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EXPERIMENT-1

AIM:

To determine the wave length of sodium light by using Newton's ring.

APPARATUS USED :

Travelling microscope (for Newton's Ring), Sodium vapour lamp, a thin plano - convex lens of large focul length, a convex lens of short focus, an optically plane glass plate.

THEORY AND FORMULA USED :

When a monochromatic parallel beam of light is incident on a thin air film enclosed between a plano-convex lens and a plane glass plate, the two reflected rays - one from top and another from bottom surface of thin air film (ray 2 and ray 3) will interfere. Ray 1 and ray 4 shown in Figure will not take part in interference due low coherency of the sodium light source. Around the point of contact, the points having equal thickness of air film lie on circles concentric with the points of contact. Hence due interference between the two reflected ray a series of alternate dark and bright fringes will be produced. These are called Newton's rings. The thickness of air film at the contact point is infinitesimally small. But due to phase change of π by reflection form rarer to denser medium (air to glass), the central ring will be dark.

The wavelength of sodium light which is used for the Newton's ring setup is given by the formula :

$$\lambda = \frac{D_{n+m}^2 - D_n^2}{4mR}$$

where,

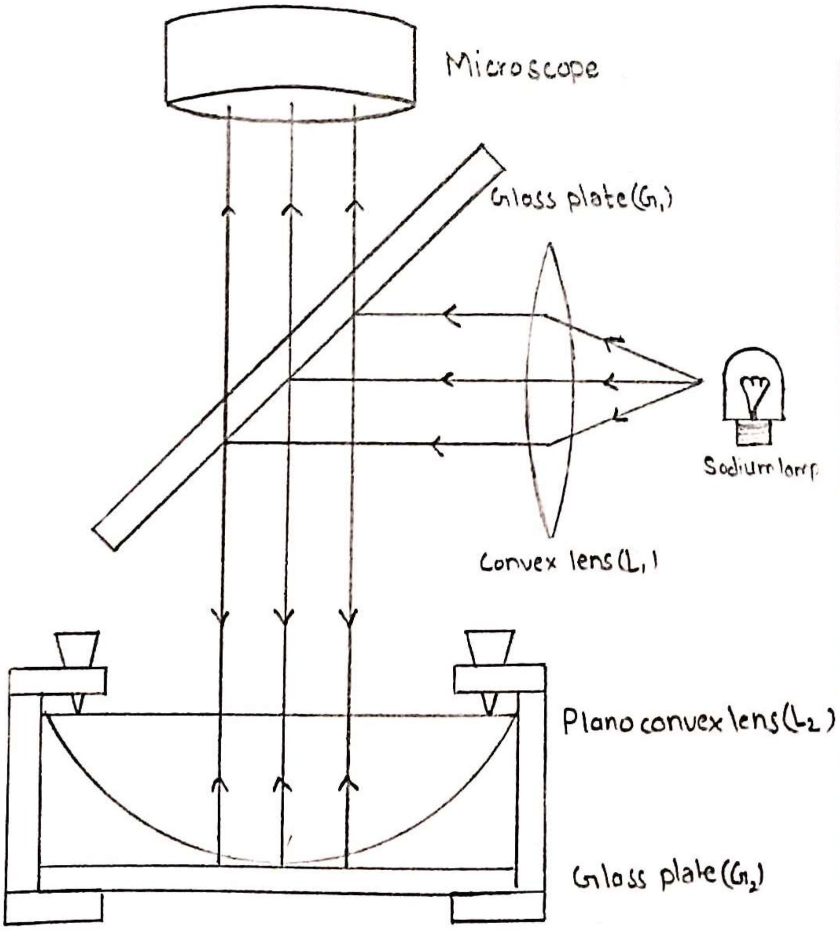
λ = wavelength of sodium light

D_{n+m} = diameter of (n+m) th ring

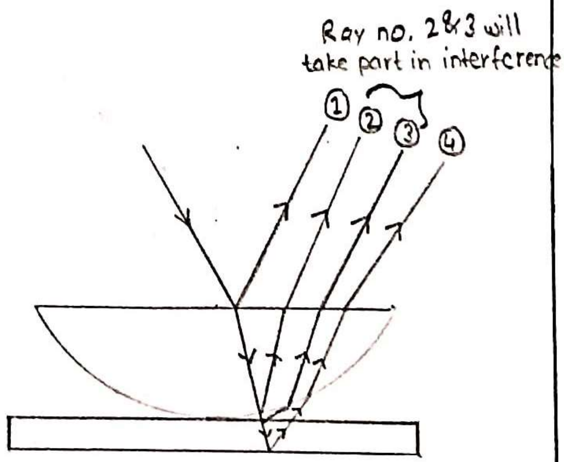
D_n = diameter of nth ring

R = Radius of curvature of the convex surface of the plano - convex lens.

SCHEMATIC OF THE NEWTON'S RING SETUP :



Newton's ring arrangement



Interference between light waves reflected from different surfaces of plano-convex lens and plane glass plate.

PROCEDURE :

1: Select the medium (air), light source (Sodium) and click the knob light ON.

2. Order no. of the rings can be view varied by moving the knob of microscope position.

3. According to the theory, the center of interference fringes should be dark.

4. Move the ~~dark~~ microscope in horizontal position direction to the left side of the fringes. Fix up the cross-wire tangentially to the (n+m)th bright ring and note down the readings of both the main scale and vernier scale. Then the microscope is moved in horizontal direction to the right side and should be fixed up tangentially to the successive bright fringes up to the 1st ring. Write down the readings of all successive rings. The the microscope is moved to the right side of the fringes and should be fixed up tangentially to the first bright fringe. Write down the readings of both scales. In this way, all the readings of successive bright fringes should be noted down up to (n+m)th bright ring.

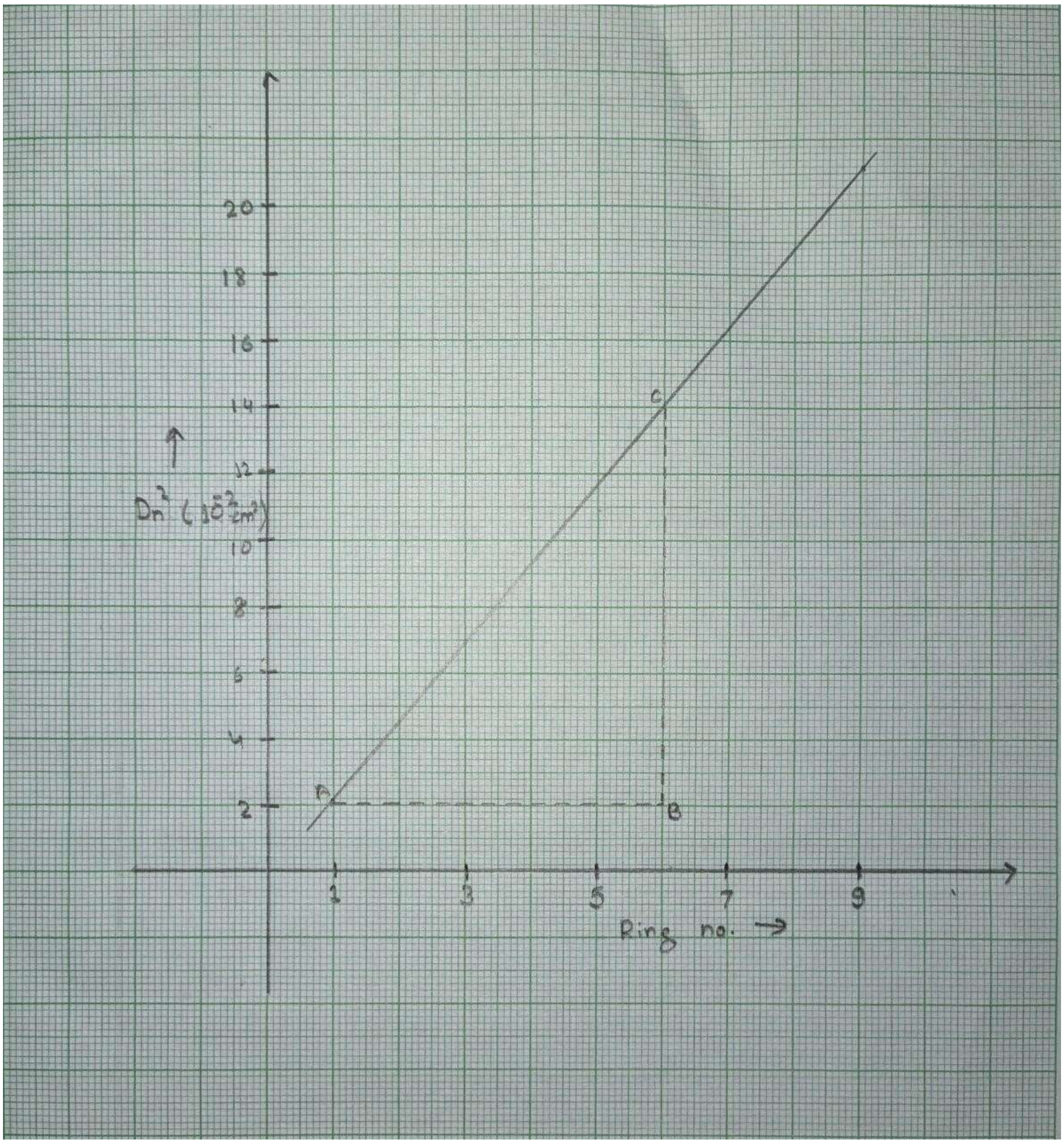
OBSERVATIONS :

(A) Radius of the plano-convex lens, R = 100 cm. Give

(B) Vernier constant of microscope : 0.001

(C) Determination of Diameter of the Newton's rings,

Graphical Representation



EXPERIMENT-2

AIM:

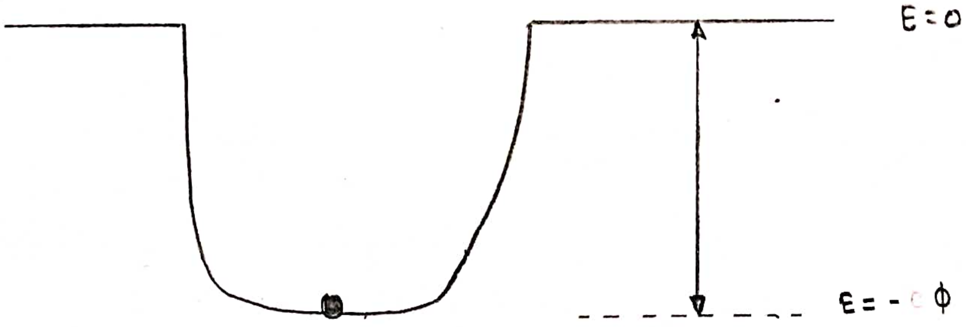
I. To determine Planck's constant 'h'
II. To determine the work function 'ϕ' of metals.

APPARATUS USED:

Vaccum phototube, Tungsten halogen lamp, votmeter, ammeter

THEORY AND FORMULA USED:

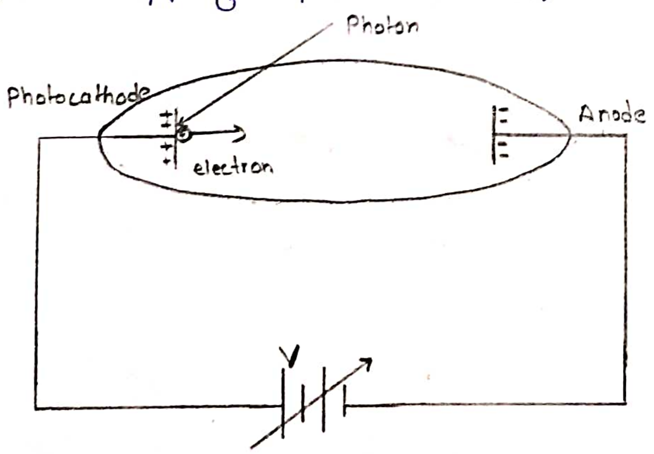
An electron in metal cap be modelled as a particle in an average potential well due to net attraction and repulsion of protons and electrons. The minimum depth that an electron is located in the potential well is called the workfunction of the metal ϕ. It is a measure of the amount of work that must be done on the electrons (located in the well) to make it free from the metal. Since different metal atoms have different number of protons and different values of electrical properties, the work function ϕ depends on the metal.

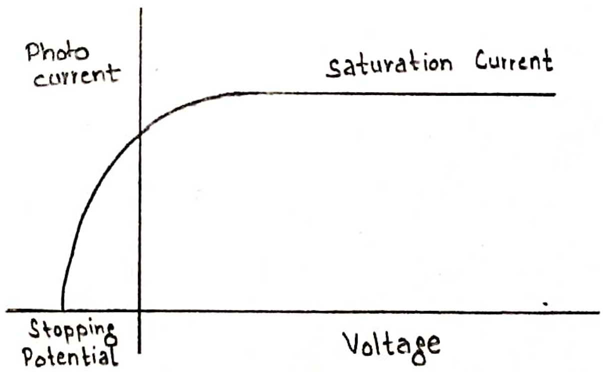


When a photon with frequency 'ν' strikes the surface of a metal, it impats all of its energy to a conduction electron near the surface of a metal, it imparts all of its energy to a conduction electron near the surface of the metal. If the energy of the photon ($h\nu$) is greater than the work function (ϕ), the electron may be ejected from the metal. By conservation of energy, the maximum kinetic energy ~~wl~~ with which the electron could be emitted from the metal surface T_{max}, is related to the the energy of the absorbed photon $h\nu$, and the work function ϕ, by the relation.

$$T_{max} = \frac{1}{2} m v_{max}^2 = h\nu - \phi$$

Now, if we consider the case of electrons being emitted by a photocathode in a vacuum tube, all the emitted are slowed down as they approach the ~~cathode~~ anode. If the voltage just stops the electrons (with maximum kinetic energy T_{max}) from reaching the anode. The voltage required to do this is called the "stopping potential" (V_0).





$$T_{max} = \frac{1}{2} m v_{max}^2 = h\nu - \phi$$

$$eV_0 = h\nu - \phi$$

$$\boxed{V_0 = \frac{h}{e}\nu - \frac{\phi}{e}}$$

PROCEDURE :

1. Choose the material from control panel.
2. Choose a suitable wavelength.
3. Fix area and intensity at a reasonable value. You should not change these values while taking data.
4. Voltage should be maximum (i.e.,0)
5. Record data for current.
6. Vary the voltage and record the current till the value of current becomes zero
7. Record data for current for each voltage
8. Plot I-V graph from the data recorded for the wavelength.
9. Repeat for atleast 5 frequencies.

OBSERVATION :

METAL: Copper **I:** 25 W/m^2 **Area:** 0.2 cm^2

Colors and corresponding wavelengths :

Colour	—	—	—	—	—
Wavelength λ(nm)	100	120	140	160	180

Table 1: For I-V characteristics

λ = 100 nm

Voltage (V)	0	-0.1	-1.4	-2.1	-2.8	-3.5	-4.2	-4.9	-5.6	-7.8
Current (μA)	38.58	38.08	31.58	28.08	24.58	21.08	17.58	14.08	10.58	0

λ = 120 nm

Voltage (V)	0	-0.5	-1	-1.5	-2	-2.5	-3	-3.5	-4.5	-5.7
Current (μA)	28.23	25.73	23.23	20.73	18.23	15.73	13.23	10.73	5.73	0

λ = 140 nm

Voltage (V)	0	-0.4	-0.9	-1.3	-1.8	-2.2	-2.7	-3.4	-3.8	-4.2
Current (μA)	20.84	18.84	16.34	14.34	11.84	9.84	7.34	3.84	1.84	0

$\lambda = 160$ nm

Voltage (V)	0	-0.3	-0.6	-0.9	-1.2	-1.6	-2	-2.4	-2.8	-3.1
Current (μA)	15.30	13.80	12.30	10.80	9.30	7.30	5.30	3.3	1.3	0

$\lambda = 180$ nm

Voltage (V)	0	-0.2	-0.4	-0.6	-0.8	-1	-1.2	-1.6	-2	-2.2
Current (μA)	10.99	9.99	8.99	7.99	6.99	5.99	4.99	2.99	0.99	0

Table 2: Data for potential (Stopping Potential) – Wavelength

Stopping Potential	-7.8	-5.7	-4.2	-3.1	-2.2
Wavelength (nm)	100	120	140	160	180
frequency (10^{14} Hz)	30	25	21.42	18.75	16.66

METAL: Platinum I – 25 W/m² Area – 0.2 cm²

Colours and corresponding wavelengths:

Colour	–	–	–	–	–
Wavelength λ (nm)	100	120	140	160	180

Table 1: For I-V characteristics

$\lambda = 100$ nm

Voltage (V)	0	-0.6	-1.2	-1.8	-2.4	-3	-3.6	-4.8	-5.4	-6.10
Current (μA)	30.33	27.33	24.33	21.33	18.33	15.33	12.33	6.33	3.33	0

$\lambda = 120$ nm

Voltage (V)	0	-0.4	-0.8	-1.2	-1.6	-2	-2.4	-2.8	-3.6	-4
Current (μA)	19.98	17.98	15.98	13.98	11.98	9.98	7.98	5.98	1.98	0

$\lambda = 140$ nm

Voltage (V)	0	-0.2	-0.4	-0.8	-1	-1.2	-1.6	-1.8	-2.2	-2.6
Current (μA)	12.59	11.59	10.59	8.59	7.59	6.59	4.59	3.59	1.59	0

$\lambda = 160$ nm

Voltage (V)	0	-0.2	-0.4	-0.6	-0.8	-1	-1.2	-1.3	-1.4	-1.5
Current (μA)	7.05	6.05	5.05	4.05	3.05	2.05	1.05	0.55	0.05	0

$\lambda = 180$ nm

Voltage (V)	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6			
Current (μA)	2.74	2.24	1.74	1.24	0.74	0.24	0			

Table 2: Data for stopping potential - Wavelength

Stopping Potential	-6.10	-4	-2.6	-1.5	-0.6
Wavelength (nm)	100	120	140	160	180
frequency (10^{14} Hz)	30	25	21.42	18.75	16.66

GRAPH:

1. Plot I-V characteristics for different wavelengths.
2. Plot stopping potential - frequency for two metals.

CALCULATION;

Value of 'h' copper $= \frac{5.7}{14} \times \frac{1.6 \times 10^{-19}}{10^{14}} = 6.51 \times 10^{-34}$ Js

Value of 'h' for platinum $= \frac{4}{9.75} \times \frac{1.6 \times 10^{-19}}{10^{14}} = 6.56 \times 10^{-34}$ Js

Average value of h $= \frac{(6.56 + 6.51) \times 10^{-34}}{2} = 6.535 \times 10^{-34}$ Js

RESULT :

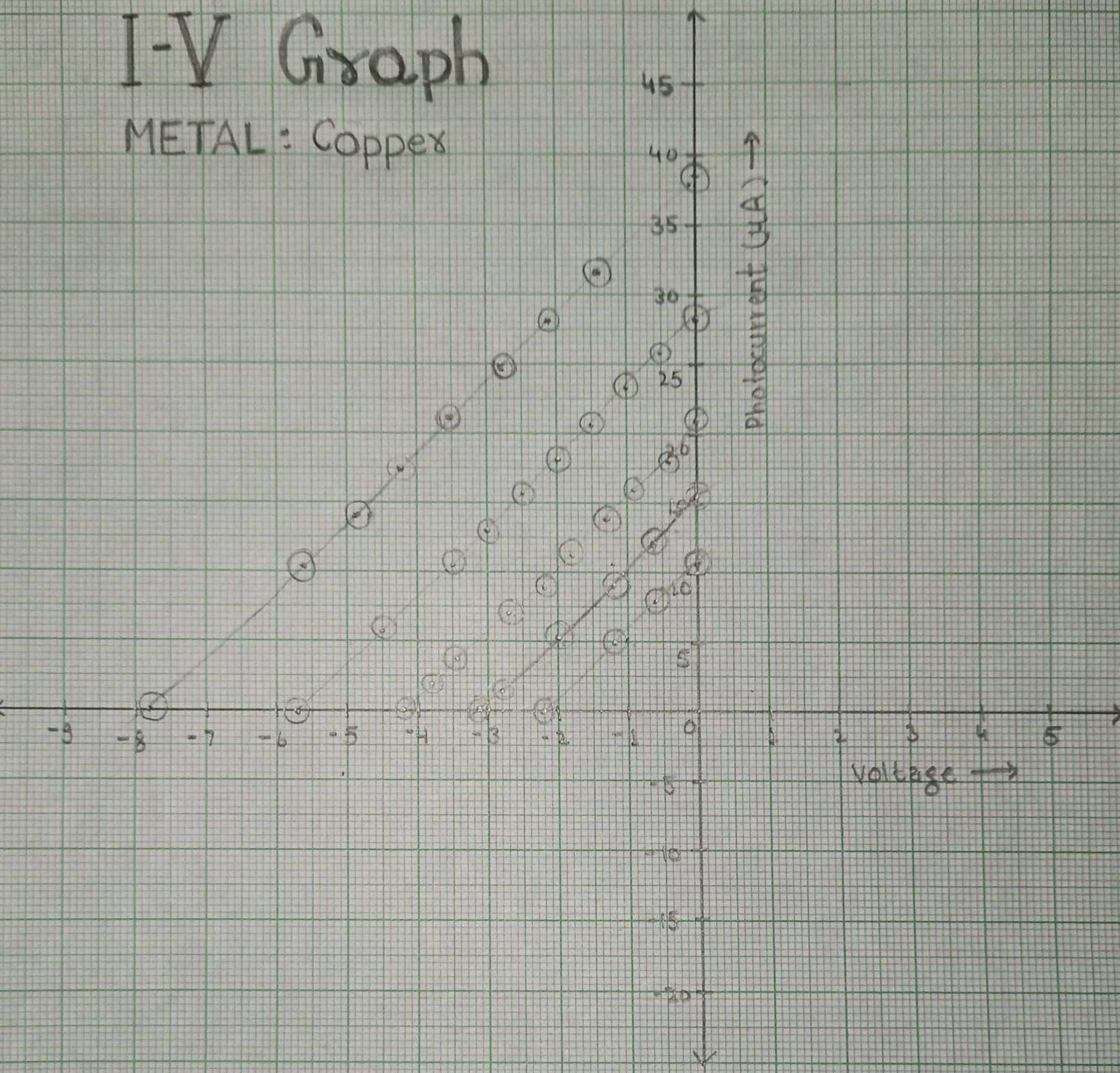
Slope $= \frac{\frac{5.7}{14} + \frac{4}{9.75}}{2} = \frac{0.407 + 0.410}{2} = 0.408$

Intercept for copper = -4.6

Intercept for platinum = -6.3

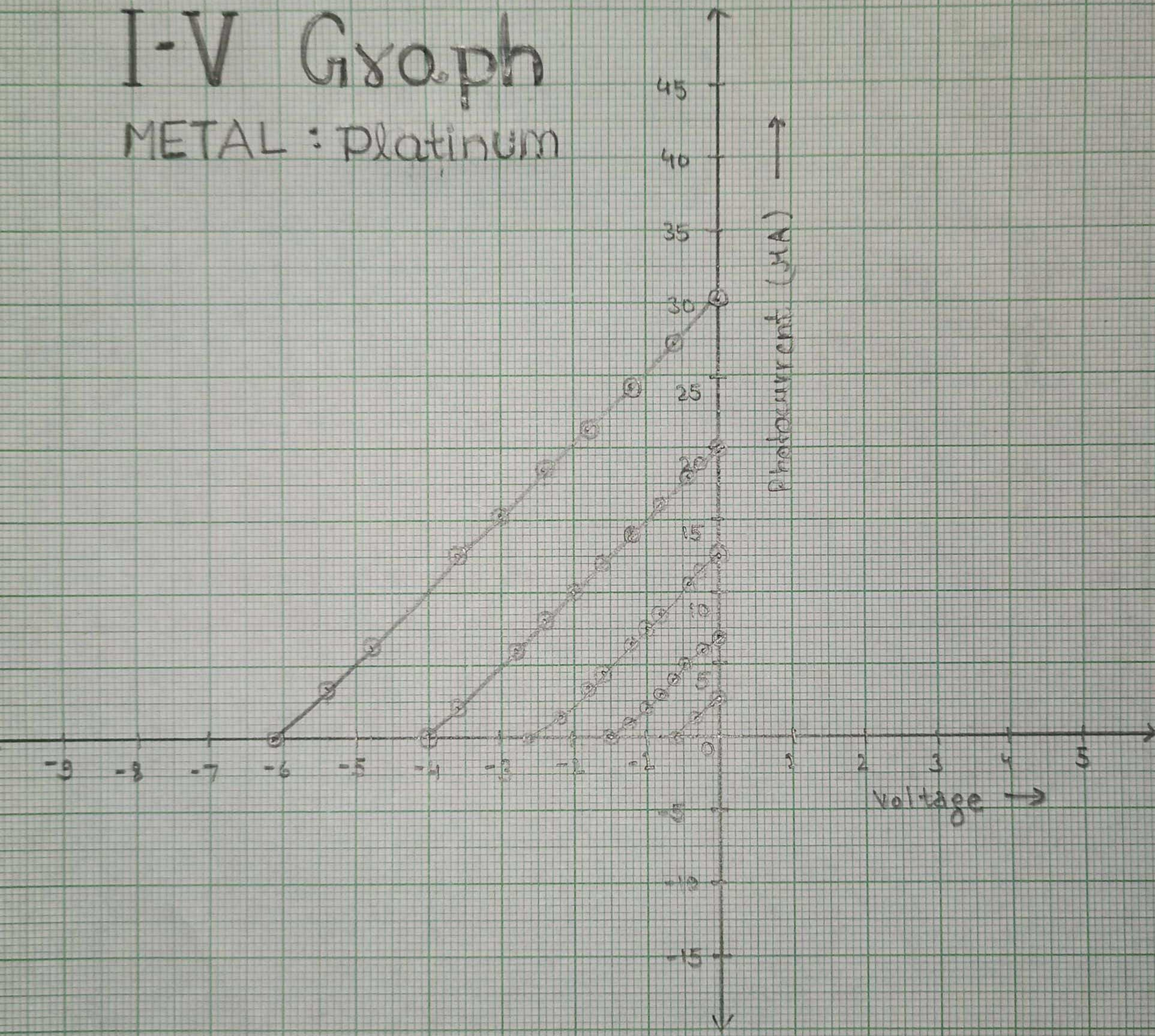
I-V Graph

METAL : Copper

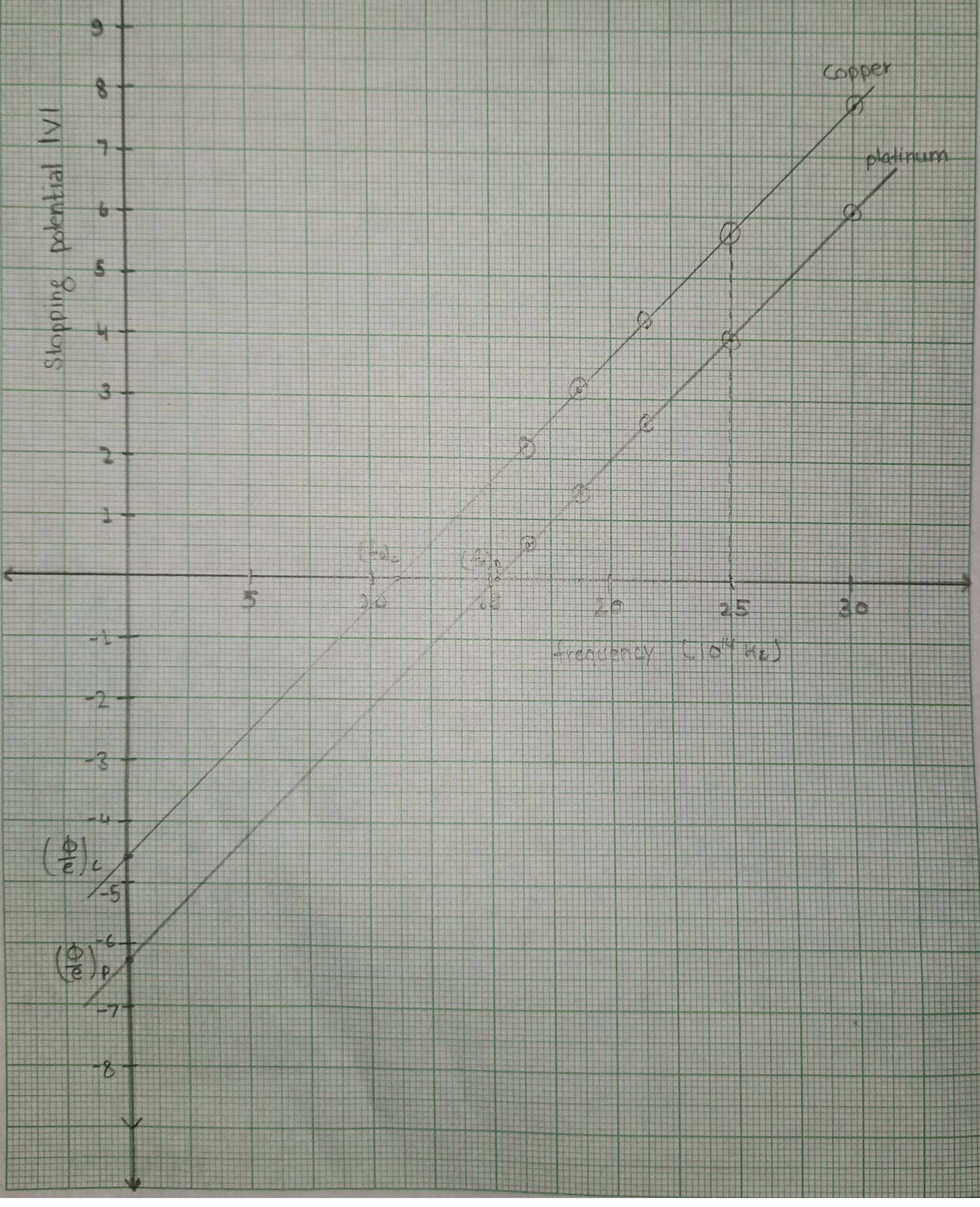


I-V Graph

METAL : Platinum



Stopping Potential Vs Frequency



PRECAUTIONS:

1. Do not use a voltage in excess of the operating voltage range.
2. Do not short circuit the load.
3. Do not reverse power supply polarity
4. Be sure to insert a load when connecting the power supply.

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Expt. No. ______ Page No. ______

EXPERIMENT 3

Aim:

To find the refractive index of liquid by travelling microscope.

Theory:

When viewed vertically from the air a point object inside the liquid, it appears to be raised by a small amount, depending on its depth below the surface and R.I. of the liquid relative to the air.

If the ray starting from (p) object, appear to come from (p') which is the image of (p) object, appears to come relative to the air is given by $\mu = \frac{u}{v} = \frac{OP}{OP'}$ where op = (u) real depth and op' = (v) apparent depth

i.e.,

$$\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$$

Required Apparatus:

1) Travelling Microscope
2) Beaker (cross mark on the base)
3) Spirit level.
4) Tissue papper
5) Magnifying glass
6) Water

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TABLE

Table for Experimental Data

All readings are in cm.

S.No.	Reading of P			Reading of P'			Reading of Q			Real Depth	Apparent Depth
	Main Scale	Vernier scale	Total	Main Scale	Vernier Scale	Total	Main Scale	Vernier Scale	Total	(Q - P) u	(Q - P') V
1.	5.1	1 1x0.001 =0.001	5.101	5.8	2 2x0.001 =0.002	5.802	7.8	2 2x0.001 =0.002	7.802	2.701	2
2.	5.1	1 1x0.001 = 0.001	5.101	5.9	3 3x0.001 = 0.003	5.903	8.3	4 4x0.001 =0.004	8.304	3.203	2.401
3.	5.1	1 1x0.001 = 0.001	5.101	6.0	2 2x0.001 =0.002	6.002	8.6	6 6x0.001 =0.006	8.606	3.505	2.604

Refractive Index of (given liquid) $\mu = \frac{\text{Real Depth}}{\text{Apparent Depth}}$

1) $u_1 = 2.701$ and $V_1 = 2$

$\therefore$ Refractive index of water $\mu_1 = \frac{u_1}{V_1} = \frac{2.701}{2} = 1.3505$

Date

Expt. No.   Page No.

2) $u_2 = 3.203$, $V_2 = 2.401$

then, R.I. (water) $\mu_2 = \frac{u_2}{V_2} = \frac{3.203}{2.401} = 1.3340$

3) $u_3 = 3.505$, $V_3 = 2.604$

then, R.I. (water) $\mu_3 = \frac{u_3}{V_3} = \frac{3.505}{2.604} = 1.3460$

Therefore mean R.I. $\mu_e = \frac{\mu_1 + \mu_2 + \mu_3}{3}$

$= \frac{1.3505 + 1.3340 + 1.3460}{3}$

$= \frac{4.0305}{3}$

$\mu_e = 1.3435$

Thus refractive index of water $= 1.3435$

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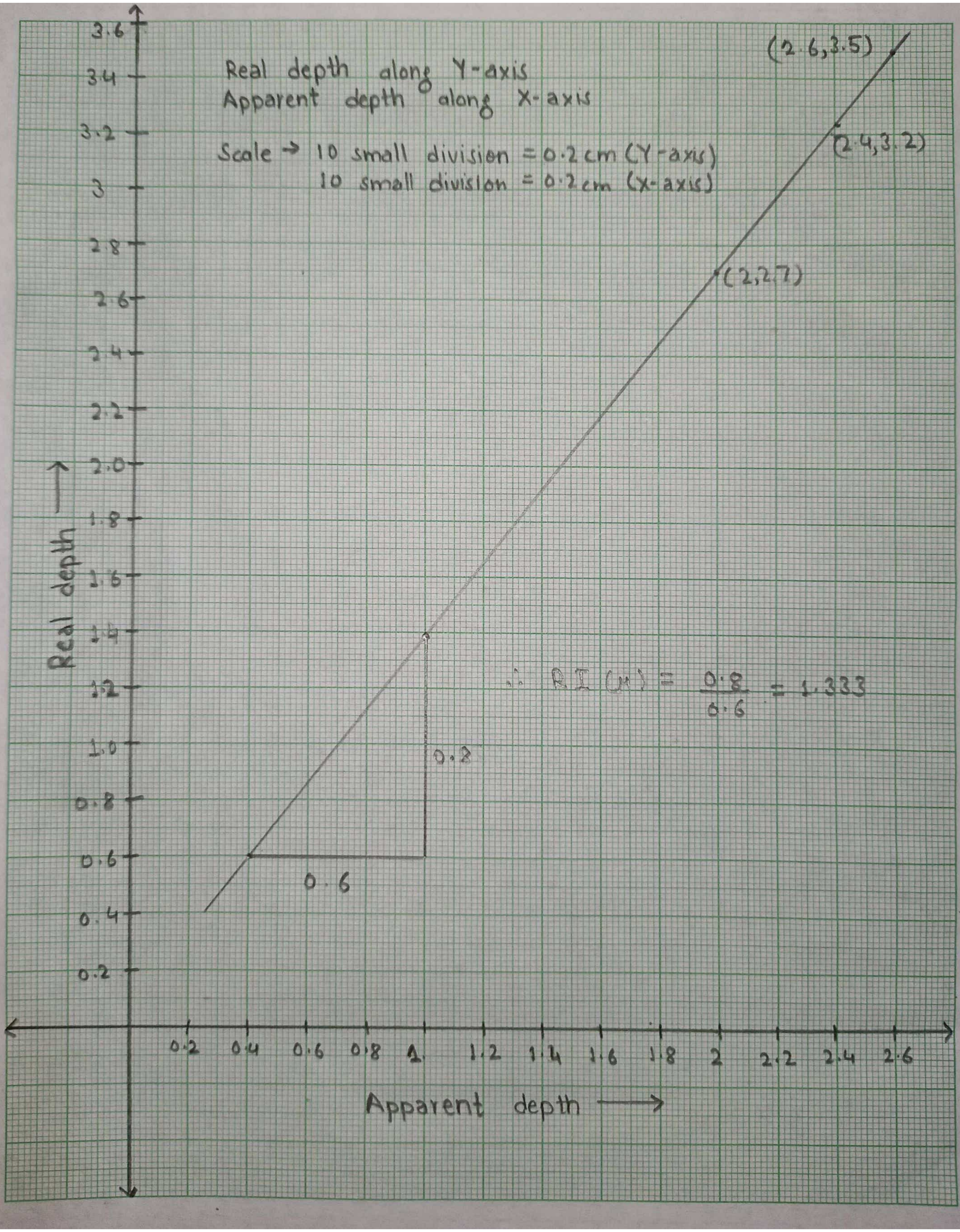
Real depth along Y-axis
Apparent depth along X-axis
Scale → 10 small division = 0.2 cm (Y-axis)
10 small division = 0.2 cm (X-axis)
(2.6, 3.5)
(2.4, 3.2)
(2, 2.7)
0.8
0.6
∴ RI (μ) = 0.8/0.6 = 1.333
Real depth →
Apparent depth →
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6

Date

Expt. No. Page No.

From the above graph R.I. of water (μ_g) = 1.333

So, R.I. of water $\mu = \frac{\mu_e + \mu_g}{2} = \frac{1.343 + 1.333}{2} = 1.338$

$\therefore \mu = 1.338$

Result :

Hence the refractive of water calculated here is 1.838 (approx.)

Percentage error = $\frac{\text{Difference of true value \& calculate value}}{\text{true value}} \times 100$

$= \frac{1.338 - 1.333}{1.333} \times 100\ \%$

% error = 0.375 %

Precautions :-

1) To take accurate reading use magnifying glass.
2) Do not alter distance of eye piece and object after taking initial reading.
3) After reading for error mark (p), do not adjust the adutable screw of the eye piece, while reading of p' and Q. Only adust the adjustable screw of the vertical seale screw.

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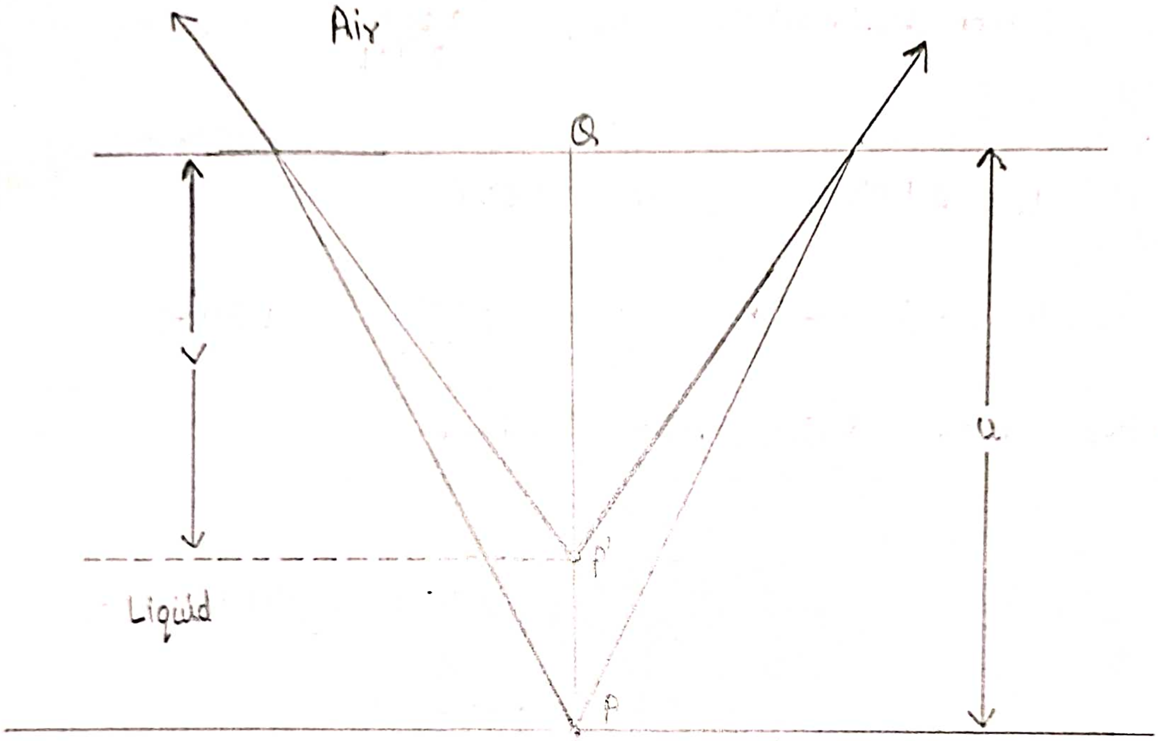


Ray Diagram

Real Depth and apparent depth of a fixed point below the liquid

EXPERIMENT No. : 4

AIM

To determine Brewster's angle for glass using a polarised light source.

APPARATUS USED

Laser, Polariser, Glass plate, Plate holder, Rotational mount, Detector, Current Output unit.

THEORY AND FORMULA USED

When light travels from one media to another having different refractive index, some of the light is reflected back from the surface of the denser medium. This reflected ray's intensity changes with change in the angle of incidence at the inferface of two media. At one specific angle of incidence of light only perpendicular vibrations of electric field vectors are reflected whereas parallel vibrations are blocked. The angle of incidence for which reflected ray is polarised is called the polarisation angle (θ_p) or Brewster's angle.

Brewster's angle for a given medium is

$$\mu = \tan \theta_p$$

$$\theta_p = \tan^{-1} \mu$$

where 'μ' is refractive index of medium and 'θ_p' the polarisation angle.

Date

Expt. No.   Page No.

PROCEDURE (virtual)

- Select the medium (air), material (crown glass) and click the switch On light.
- Rotate the glass plate at an interval of 5°, move down the rotation angle (θ) and corresponding current value (I).
- Plot a graph of reflected power (current I) v/s angle θ.
- From the graph find Brewster's angle as well as refractive index of the material.

OBSERVATION TABLE

Rotation Angle θ	40	45	50	55	60	65	70	75	80	85
Current (I)	5.603	3.607	1.938	1.061	1.245	2.432	4.267	6.265	8.020	9.321

RESULT

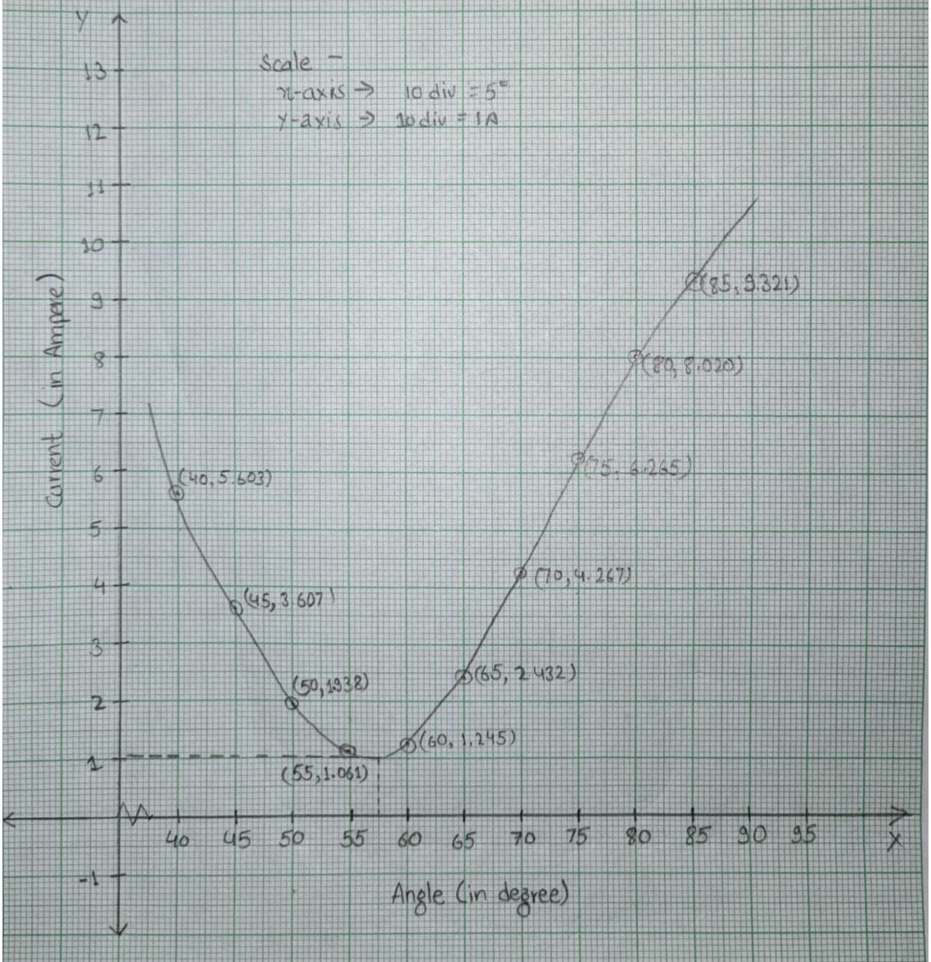
Reflected Power (current I) v/s angle θ graph is plotted.

1. Brewester's angle for the material (crown glass) is <u>56.2°</u>
2. The Refractive index of the material (crown glass) is

$$\tan(56.2^\circ) = 1.49$$

Teacher's Signature

• GRAPHICAL ANALYSIS



EXPERIMENT No. : 5

AIM

To determine the relationship between the intensity of the transmitted light through analyser and the angle between the area of polariser and analyser.

APPARATUS USED

Loser, polariser, Analyser, Photo detector, ~~Dect~~ Detector output measuring unit, optical bench.

THEORY AND FORMULA USED

When light falls on a polariser, the transmitted light gets polarised. The polarised light falling on another polariod, called analyser is given by Malus' law. The law describes how the intensity of light transmitted by the analyser varies with the angle that its plane of transmission makes with that of the polariser. The law can be mathematically written as

$$I_t = I_o \cos^2\theta$$

Where I_t is the intensity of the light transmitted through the analyser and I_o is the intenrity of the incident plane polarised light.

Date

Expt. No.   Page No.

PROCEDURE (virtual)

- Click the power on knob
- Rotate the polarizer angle at an interval of 10 degree, not down the rotation angle (θ) and corresponding current value (I_{expt})
- Plot a graph between I_{expt} V/s θ

Observation table

S. No.	Angle of polarizer θ (Here it is polariser degrees)	$\cos\theta$	$\cos^2\theta$	Current I_{exp} (mA)	Current $I_{th} = I_{max} \times \cos^2\theta$
1.	0	1	1	10.0	10.0
2.	30	0.866	0.75	7.50	7.5
3	60	0.5	0.25	2.50	2.5
4.	90	0	0	0.0	0
5.	120	-0.5	0.25	2.50	2.5
6.	150	-0.866	0.75	7.50	7.5
7.	180	-1	1	10.00	1
8.	210	-0.866	0.75	7.50	7.5
9.	240	-0.5	0.25	2.50	2.5
10.	270	0	0	0.00	0

GRAPHICAL ANALYSIS

Current (I_{expt}) Vs Polarizer angle (θ) is plotted

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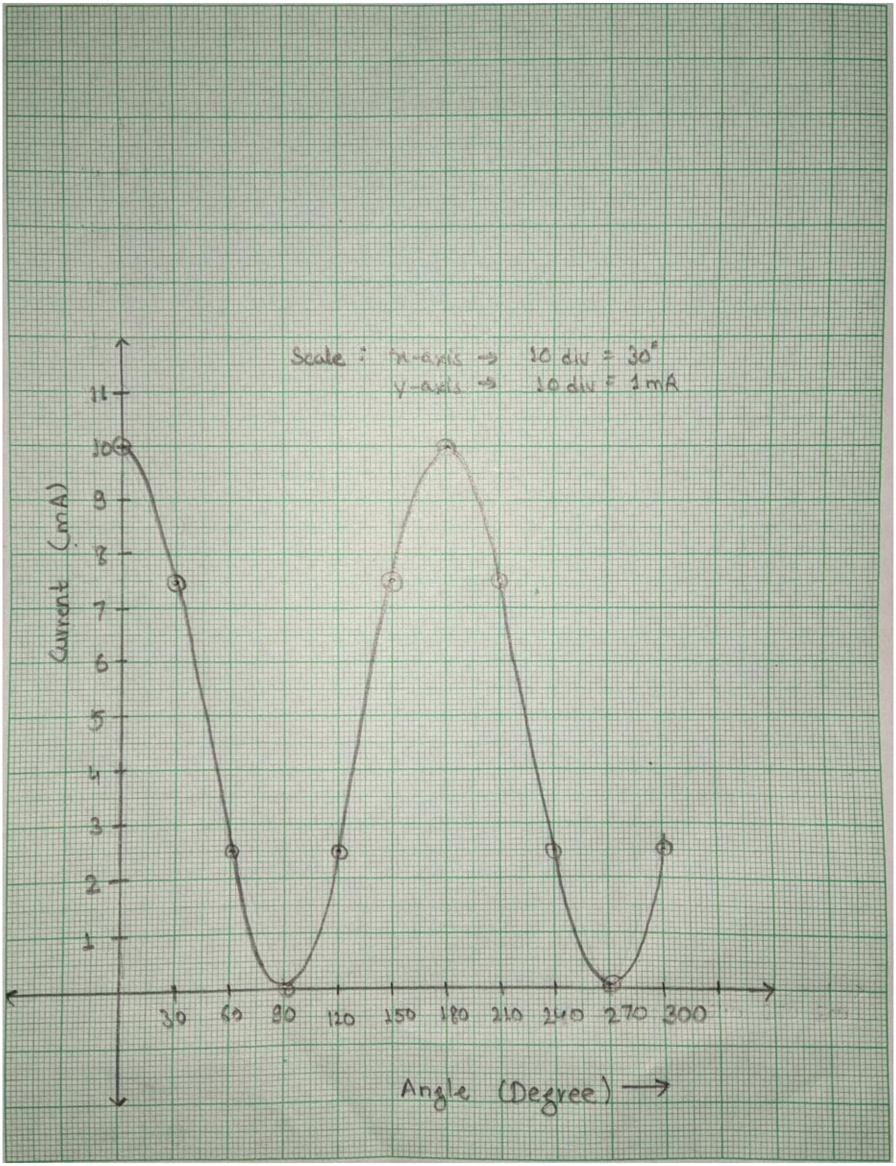
Scale : x-axis → 10 div = 30°
y-axis → 10 div = 1 mA
Current (mA)
11
10
9
8
7
6
5
4
3
2
1
30
60
90
120
150
180
210
240
270
300
Angle (Degree) →

Date

Expt. No. Page No.

DISCUSSION

The experimentally measured current (I_{expt}) and (I_{theo}) that calculated using equation $I_{theo} = I_{max} \cos^2\theta$ agree within the limits of the experimental error.

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