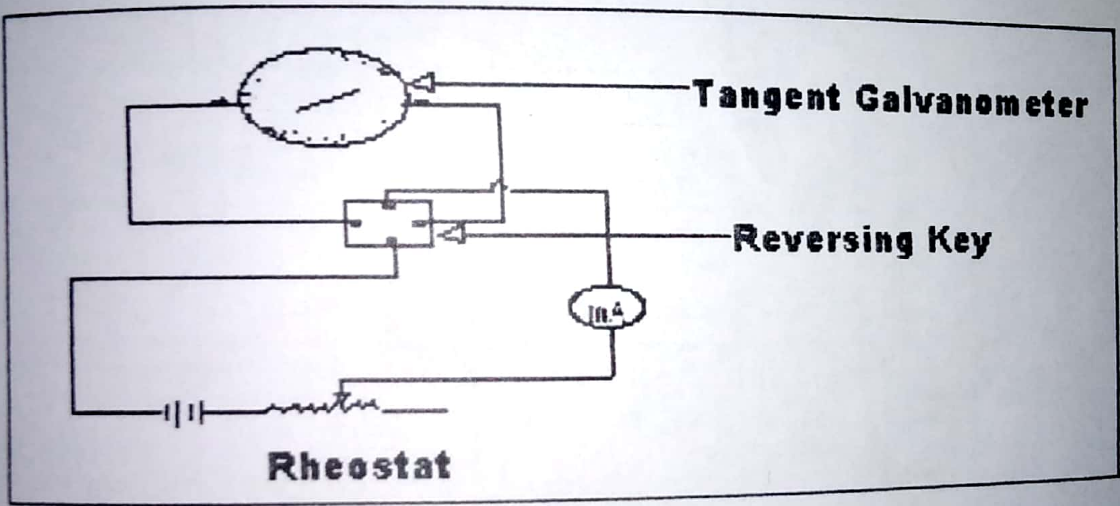
RESULT:

The value of H_e is found to be = 0.3513 (Oersted)

PRECUTIONS:

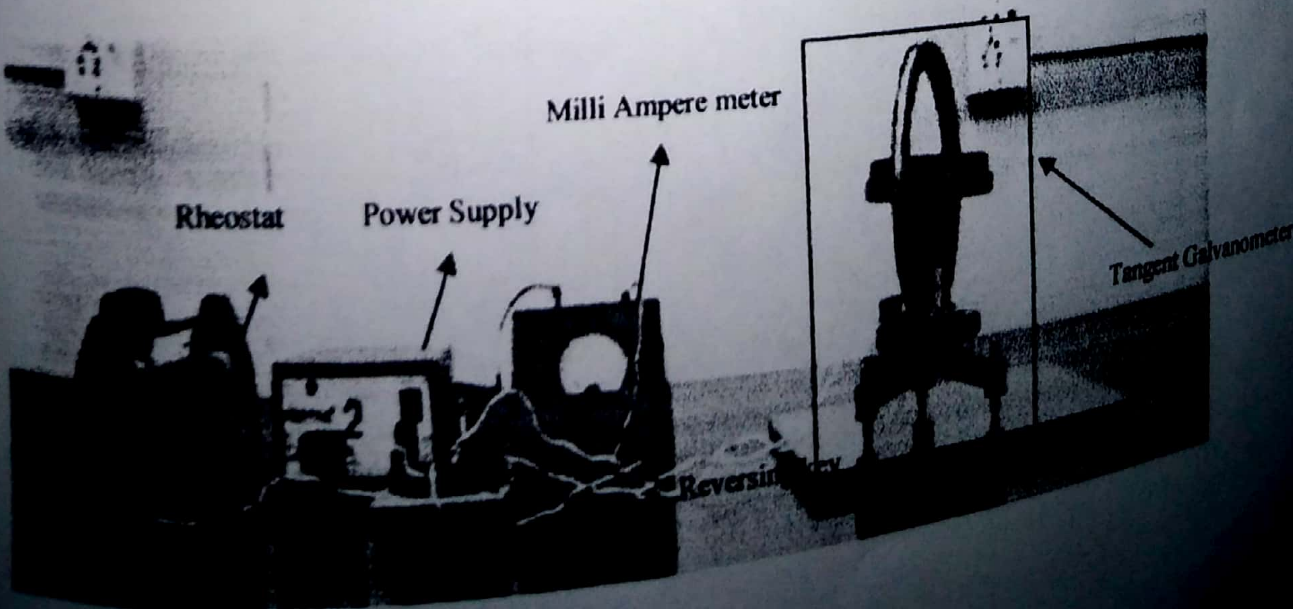
1. Connections should be tight.
2. Angle should be adjusted with care
3. Dial of galvanometer should be leveled properly.
4. Keep Metallic Material away from magnetic dial.

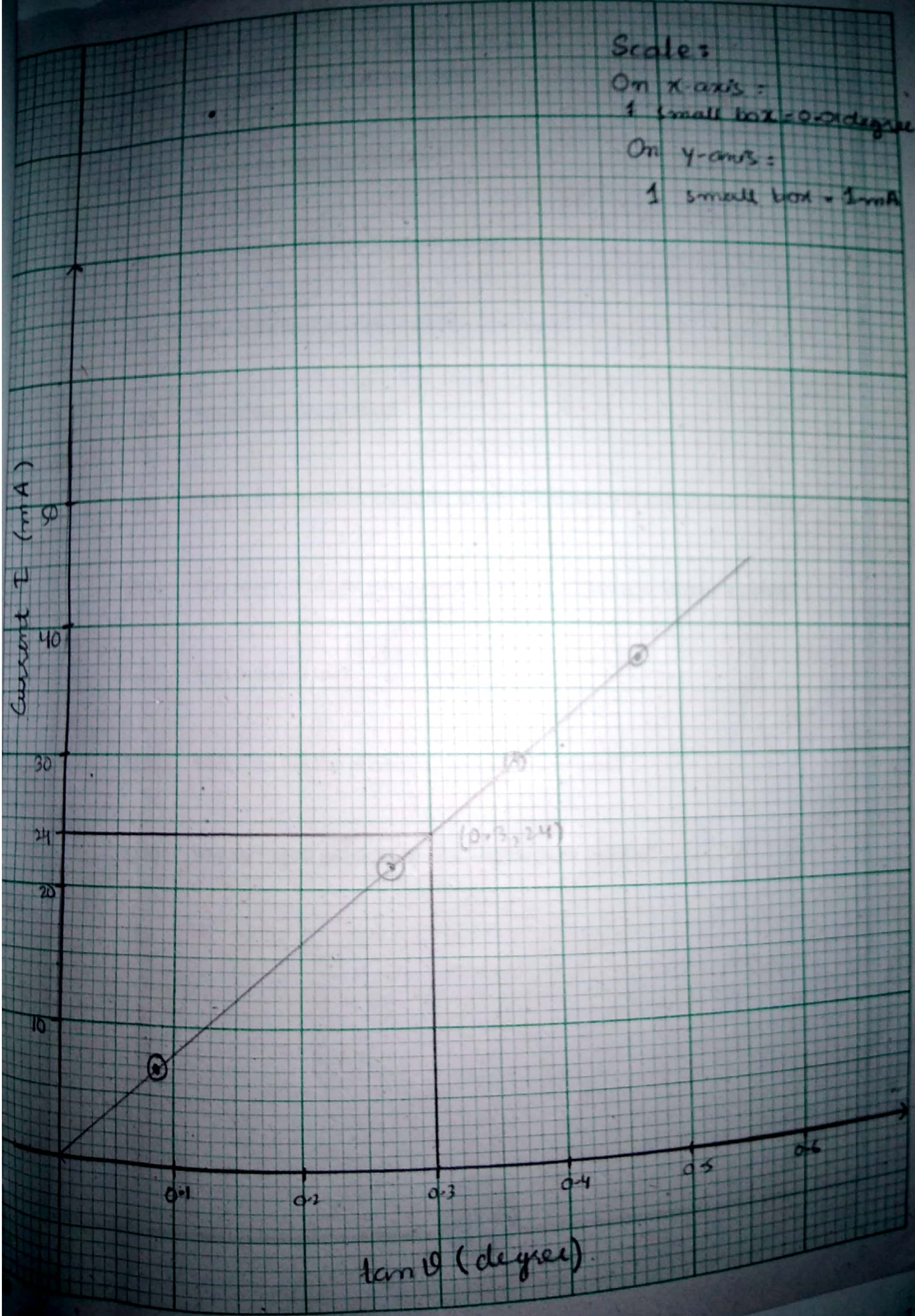
CIRCUIT DIAGRAM:



"H" by Tangent Galvanometer

PHOTOGRPAH OF THEAPPARATUS





Scale:
On x-axis :
1 small box = 0.01 degree
On y-axis :
1 small box = 1 mA
Current I (mA)
50
40
30
24
20
10
(0.3, 24)
0.1
0.2
0.3
0.4
0.5
0.6
tan θ (degree)

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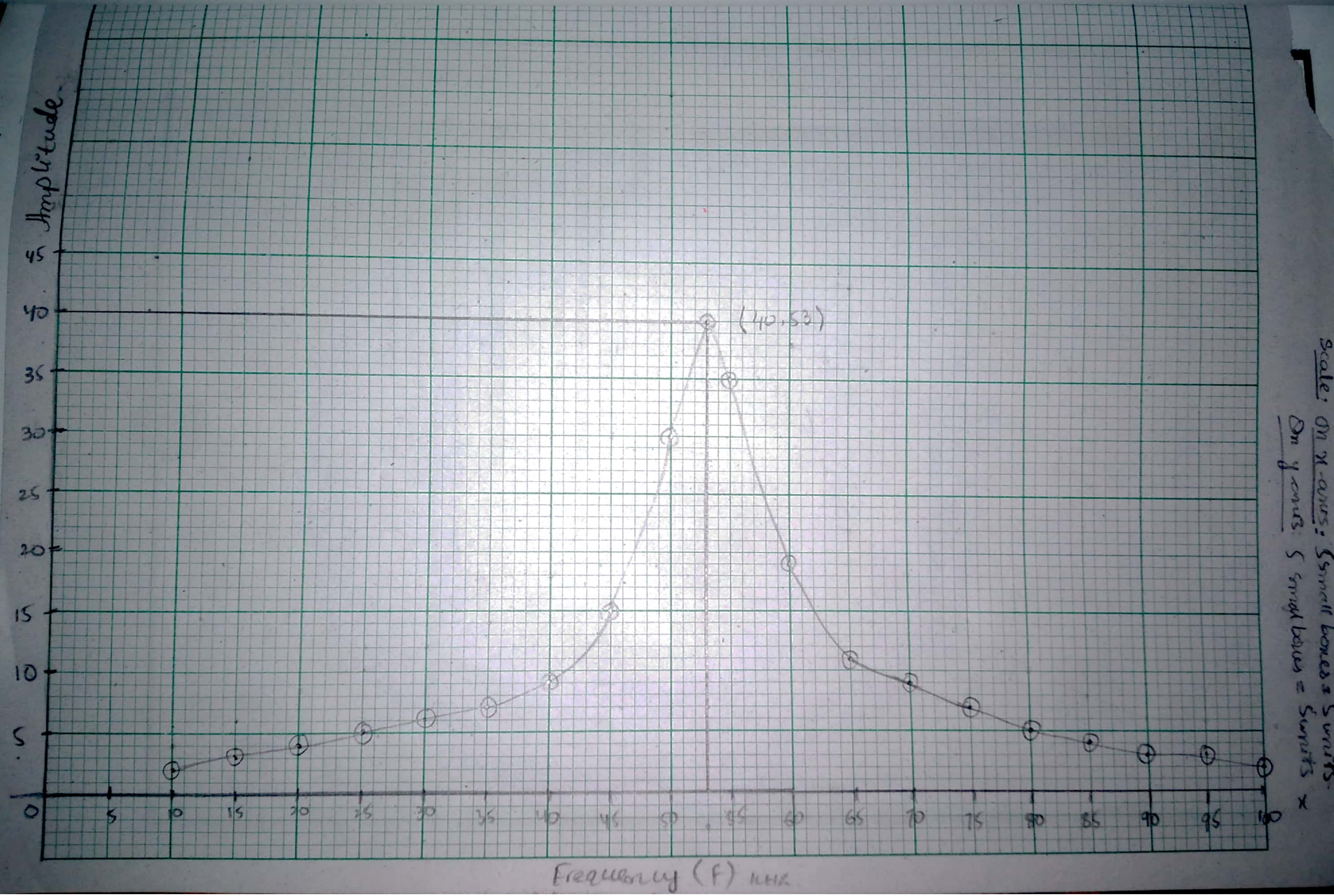
OBSERVATIONS:

Capacitance of capacitor C=......0.001.. μF .

S. No.	*Frequency* **f** *Hz*	*Amplitude of Signal division*
1	10000	2
2	15000	3
3	20000	4
4	25000	5
5	30000	6
6	35000	7
7	40000	9
8	45000	15
9	50000	30
10	53000	40
11	55000	35
12	60000	19
13	65000	11
14	70000	9
15	75000	7
16	80000	5
17	85000	4
18	90000	3
19	95000	3
20	100000	2



Amplitude
Frequency (F) kHz
(40, 53)
Scale: On x-axis: 5 small boxes = 5 units
On y-axis: 5 small boxes = 5 units

CALCULATIONS:

From Graph:

1- Value of resonant frequency f = ...53 K...Hz.

$$L = \frac{1}{4\pi^2 f^2 c}$$

$$L = \frac{1}{4 \times (3.142)^2 \times (53000)^2 \times (0.001 \times 10^{-6})}$$

$$\boxed{L = 0.009H}$$

RESULT:

1. Characteristics of a acceptor circuit studied. It is seen that at resonant frequency the output signal is *maximum / minimum*.
2. The value of inductance is found L = 9×10^{-3} Henry.

PRECAUTIONS AND SOURCES OF ERROR:

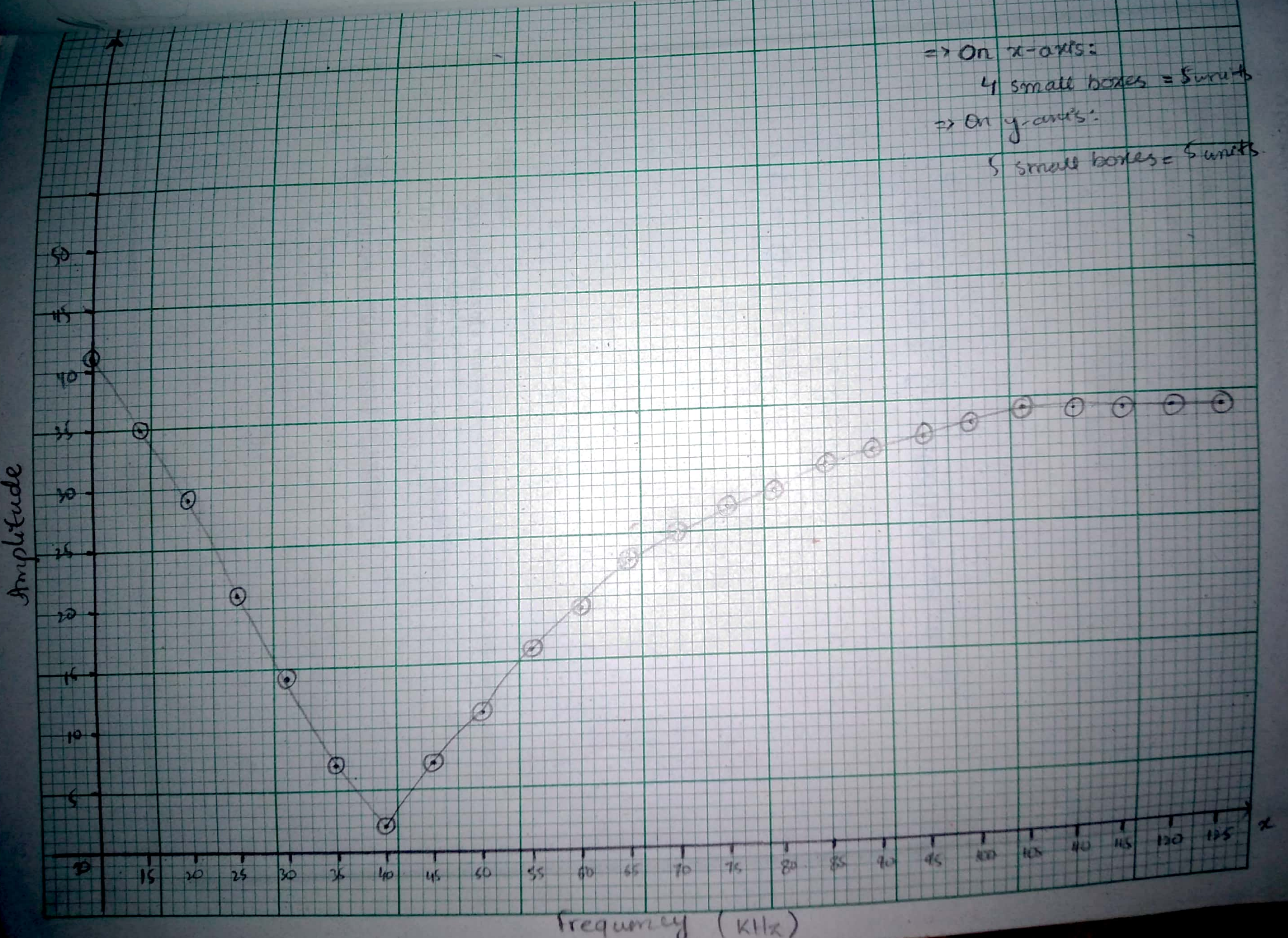
1. Before switching on, get connections checked by teacher.
2. The amplitude of the signal at resonant frequency may not be exactly zero, which is due to the presence of the resistance.
3. Choose proper combinations of L, C & R

4. Plot a graph between frequency 'f' and the corresponding amplitude 'A' of the output signal.
5. Calculate the inductance with the help of resonate frequency obtained through graph.

OBSERVATIONS:

Capacitance of capacitor C=..0·001... μF .

S. No.	*Frequency* f KHz	*Amplitude of Ouput Signal division*
1	10	41
2	15	35
3	20	29
4	25	21
5	30	14
6	35	7
7	40	2
8	45	7
9	50	11
10	55	16
11	60	19
12	65	23
13	70	25
14	75	27
15	80	28
16	85	30
17	90	31
18	95	32
19	100	33
20	105	34
21	110	34
22	115	34
23	120	34
24	125	34
25	130	34



=> On x-axis:
4 small boxes = 5 units
=> On y-axis:
5 small boxes = 5 units
Amplitude
Frequency (KHz)
x
50
45
40
35
30
25
20
15
10
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125

CALCULATIONS:

From Graph:

1- Value of resonant frequency f = 40 kHz.

$$L = \frac{1}{4\pi^2 f^2 c}$$

$$L = \frac{1}{4(3.142)^2 (40 \times 1000)^2 (0.001 \times 10^{-6})}$$

$$\boxed{L = 0.0158H}$$

RESULT:

1. Characteristics of a rejecter circuit studied. It is seen that at resonant frequency the output signal is minimum/maximum.
2. The value of inductance is found L = 0.0158. Henry.

PRECAUTIONS AND SOURCES OF ERROR:

1. Before switching on, get connections checked by teacher.
2. The amplitude of the signal at resonant frequency may not be exactly zero, which is due to the presence of the resistance.
3. Choose proper combinations of L, C & R

6. Note down the voltmeter and ammeter reading ... give voltage V across the resistor and Current I passing through the Circuit.

OBSERVATIONS:

Voltage across the two ends of the resistor	V	=	10.4	Volts
Current passed though	I	=	1.2	Amps
Time for the flow of water	t	=	60	Sec
Mass of water flowing out for t sec	M	=	20	gm
Initial temperature of water (at inlet)	T_1	=	28	°C
Final temperature of water (at outlet)	T_2	=	37	°C
Specific heat of water	C	=	1	Cal / gm°C

CALCULATIONS:

$$J = \frac{VIt}{MC\,(T_2 - T_1)}$$

density = $\frac{\text{mass}}{\text{volume}}$

$\frac{1g}{ml} = \frac{\text{mass}}{20ml}$

$\frac{1g}{ml} \times 20ml = \text{mass}$

$\boxed{\text{mass} = 20g}$

$$J = \frac{(10.4)(1.2)(60)}{(20)(1)(37-28)}$$

$$\boxed{J = 4.16\ J/Cal}$$

$$P.E = \left|\frac{\text{Obs. Value} - \text{Act. Val}}{\text{Act. Val}}\right| \times 100$$

$$\boxed{= 0.47\%}$$

RESULT:

Mechanical equivalent of heat J is found to be = 4.16 J / Cal

Percentage error = 0.47 %

PRECAUTIONS AND SOURECS OF ERROR:

1. There should be no air bubbles in the glass tube.
2. The glass tube must be horizontal.
3. The turns of the resistance wire should not touch each other or the sides of the tube.
4. The most important source of error is the loss of heat by radiation so in order to account for this loss of heat temperature correction must be applied.

OBSERVATIONS

Position of the lamp: 25 cm
Position of the cell: 0 cm

S.No	Colour of filter	Wavelength(λ) m	Frequency(f) Hz	Stopping Potential (Vo) Volt
1.	Red	635×10^{-19} m	4.72×10^{14}	-0.40
2.	Blue	460×10^{-9} m	6.52×10^{14}	-1.06
3.	Green	500×10^{-9} m	6×10^{14}	-0.85
4.	Yellow	540×10^{-9} m	5.5×10^{14}	-0.75
5.	Orange	570×10^{-9} m	5.26×10^{14}	-0.60

CALCULATIONS:

Plank's Constant (h):

$h = me$

$$h = \left(\frac{0.66 - 0.32}{5.4 \times 10^{14} - 4.5 \times 10^{14}}\right) \times e$$

$h = 3.77 \times 10^{-15} \times 1.6 \times 10^{-19}$

$\boxed{h = 6.04 \times 10^{-34}\ J.s}$

Percentage Error:

$$P.E = \left|\frac{Obs.Val - Act.Val}{Act.Val}\right| \times 100$$

$$P.E = \left|\frac{6.04 \times 10^{-34} - 6.62 \times 10^{-34}}{6.62 \times 10^{-34}}\right| \times 100$$

$\boxed{P.E = 8.89\%}$

Work Function (ϕ):

$\phi = hf_0$

$\phi = (6.62 \times 10^{-34})(3.65 \times 10^{14})$

$\boxed{\phi = 2.41 \times 10^{-19}\ J}$

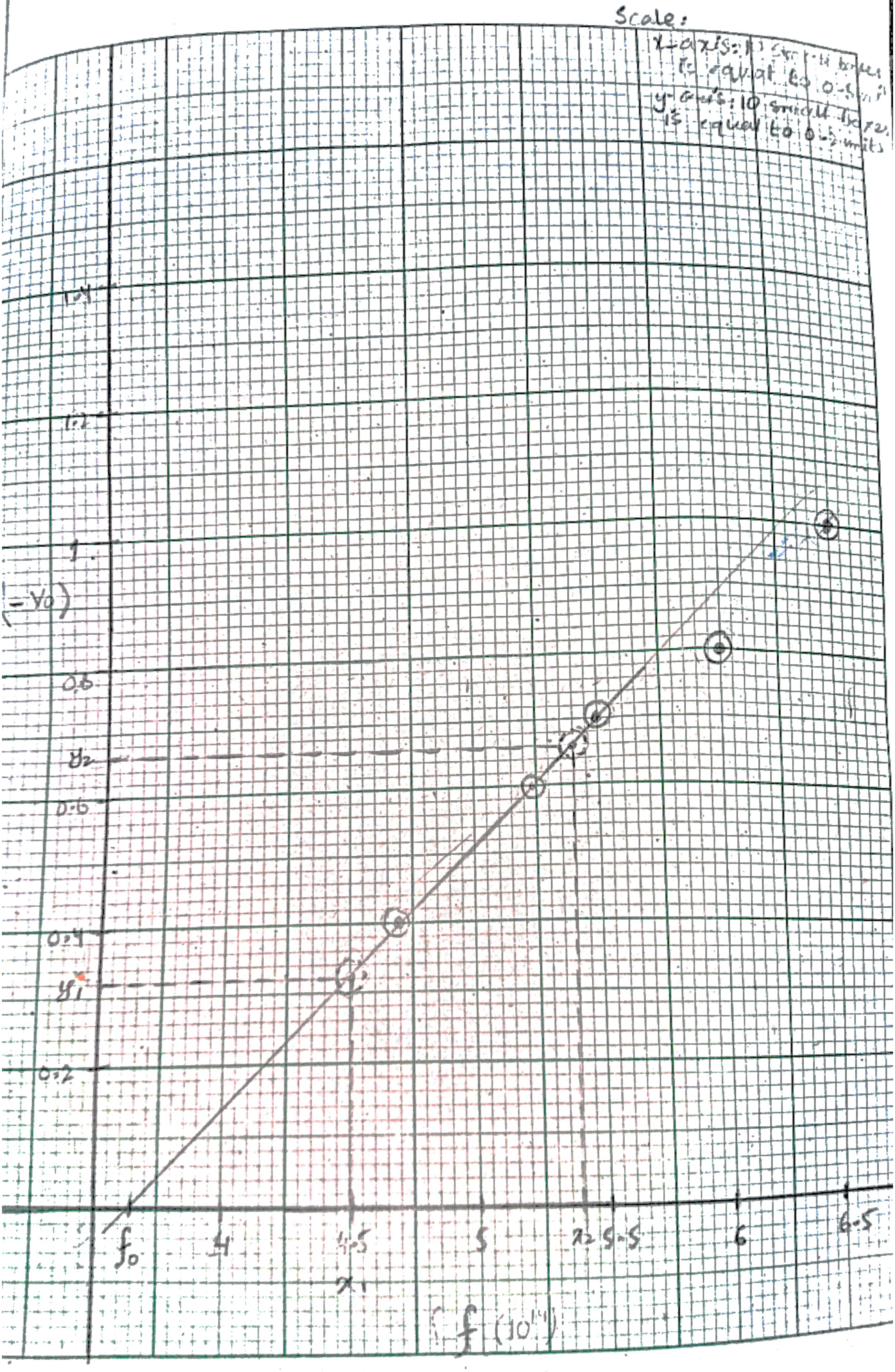
In eV:

$$\phi = \frac{2.41 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$\boxed{\phi = 1.51\ eV}$

RESULT

The value of Planck's constant is 6.04×10^{-34} Js
The percentage error in observed value is 8.89%.
The work function of cathode material is 1.51 eV.



Scale:
x-axis:
is equal to 0.5
y-axis: 10 small boxes
is equal to
units
1.4
1.2
1
$(-V_0)$
0.8
y_2
0.6
0.4
y_1
0.2
f_0
4
4.5
5
x_2
5.5
6
6.5
x_1
$f\ (10^{14})$

The ... μ_0 ...

$$\frac{e}{m} = 9.86 \times 10^6 \frac{V}{D^2 I^2}$$

Thus by determining the accelerating voltage V, diameter D of the circulating electrons and magnetizing current I, we can determine the e/m ratio of electron.

Procedure:-

1. Turn the power switch on, the indicator lamp emits red light. Keep accelerating voltage minimum for 5 minutes which is warming time for the Lorentz tube.
2. After pre warming gradually increase the accelerating voltage up to 200V.
3. Observe the rectilinear path of moving electrons.
4. Revolve the Lorentz force tube so that pointer point out angle is 90°.
5. Adjust the magnetizing current direction of coil to clockwise.
6. Gradually increase the magnetizing current and observe the circular motion of electrons.
7. Note down the diameter D of the circulating electrons for a particular magnetizing current.
8. At least take five readings of the diameter of circulating electrons at different magnetizing currents.
9. Plot the graph between I^2 and D^2. Select one point on the line of graph and determine the value of e/m.

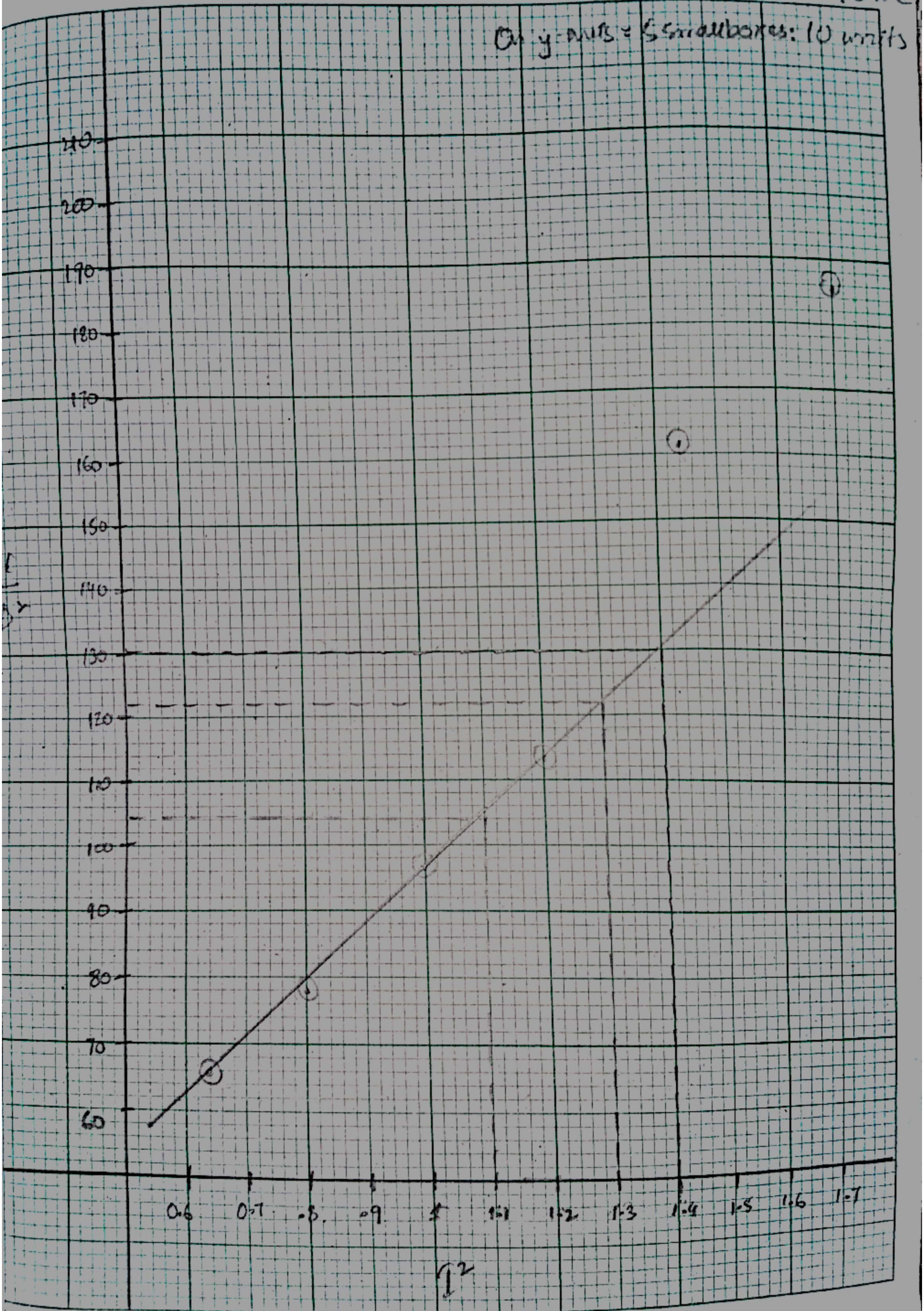
Observations:-

S.No	Accelerating Voltage (V) Volts	Magnetizing Current (I) Amp	Diameter (D) cm	I^2	D^2	$1/D^2$
1	240	0.8 A	0.124 m	0.64	0.015376	65.036
2	240	0.9 A	0.113 m	0.81	0.012769	78.314
3	240	1 A	0.101 m	1	0.010201	98.029
4	240	1.1 A	0.094 m	1.21	0.008836	113.173
5	240	1.2 A	0.079 m	1.44	0.006241	160.230
6	240	1.3 A	0.073 m	1.69	0.005329	187.652

Scale:-

On x-axis: 5 small boxes: 0.1 unit

On y-axis: 5 small boxes: 10 units



Calculation:

$$\frac{e}{m} = 9.86 \times 10^6 \frac{V}{D^2 I^2}$$

$$\frac{e}{m} = 9.86 \times 10^6 \times \frac{240}{(1.266)} \times 118.66$$

$$\frac{e}{m} = 2.217 \times 10^{11} \, C/Kg$$

Percentage Error:

$$P.E = \left| \frac{Obs.Value - Act.Value}{Act.\ Value} \right| \times 100$$

$$P.E = \left| \frac{2.217 \times 10^{11} - 1.76 \times 10^{11}}{1.76 \times 10^{11}} \right| \times 100$$

$$\boxed{P.E = 25.9\%}$$

RESULT:

e/m ratio of electron is = $2.217 \times 10^{11} \, C/Kg$.

PRECUTIONS AND SOURCES OF ERROR:

1. Keep accelerating voltage minimum during the warming time (5 min) of tube.
2. Magnetizing current must be set to zero, while changing the direction of magnetizing current.
3. For rotation of the of Lorentz force tube, only move the tube support and not move the glass lamp.
4. Carefully observe and measure the diameter of circulating electrons.

OBSERVATIONS:

Vernier constant = ...0.016.......Degree.

(a) For Angle of prism:

S.No.	R.H.S Reading a deg	L.H.S Reading b deg	Twice of angle of prism $\theta = \lvert b-a \rvert$ deg	Angle of prism $\therefore A \doteq \theta/2$ deg	Mean A deg
1	171	55	116°	58°	58°
2	173	58	115°	57.5°	
3	171	54	117°	58.5°	

(b) For Angle of minimum deviation position:

S.No.	Direct Reading a deg	Position of minimum deviation b deg	Angle of minimum deviation $D_m = \lvert b-a \rvert$ deg	Mean angle of minimum deviation D_m deg
1	118	81	37°	37.3°
2	118	80	38°	
3	118	81	37°	

CALCULATION:

$$\mu = Sin\frac{A+D_m}{2} \Big/ Sin\frac{A}{2}$$

$$\mu = \sin\left(\frac{58+37.3}{2}\right) \Big/ \sin\left(\frac{58}{2}\right)$$

$$\boxed{\mu = 0.7567}$$

RESULT:

Refractive index of the material of prism if found to be = ..0.7567..

The above equation gives the frequency of transverse wave in a staring.

$$\mu = \frac{1}{4L^2}\frac{T}{f^2}$$

PROCEDURE:

1. Set up the Sonometer as shown in Figure.
2. Set the bridges 60cm apart. Use any of the included strings and hang a mass of approximately 1 kg from the tensioning lever. Adjust the string knob so that the tensioning lever is horizontal. Position the driver coil approximately 5 cm from one of the bridges and position the detector coil near the center of the wire.
3. Set the signal generator to produce a sine wave.
4. Slowly increase the frequency of the signal driving the driving coil, starting with a frequency of 1 Hz. Determine the lowest frequency for a given tension at which resonance occurs. Record this value in table.
5. Record the string tension (T) in the table. Note the distance between the two wedges.
6. Repeat steps (4) and (5) for different values of tension in the string.
7. Plot a graph between $f^2$and tension T.
8. Calculate slope of the graph and find out linear density of string by using $$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}.$$
9. Take one value of tension of string from graph paper and determine velocity of waves in string by $$v = \sqrt{\frac{T}{\mu}}.$$

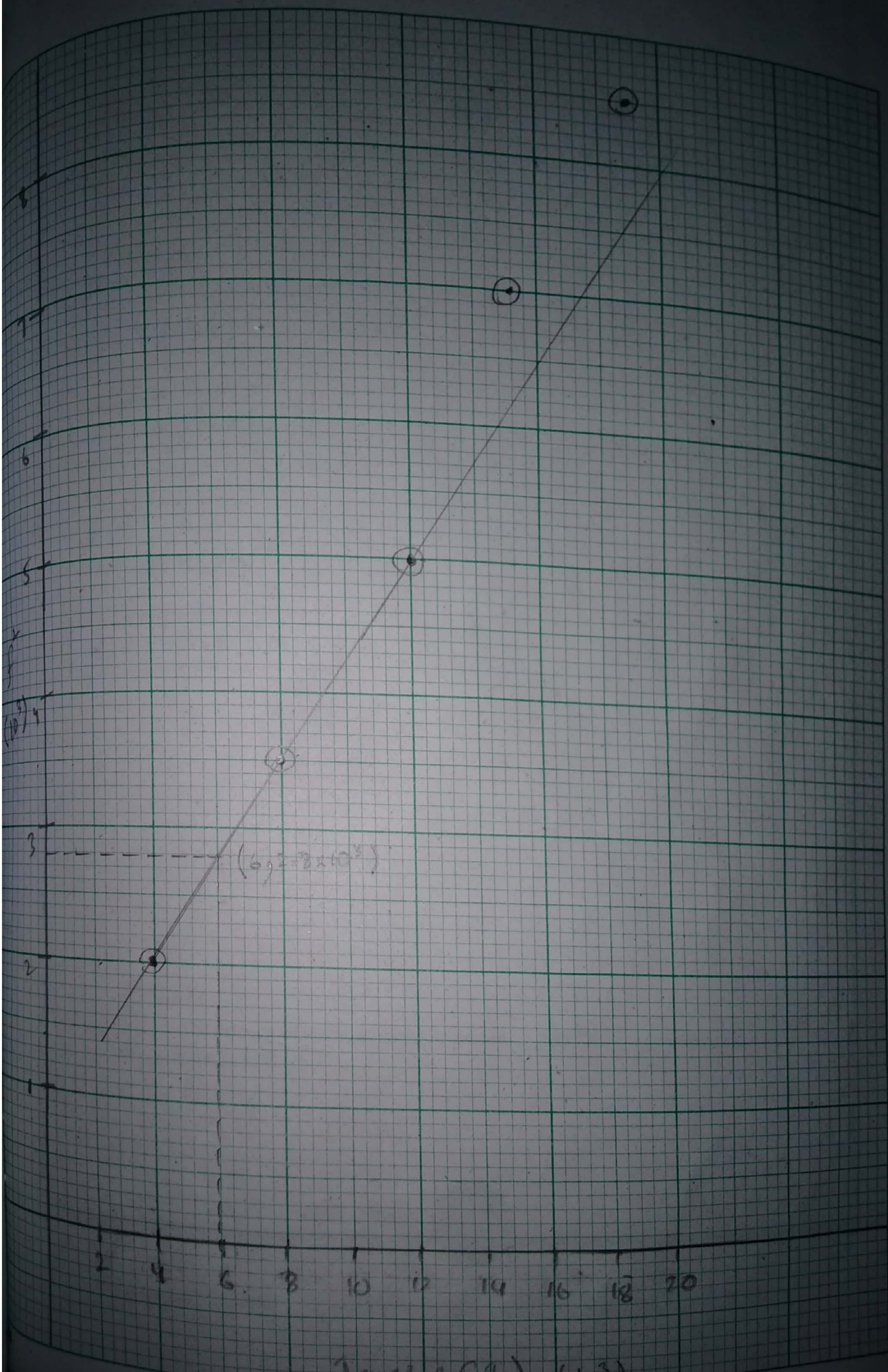
OBSERVATIONS:

Length of string between two bridges: L= 60cm

S.No.	Tension Dyne	Fundamental Frequency(f) Hz	f^2 Hz^2
1	$400 \times 1 \times 980 = 392 \times 10^3$	$\frac{87.5}{2} = 43.7$	1.914×10^3
2	$2 \times 400 \times 980 = 784 \times 10^3$	$\frac{117.9}{2} = 58.95$	3.475×10^3
3	$3 \times 400 \times 980 = 1176 \times 10^3$	$\frac{143.5}{2} = 71.75$	5.148×10^3
4	$4 \times 400 \times 980 = 1568 \times 10^3$	$\frac{170.5}{2} = 85.25$	7.267×10^3
5	$5 \times 400 \times 980 = 1960 \times 10^3$	$\frac{186}{2} = 93$	8.649×10^3.

Converting Tension from Dyne to Newton

1) $392 \times 10^3 \times 10^{-5} = 3.92$
2) $784 \times 10^3 \times 10^{-5} = 7.84$
3) $1176 \times 10^3 \times 10^{-5} = 11.76$
4) $1568 \times 10^3 \times 10^{-5} = 15.68$
5) $1960 \times 10^3 \times 10^{-5} = 19.6$



f²
(10³)
1
2
3
4
5
6
7
8
(6, 2.8×10³)
2
4
6
8
10
12
14
16
18
20
Tension (T) (10³)

CALCULATIONS:

$$\mu = \frac{1}{4L^2}\frac{T}{f^2}$$

$$v = \sqrt{\frac{T}{\mu}}$$

$$\mu = \frac{1}{4(0.6)^2} \times \frac{6}{2.8\times10^3}$$

$$\boxed{\mu = 1.48\times10^{-3}}$$

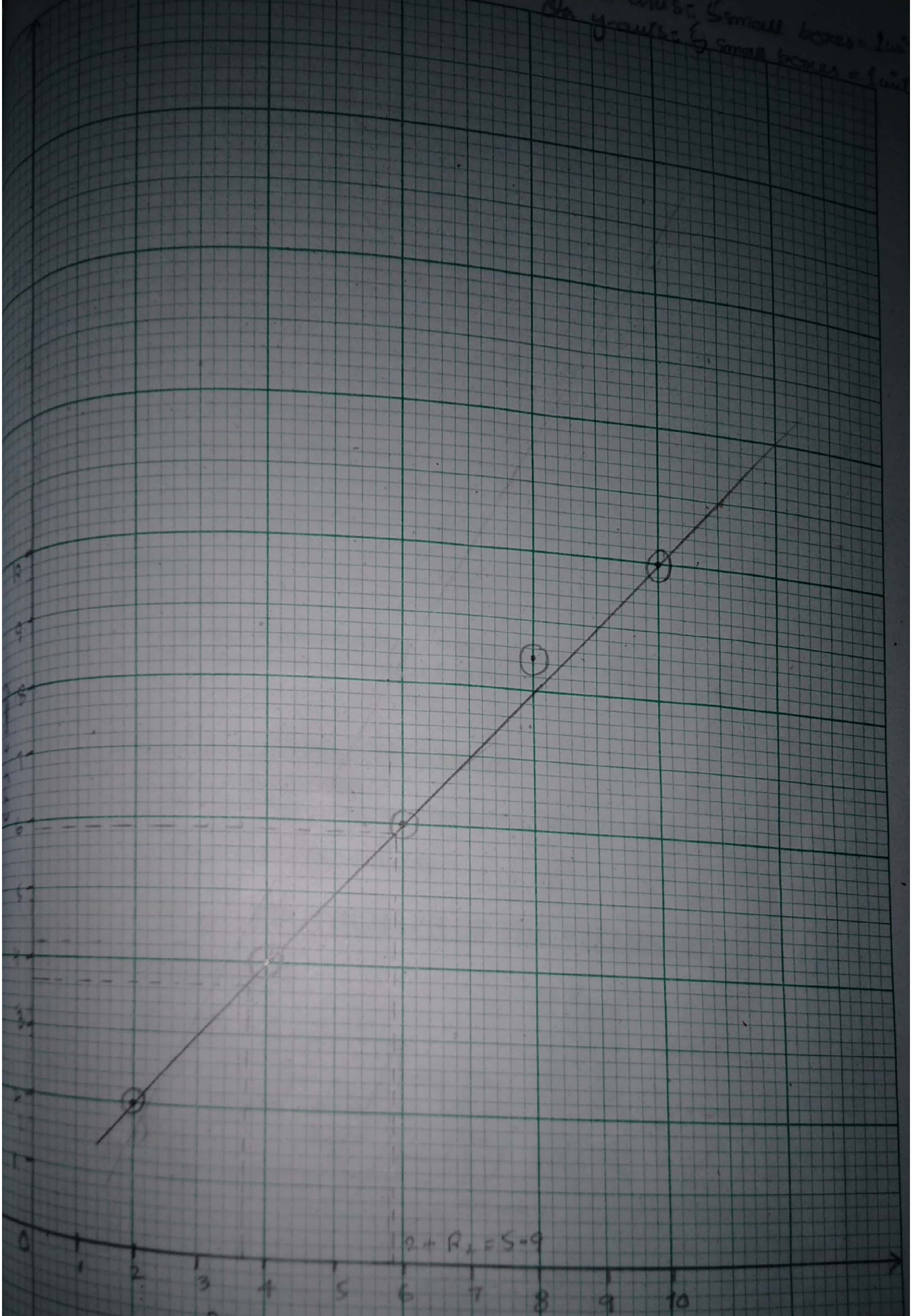
$$v = \sqrt{\frac{6}{1.48\times10^{-3}}}$$

$$\boxed{v = 63.67\,m/s}$$

RESULT:

The velocity of vibrating string at tension 6N is found to be 63.67m/s.

Scale:
On x-axis = 5 small boxes = 1 unit
On y-axis = 5 small boxes = 1 unit



OBSERVATIONS:

The capacitance of the capacitor = ...2.2.......... μF

S.No.	Resistance R MΩ	Time for Ten flashes Seconds t₁	t₂	t₃	Mean Time t Seconds	Time for one flash T=t/10(sec)
1	2	21.5	21.4	21.8	21.56	2.156
2	4	39.5	39.55	39.9	39.57	3.957
3	6	64.58	64.23	64.5	64.3	6.43
4	8	87.97	87.25	87.6	87.62	8.762
5	10	102.52	102.6	102.8	102.6	10.26
6	2 + R_1	39.50	39.6	39.49	39.4	3.94
7	2 + R_2	62.69	62.15	62.7	62.5	6.25
8						
9						
10						

RESULT:

From Graph:

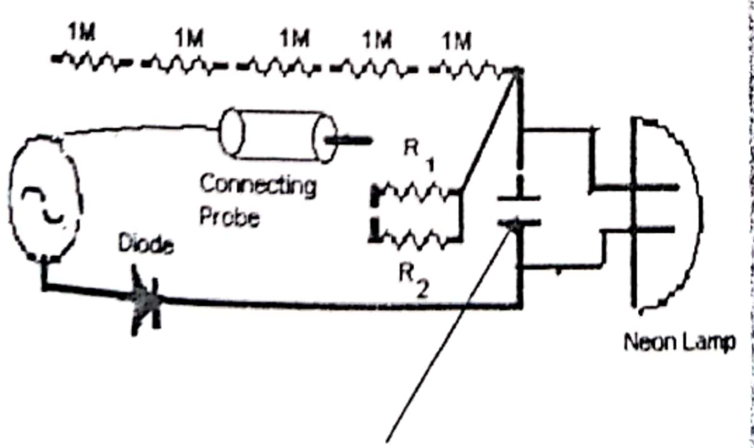
The value of unknown resistance from the graph R_1=....1.7........ MΩ.
The value of unknown resistance from the graph R_2=....3.9........ MΩ.

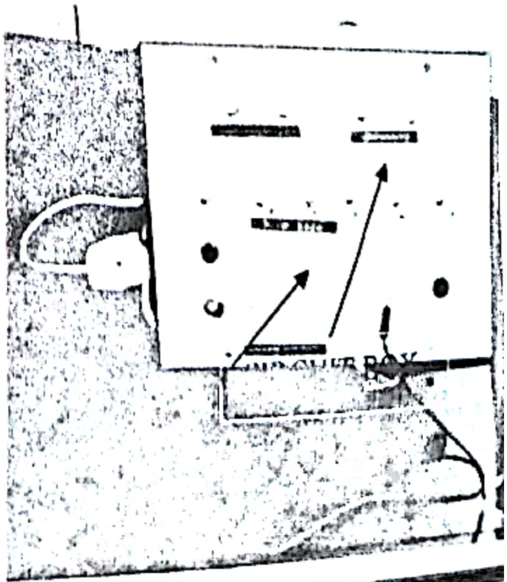
PRECAUTIONS AND SOURCES OF ERROR:

1. Don't touch naked wires.
2. The applied voltage must be uniform and must be kept constant throughout the experiment.
3. Note the time for flashes carefully.

PHOTOGRAPH OF THE APPARATUS

CIRCUIT DIAGRAM:





Least Count of Screw Gauge:

$$L.C = \frac{0.5mm}{50} = 0.01mm$$

mm into cm → $\frac{0.01}{10} = 0.001cm$

Diameter of Small Bearing:

M.S	C.S.R	C.S.R x L.C = FP	Total Reading	Mean
			0.341	
0.3cm	41 cm	0.041 cm	0.341	0.341cm
0.3cm	41 cm	0.041 cm	0.341	
0.3cm	41cm	0.041cm		

Diameter of Medium Bearing:

M.S	C.S.R	C.S.R x L.C = FP	Total Reading	Mean
0.45cm	24 cm	0.024cm	0.474cm	
0.45cm	24cm	0.024cm	0.474cm	0.747cm
0.45cm	24 cm	0.024cm	0.474cm	

Diameter of Large Bearing:

M.S	C.S.R	C.S.R x L.C = FP	Total Reading	Mean
0.55cm	33 cm	0.033cm	0.583 cm	
0.55cm	33cm	0.033cm	0.583cm	0.583cm
0.55cm	33cm	0.033cm	0.583 cm	

OBSERVATIONS:

Density of the ball bearings d = ...7·8....gm / c.c.
Density of the given liquid D = ...1·26....gm / c.c.
Diameter of the tube a= ....5·1....cm

$\therefore$ Radius of the tube $R = \frac{a}{2}$ =....2·55....cm

Acceleration due to gravity g = ...980....cm / sec^2
Diameter of small ball bearing = ...0·391..cm
Diameter of medium ball bearing = .0·474...cm
Diameter of large ball bearing = ...0·583...cm
Radius of the small ball bearing r_1 = ..0·1955.cm
Radius of the medium ball bearing r_2=...0·337..cm
Radius of the large ball bearing r_3= ..0·2915.cm

Distance between points X and Y = s= ....70.... cm

S.No.	*Size of the Ball Bearing*	*Time taken to travel distance 's' cm between points X and Y t sec*				*Observed Terminal Velocity* $v = \frac{s}{t}$ *cm/sec*
		t_1	t_2	t_3	*Mean*	
1	Small	2·19	2·07	2·18	2·14	32·7
2	Medium	1·78	1·87	1·79	1·81	38·67
3	Large	1·37	1·25	1·27	1·29	54·266

CALCULATION:

$$v_o = v\left(1+\frac{2.4r}{R}\right) \quad \& \quad \eta = \frac{2r^2 g(d - D)}{9v_0}$$

$$V_o = 32.7\left[1+\frac{2.4(0.1955)}{2.55}\right]$$

$$V_o = 38.7168$$

$$\eta = \frac{2(0.19)^2(980)(6.54)}{9 \times 38.7168}$$

$$\boxed{\eta_1 = 1.32 \text{ porse}}$$

$$V_o = 38.67\left[1+\frac{2.4(0.237)}{2.55}\right]$$

$$V_o = 47.29$$

$$\eta = \frac{2(0.237)^2(980)(6.54)}{9 \times 47.29}$$

$$\boxed{\eta_2 = 1.69 \text{ porse}}$$

$$V_o = 53.98\left[1+\frac{2.4(0.2915)}{2.55}\right]$$

$$V_o = 68.78$$

$$\eta = \frac{2(0.2915)^2(980)(654)}{9 \times 68.78}$$

$$\boxed{\eta_3 = 1.759 \text{ porse}}$$

$$\eta = \frac{\eta_1 + \eta_2 + \eta_3}{3}$$

$$\eta = \frac{1.32 + 1.69 + 1.759}{3}$$

$$\boxed{\eta = 1.58 \text{ poise}}$$

RESULT:

Coefficient of viscosity of the given liquid by Stock's method is found to be =.....1.58.....Poise at temperature =.......25.....°C

PRECAUTION AND SOURCES OF ERROR:

1. The ball bearing must be wet with used liquid to present from air bubbles.
2. The ball bearing must be released slowly from just above the liquid surface.
3. The temperature of the liquid should be kept constant throughout the experiment, since the coefficient of viscosity varies with temperature.
4. Ball bearing must be released at the center of the tube.
5. The liquid should be transparent and should be free from dust particles.

OBSERVATIONS:

S.No.	Plate voltage volts	Plate current μA
1	1	0
2	2	0
3	3	2
4	4	4
5	5	8
6	6	13
7	7	18
8	8	22
9	9	27
10	10	33
11	11	48
12	12	72
13	13	not in range.
14		
15		
16		
17		
18		
19		
20		

CALCULATIONS:

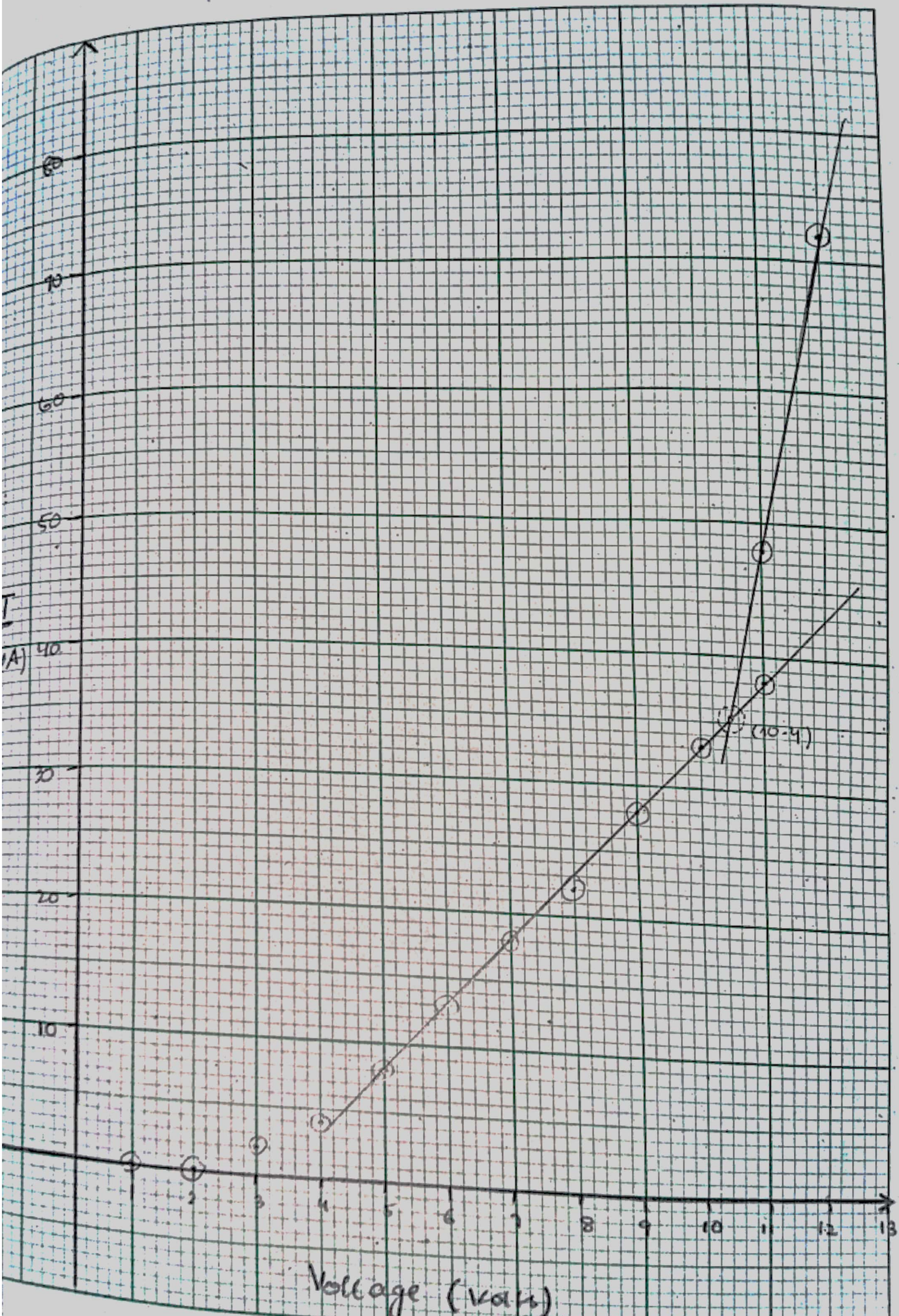
$$Percentage error = \left|\frac{Obs.\ value - s\tan d.value}{s\tan d.value}\right| \times 100$$

$$= \left|\frac{10.4 - 10.4}{10.4}\right| \times 100$$

$$= 0\ \%$$

RESULTS:

Ionization potential of mercury from the graph = 10.4 Volts
Standard value of ionization potential = 10.4 Volts
Percentage error = 0 %



I
(mA)
80
70
60
50
40
30
20
10
(10.4)
1
2
3
4
5
6
7
8
9
10
11
12
13
Voltage (kv)