Date: 2021/01/.. Experiment No.: 1 Set :

PHY 1701 (Engineering Physics) Reg. No:- 20BDS0405

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OBJECTIVE OF THE EXPERIMENT:

MONOCHROMATORS IN SOPHISTICATED INSTRUMENT

APPARATUS AVAILABLE:-

(i) Laser Source

(ii) Grating

(iii) Scale with measurements.

SLO:

To determine the wavelength of light produced by given laser source using transmission diffraction grating.

Suppose, D = the distance from the grating to the screen.

d = the spacing between every two lines (same thing as every two sources).

If there are 'N' lines per mm of the grating, then (d), the space between every two adjacent lines or (every two adjacent sources) is

$d = \frac{1}{N}$

The diffraction grating formula for the principal maxima is:-

$d\sin\theta = n\lambda$

where, n is the order of diffraction (=1,2,3...) and θ is the angle of diffraction.

$\lambda = \frac{\sin\theta}{Nn}$ (meter)

OBSERVATION:

Number of lines per meter on grating is 10^5.

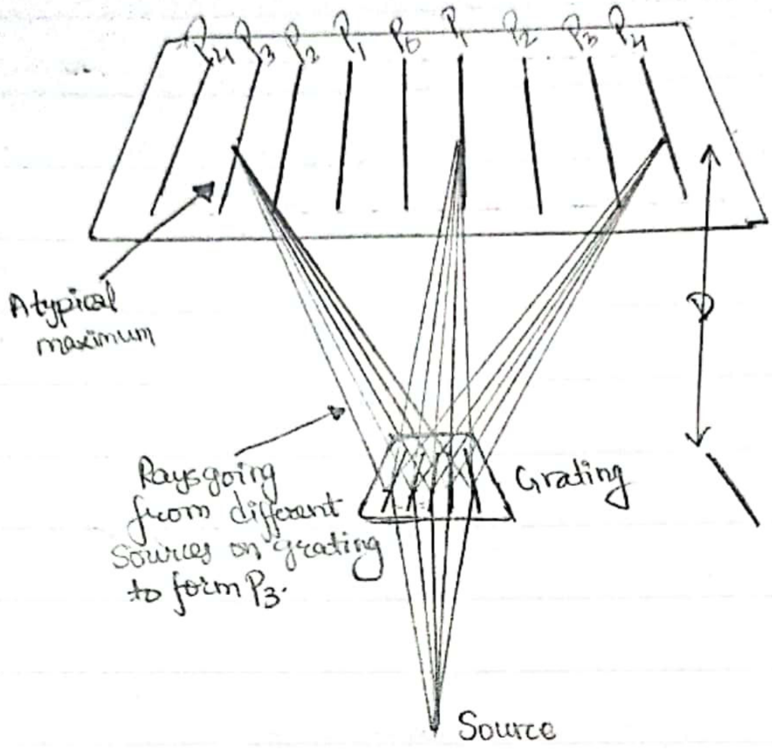

Fig :- Diffraction through a grating

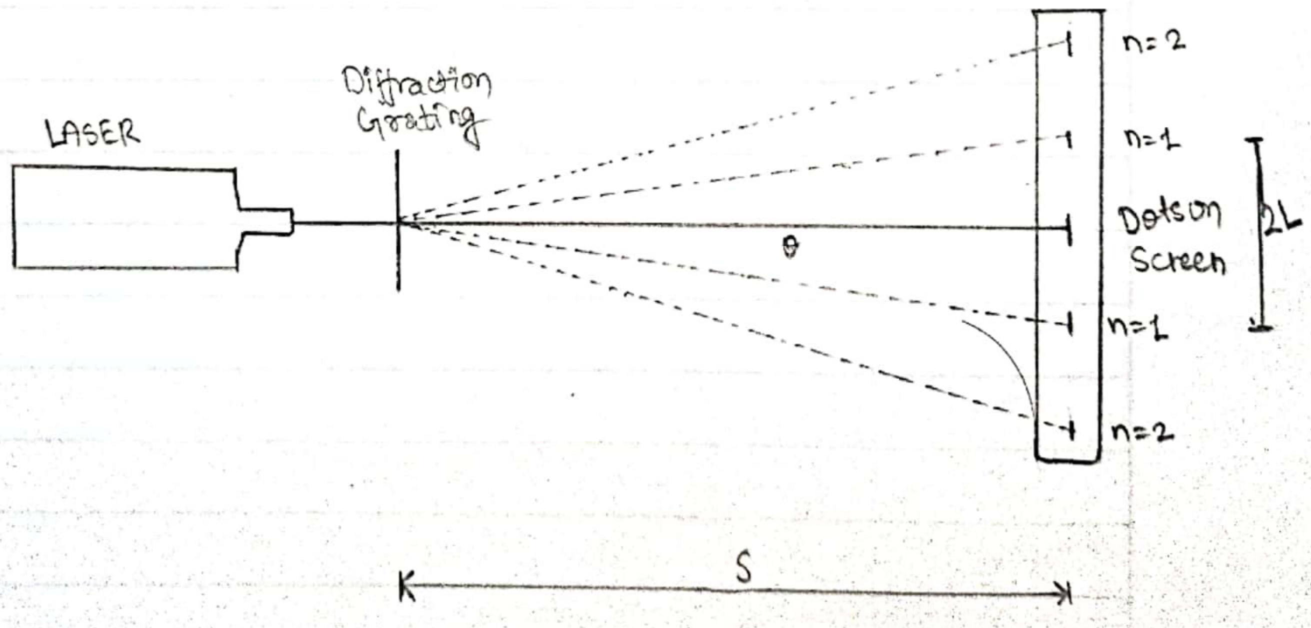

Fig :- Experimental Setup.

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n	S (cm)	2L (cm)	L (cm)	$\tan\theta = L/s$	$\theta = \tan^{-1}(L/s)$	$\sin\theta$	Mean	λ (mm)
1	25	3.3	1.65	0.066	3.7760°	0.0659		
1	30	4.0	2.00	0.067	3.8141°	0.0665	0.066	660
	35	4.6	2.30	0.066	3.7597°	0.0656		
	25	5.5	2.75	0.11	6.2773°	0.1093		
2	30	7.8	3.9	0.13	7.4069°	0.1289	0.1228	614
	35	9.2	4.6	0.1314	7.4874°	0.1303		
	25	9.9	4.95	0.198	11.1997°	0.1942		
3	30	12	6	0.2	11.3099°	0.1961	0.1959	653
	35	14.1	7.05	0.2014	11.3886°	0.1975		

Sample Calculation:-

① $n=3$, $\sin\theta = 0.1959$ (mean value), $N = 10^5$ lines/m

$$\therefore \lambda = \frac{\sin\theta}{n \cdot N} = \frac{0.1959}{10^5 \times 3} = 6.5311 \times 10^{-7}\ \text{m}$$

$$\approx 6531\ \text{Å}$$

$$= 653\ \text{nm}$$

Similarly, the calculations were carried out for 1st and 2nd order maxima and respective results are noted in the table.

Thus, Average wavelengths from three different orders of maxima is.

$$\lambda_{mean} = \frac{660 + 614 + 653}{3}$$

$$= 642\ \text{nm}$$

RESULT:

The wavelength of the laser source is found to be 642 nm.

ADVANCED MATERIAL ANALYSIS THROUGH QUANTUM PHYSICS.

Apparatus available:-

- Photoelectric equipments
- filters

SLO :

Determination of Plank's Constant
Determination of 'work-function' of given metal.
· Study of photoelectric effect.

Theory:-

Hertz noticed a spark between two metallic balls when a high frequency radiation is incident on it. This is called photoelectric effect. Photoelectric effect is the emission of electrons when electromagnetic radiations having sufficient frequency is incident on certain metal surfaces. We call the emitted electrons as photoelectrons and the current they constitute as photocurrent. The phenomenon was first observed by Heinrich Hertz in 1880 and explained by Albert Einstein in 1905 using Max Planck's quantum theory of light. As the first experiment which demonstrated the quantum theory of energy levels, photoelectric effect experiment is of great historical importance.

It has been observed that there must be minimum energy needed for electrons to escape from a particular metal surface and is called work function(ϕ). The work function can be expressed in terms of frequency as,

$$w = h\nu_0$$

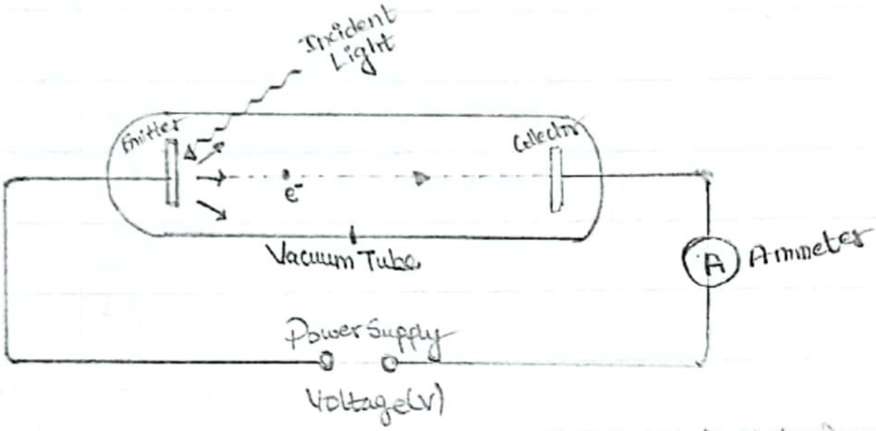

Fig:- Photoelectric Effect (Experimental Setup)

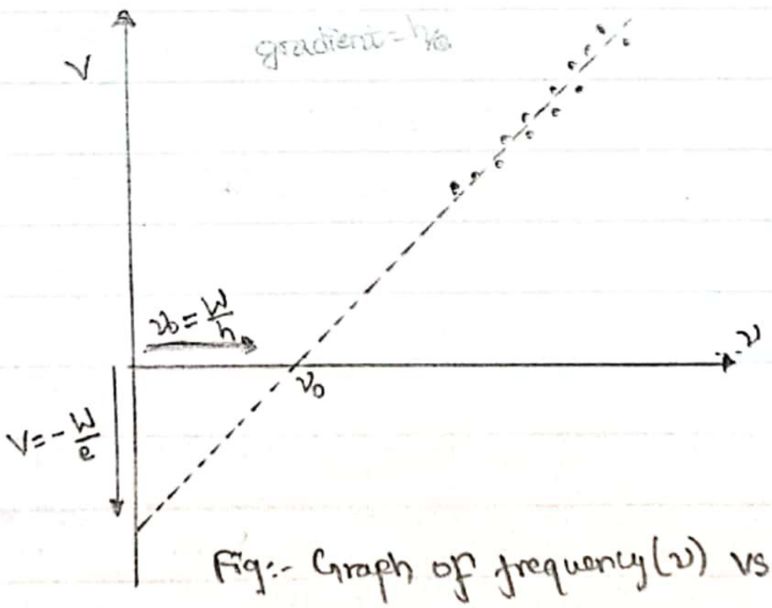

Fig:- Graph of frequency (ν) vs. stopping potential (V) where h is the Planck's constant and V_0 is.

The work functions for some metals are listed in the table.

Metal	Work function(ev)
Pt	6.4
Ag	4.7
Na	2.3
K	2.2
Cs	1.9

According to Einstein the photoelectric effect should obey the equation,

$$h\nu = KE + W$$

$$h\nu = eV_s + W$$

$$V_s = \frac{h}{e}\nu - \frac{W}{e}$$

Results:

Work function of given metal is 1.45 eV.

Planck's constant $\approx 6.6\times10^{-34}$ Js

S.No	Incident photon wavelength (nm)	Incident Photon frequency ~~wavelength~~ (sec⁻¹)	Stopping Voltage (V).
1	460	6.52×10^{14} Hz	1.1
2	500	6×10^{14}	0.84
3	540	5.55×10^{14}	0.71
4	570	5.26×10^{14}	0.55
5	635	4.72×10^{14}	0.35

Sample Calculations:-

From graph, we get, slope of graph $= \frac{\Delta V}{\Delta \nu} = \frac{0.75}{1.8 \times 10^{14}} = 4.167 \times 10^{-15}$ Vs

y-intercept = 1.45 volt.

Then, $\frac{W}{e}$ = y-intercept

$\Rightarrow$ Work function (W) = e × y-intercept.

= 1.45 eV

Now, $\frac{h}{e}$ = slope of graph

$\Rightarrow$ planck's constant (h) = e × slope of graph.

$= 1.6 \times 10^{-19}$ C $\times 4.167 \times 10^{-15}$ Vs

$= 6.67 \times 10^{-34}$ Js

$\approx 6.6 \times 10^{-34}$ Js (approximately).

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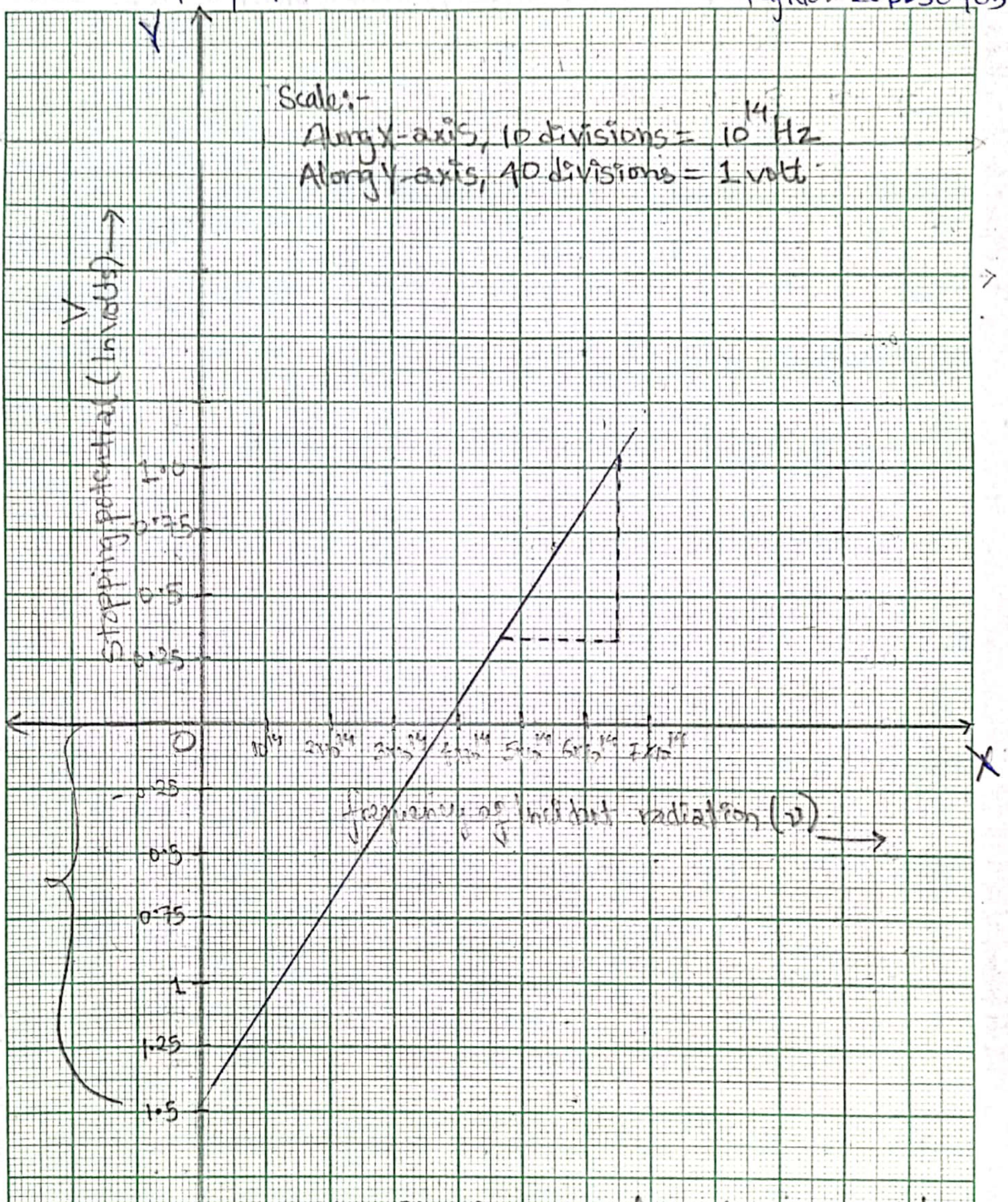


Graph:- Stopping potential 'vs' frequency of Incident light-

OBJECTIVE OF THE EXPERIMENT:

ENGINEERING APPLICATIONS OF NANOMATERIALS

Tools Required:-

- XRD pattern
- Peak fitting program (fityk, gnuplot or qtiplot)
- Usage of

SLO :-

To determine the average crystallite size from the X-ray diffraction (XRD) pattern of a polycrystalline materials.

Formula to Use:-

The scherrer equation is to calculate the crystallite size. This method gives qualitative results. The Scherrer Equation is:-

$$D = \frac{K\lambda}{\beta\cos\theta}$$

Here,

- Peak width (β in radians).
- Crystallite Size (D)
- Scherrer Constant (K).
- X-ray wavelength (λ).
- Peak-position (θ).

DATA GIVEN:

Instrumental Broadening : 0.01°

Wavelength of X-ray Used : $1.546\ \text{Å}$

Scherrer Constant: 0.94 (assuming the crystallites are spherical in shape).

Scanned with CamScanner

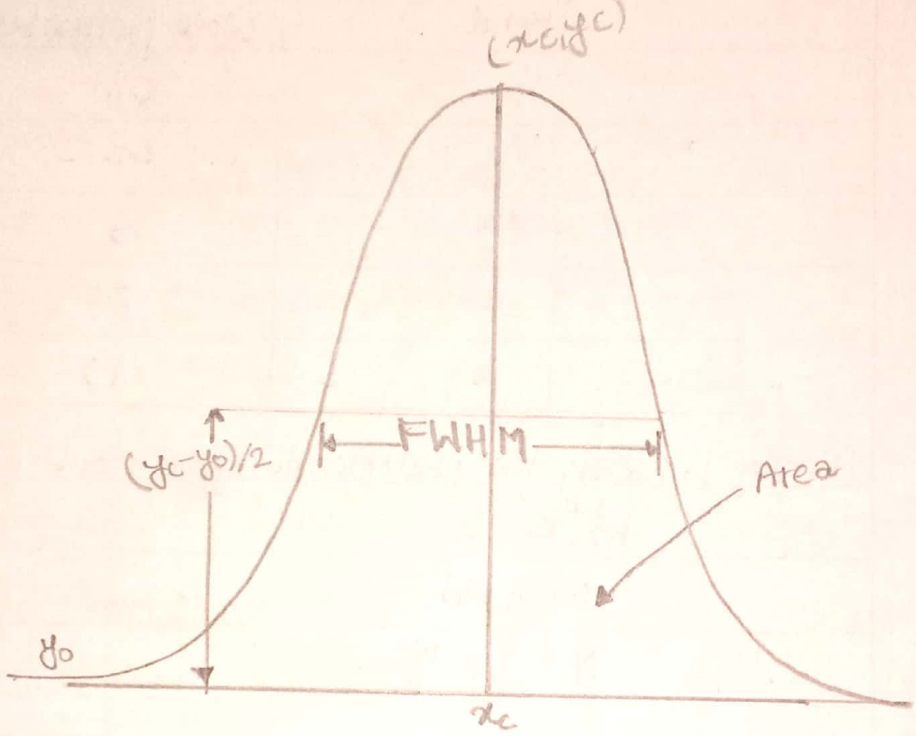


Fig:- Peak Fitting using Gaussian/Pseudovoigt function.

Date:- 01/22/2020

Tabulation:-

Peak Center (degree)	FWHM (degree)	FWHM after instrumental broadening correction. (degree)	FWHM (in radian)	Average Crystallite Size (Å)
28.57	0.33	0.320	0.00558	267.81
47.540	0.390	0.380	0.00663	238.67
56.370	0.389	0.379	0.0066	248.93
33.130	0.420	0.410	0.00716	211.01
59.13	0.430	0.420	0.00733	227.14

Sample Calculation:-

For 1st order maxima, $K = 0.94$, $\lambda = 1.06 \text{Å}$

Peak Center $(\theta) = 14.285°$

FWHM $(\beta) = 0.00558^c$

$$\therefore \text{Crystallite size} = \frac{K\lambda}{\beta\cos\theta} = \frac{0.94 \times 1.}{0.00558 \times \cos(14.285^c)} \text{Å}$$

$$D_1 = 267.81 \text{Å} \approx 268 \text{Å}$$

Similarly, $D_2 = 238$ Å, $D_3 = 248$ Å, $D_4 = 211$ Å, $D_5 = 227$ Å

Now, Average of all values is $D = \frac{D_1 + D_2 + D_3 + D_4 + D_5}{5} = 238.8 \text{ Å} \approx 23.8 \text{ nm}$

Inference:-

The Crystallite Size was calculated to be 23.8 nm.

DATE: 2021/02/04

CLEAN ENERGY

Apparatus Required:

- Solar Cell (p-n junction diode)
- Light Source (100 W bulb)
- Ammeter
- Voltmeter
- Load Circuit
- Connecting Wires

SLO:

- To draw the I-V characteristics of a solar cell and to find out the efficiency and fill factor.

The maximum power generated $P_{max} = I_{mp} V_{mp}$ (where I_{mp} and V_{mp} are the current and voltage corresponding to maximum power).

$$FF = \frac{V_{mp} I_{mp}}{V_{oc} I_{sc}}$$

$$\eta = \frac{P_{max}}{A_c \Omega}$$ (where, $A_c \rightarrow$ Area of solar cell
$\Omega \rightarrow$ Incident Intensity).

DATE: 2021/02/04

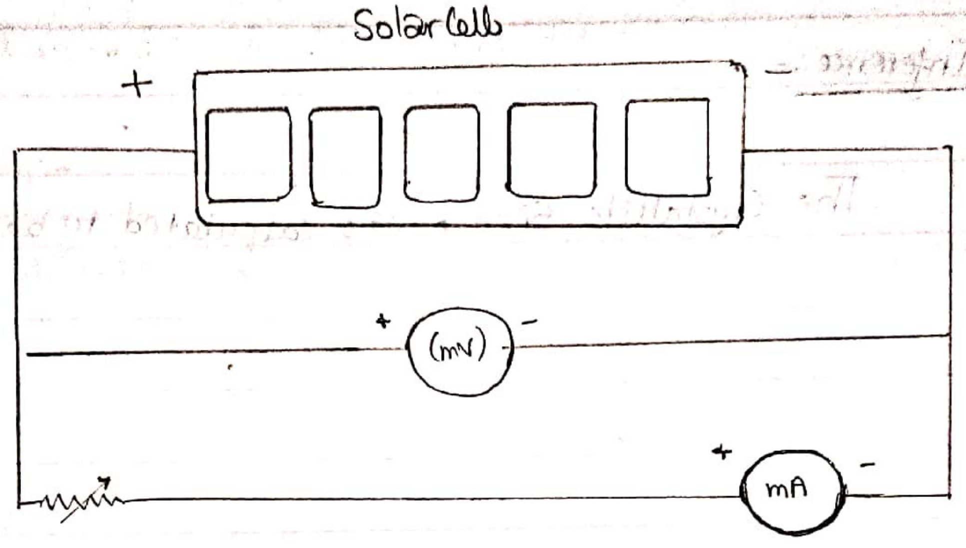


Fig:- Experimental Arrangement of Circuit

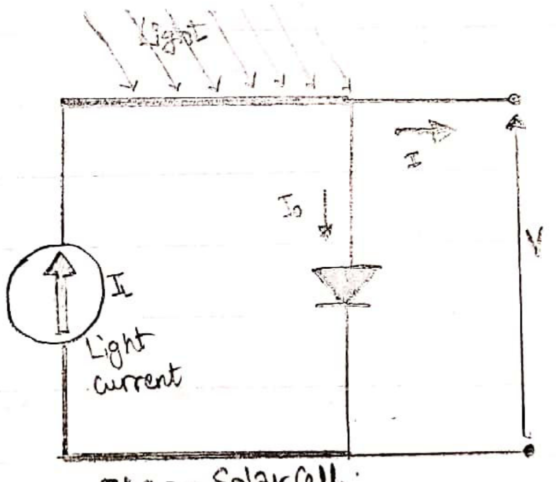


Fig:- Solar Cell

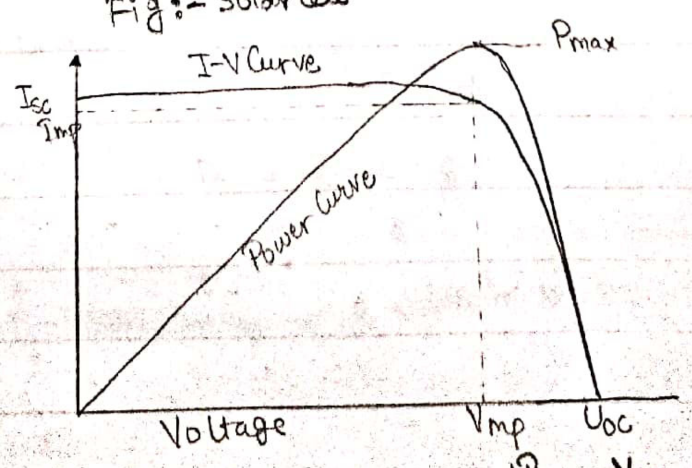


Fig:- Nature of Curve of I and P vs V.

Date:- 2021/02/04

Table:- IV characteristics

Distance (x) = 7cm Intensity of light = 217 W/m² Area of the solar cell = 22.75×10^{-4} m²			I_{sc} = 14mA V_{oc} = 1.74V
Load Resistance (ohms)	Current (mA)	Voltage (V)	Power (mW)
10	14	0	0
22	14	0.15	2.1
33	14	0.35	4.9
47	14	0.7	9.8
68	14	0.85	11.9
82	12	0.9	10.8
100	12	1.15	13.8
150	10	1.3	13
220	7	1.5	10.5
470	3	1.6	4.8

Calculation:-

$$\text{Fill factor (FF)} = \frac{V_{mp} I_{mp}}{V_{oc} I_{sc}}$$

$$= \frac{1.15 \times 11.8 \times 10^{-3}}{14\times10^{-3} \times 1.74}$$

$$= 0.557$$

$$\text{Efficiency } (\eta) = \frac{P_{max}}{A\,\Omega} = \frac{1.357\times10^{-2}}{22.75\times10^{-4} \times 217}$$

$$= 0.0275$$

$$= 2.7\%$$

Date:- 2021/02/04

Observations :-

1). For distance ($x_1 = 7cm = 7 \times 10^{-2} m$)

$I_{mp} = 11.8 mA = 11.8 \times 10^{-3} A$

$V_{mp} = 1.15$ Volts

$P_{max} = I_{mp} \times V_{mp} = 11.8 \times 1.15 \times 10^{-3} = 1357 \times 10^{-2}$

$\Omega = 217 Wm^{-2}$

$A_c = 22.75 \times 10^{-4} m^2$

Results:

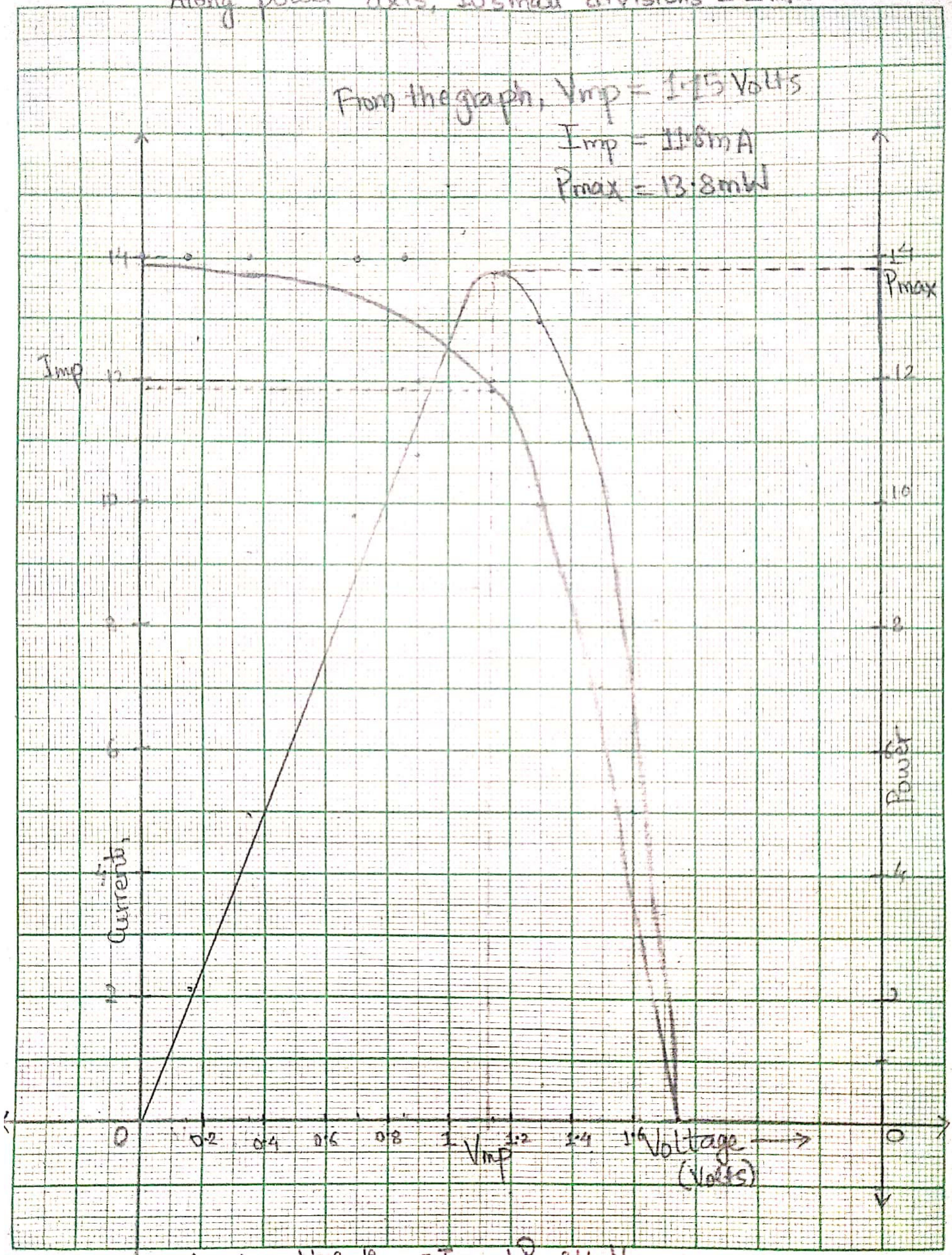
I-V characteristics of the solar cell were studied and the maximum power generated; FF and efficiency were calculated for two different source-cell distances.

For, $x_1 = 0.07 m$

Efficiency, η = 2.75%

FF = 0.557

Along Voltage axis, 10 small divisions = 0.2 volt
Along current axis, 10 small divisions = 1 mA
Along power axis, 10 small divisions = 1 mW



Graph:- Variation of I and P with V.

OF THE EXPERIMENT: QUALITY CHECK FOR SOFT DRINKS

Apparatus Required:

- Travelling Microscope
- Transparent Liquid (water)
- Reading lens
- Glass Beaker
- Pin
- Saw dust

SLO:

To determine the refractive index of the given transparent liquid using travelling microscope.
To determine the refractive index of impure liquid.

Formula:

The refractive index of liquid

$$\mu = \frac{\text{Real depth of the liquid}}{\text{Apparent depth of the liquid}} = \frac{(C-A)}{(C-B)} \text{ (No Units)}.$$

where,

A is the microscopic reading when tip of the pin is focused directly.
B is the microscopic reading when tip of the pin is focused through liquid.
C is the microscopic reading when saw dust sprinkled on surface of liquid is focused

Result:

Refractive index of the given liquid (water) is found to be 1.4438 (Units).

Date:-2021/02/11.

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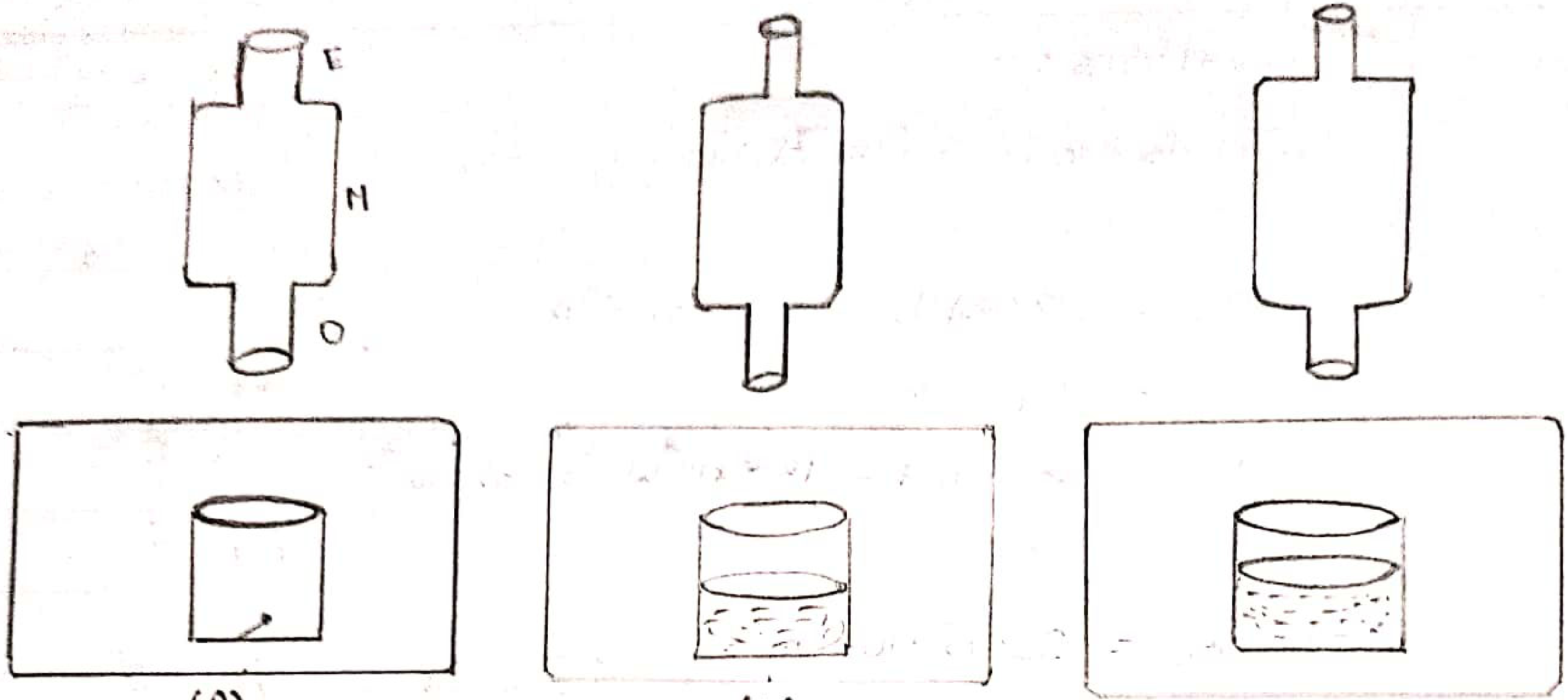

(A) (B) (C)

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Table 1:

Least Count of Travelling Microscope = 0.001cm

Volume of water in the Beaker	Clear image of the tip of pin (Reading A)			Clear image of tip of pin seen through the liquid (Reading B)			Clear image of saw dust scattered on the surface of liquid (Reading C).			C−A (cm)	C−B (cm)	μ
	MSR (cm)	VSC	OR (cm)	MSR (cm)	VSC	OR (cm)	MSR (cm)	VSC	OR (cm)			
40ml	5.25	36	5.286	5.30	25	5.325	5.9	9	5.909	0.623	0.584	1.0668
60ml	5.25	36	5.286	6.15	7	6.157	7.2	18	7.218	1.932	1.061	1.8209
VSR = VSC × LC ; Observed Reading = MSR + VSR											Mean	1.4438

For 40ml water, For Reading A, OR = MSR + VSR = 5.25 + 36×0.001 = 5.286 cm

For Reading B, OR = MSR + VSC×LC = 5.3 + 25×0.001 = 5.325 cm

For Reading C, OR = MSR + VSC×LC = 5.9 + 9×0.001 = 5.909 cm

For 60ml water, For Reading A, OR = MSR + VSC×LC = 5.25 + 36×0.001 = 5.286 cm

For Reading B, OR = MSR + VSC×LC = 6.15 + 7×0.001 = 6.157 cm

For Reading C, OR = MSR + VSC×LC = 7.2 + 18×0.001 = 7.218 cm

Now, Refractive Index for 40ml sample = 1.0668

for 60ml sample = 1.8209 Mean Value = $\frac{1.0668 + 1.8209}{2} = 1.4438$

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Electron Diffraction.

Apparatus Required

1. Electron diffraction tube with stand.
2. High voltage power supply (upto 10 KV).
3. Connecting wires.
4. Plastic measuring scale.

OBJECTIVE:-

To calculate the interplanar spacing in graphite from the diffraction pattern.

BASIC INFORMATION:

In this experiment, electrons get transmitted through a very thin polycrystalline graphite sheet. The schematic sketch is shown in fig 1. Graphite has two independent lattice spacings (d_1 and d_2) and these are shown in Fig. 2 The two diffraction rings that will be seen at each voltage are due to these planes.

Applying the diffraction formula for first order, we get,

$$\lambda = d\sin\theta.$$

where λ is the de-Broglie wavelength of e^-, d is interplanar spacing and θ is the angle of diffraction. Electrons are accelerated through a p.d. of V volts and hence their de-Broglie wavelength is:

$$\lambda = \frac{12.3}{\sqrt{V}} \text{Å}$$

From the geometry of Fig. 1 we have,

$$\sin\theta = \frac{R}{\sqrt{R^2+L^2}}$$

Upon simplifying and using the fixed value of L = 13.5cm and R is expressed in cm,

$$\sin\theta = \frac{1}{\left(1+\left(\frac{13.5}{R}\right)^2\right)^{0.5}}$$

Interplanar spacing can be calculated from equation (1) by substituting equations (2) and (4) into it.

SAFETY GUIDELINES AND PRECAUTIONS:-

1. Never accelerate beyond 5KV.
2. Never touch any controls on the power supply other than the 'on-off' switch and voltage varying knob.
3. Never use force to measure the ring diameters. Keep a plastic scale very gently over the tube to measure the diameters. Metal scales are not allowed.
4. You are working with a very high energy source (>5KV) and hence touching any part of the entire setup other than what is mentioned in point 3 (just for the purpose of measurement) is prohibited. This is for the purpose of your own safety and the safety of the Lab.

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Procedure:-

1. Set the accelerating voltage at 4 KV.
2. For the inner ring, measure the diameter ($2R_1$).
3. Fill up the radius (R_1) in the tabular column.
4. For the outer ring, measure the diameter ($2R_2$).
5. Fill up the radius (R_2) in the tabular column.
6. Calculate λ, $\sin\theta$ and d from the equations (2), (4) and (1) respectively and fill up the corresponding cells in the tabular column.
7. Repeat steps 2 to 6 for accelerating voltages 4.5 and 5 KV.
8. Calculate the average 'd' for both inner and outer rings.

~~RESU~~

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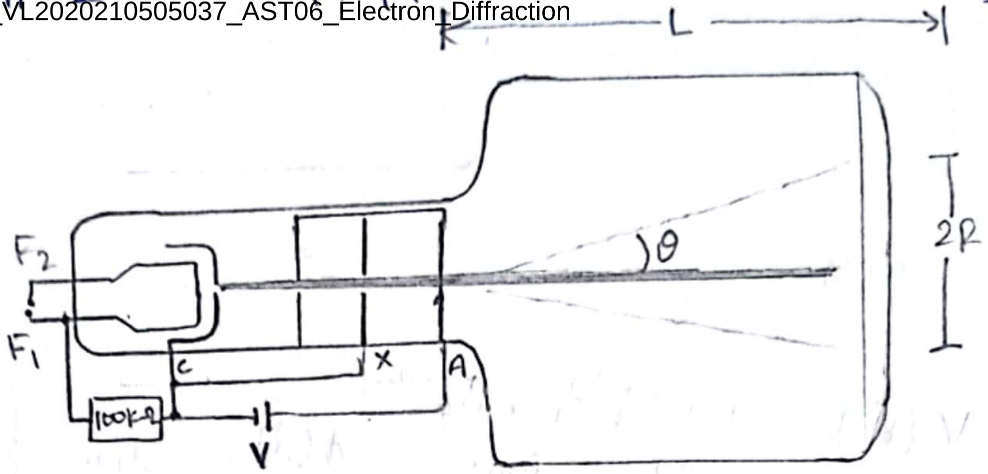

Fig:- Schematic diagram of experimental setup.

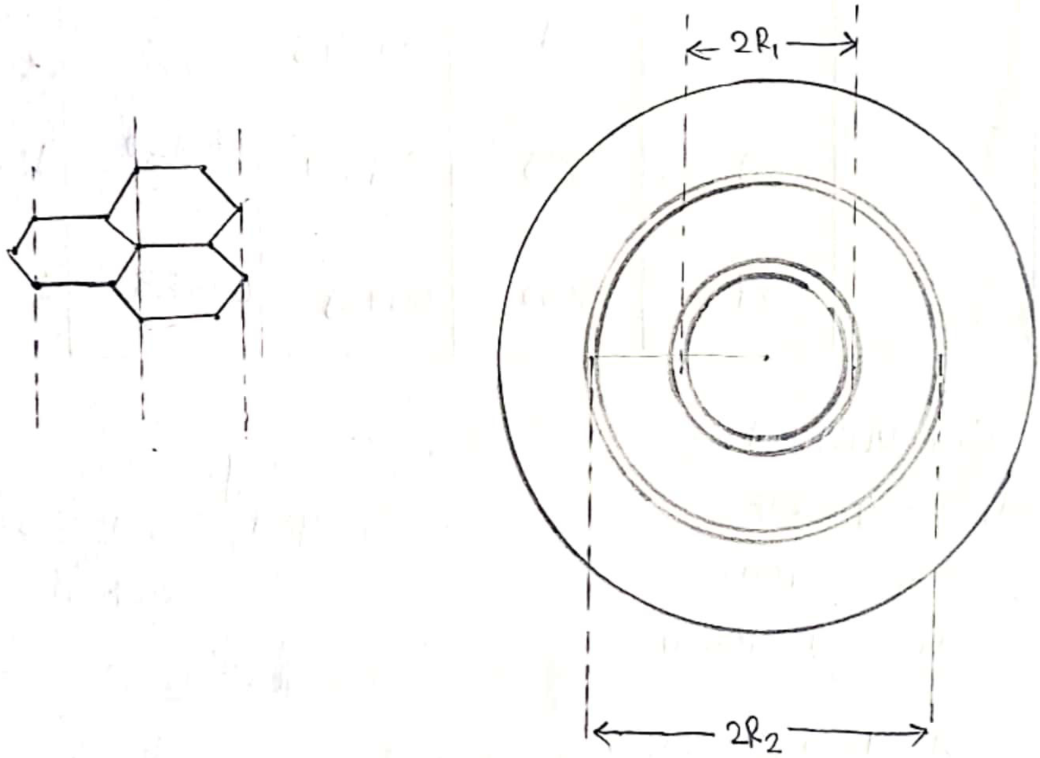

Fig:- Left(Two independent types of lattice planes in polycrystalline.

Tabular Column:-

Ring	V (kV)	$2R_1$ or $2R_2$ (cm)	R_1 or R_2 (cm)	λ (Å)	$\sin\theta$	d (Å)
Inner	4.0	2.4	1.2	0.1945	0.0885	2.198
	4.5	2.2	1.1	0.1834	0.0812	2.259
	5.0	2.0	1.0	0.1739	0.0739	2.353
Outer	4.0	4.2	2.1	0.1945	0.1537	1.265
	4.5	3.9	1.95	0.1834	0.1430	1.282
	5.0	3.7	1.85	0.1739	0.1358	1.280

SAMPLE CALCULATION:-

For Inner radii, V = 4.0 kV

$$2R_1 = 2.4\,cm$$

$$R_1 = \frac{2.4}{2} = 1.2\,cm$$

$$\lambda = \frac{12.3}{\sqrt{V}}\,Å = \frac{12.3}{\sqrt{4000}}\,Å = 0.1945\,Å$$

$$\sin\theta = \frac{1}{\left(1+\left(\frac{13.5}{R}\right)^2\right)^{0.5}} = \frac{1}{\left(1+\left(\frac{13.5}{1.2}\right)^2\right)^{0.5}} = 0.0885$$

$$d = \frac{\lambda}{\sin\theta} = \frac{0.1945}{0.0885}\,Å = 2.198\,Å$$

For outer ring,

$$\text{Average } d = \frac{2.198+2.259+2.353}{3} = 2.27\,Å$$

For inner ring,

$$\text{Averaged } d = \frac{1.265+1.282+1.280}{3} = 1.276\,Å$$

Similarly, inner diameter and outer ones were calculated and observed by mean that the interplanar spacing are $d_1 = 2.27\,Å$

$d_2 = 1.276\,Å$

RESULT:-

The Interplanar spacings in graphite were measured as $d_1 = 0.227$ nm and $d_2 = 0.1276$ nm.

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Phase and Group Velocity of EM waves:-

Tools Required:-

https://demonstrations.wolfram.com/GroupandPhaseVelocity/.

Objective:-

- To understand the nature of EM waves travelling in a medium with the help of Phase and Group Velocities

Theory:-

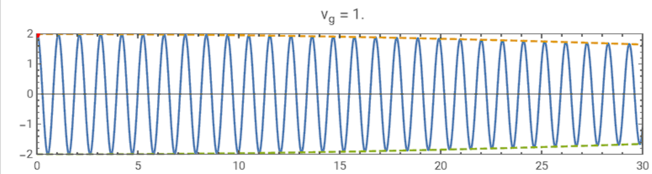
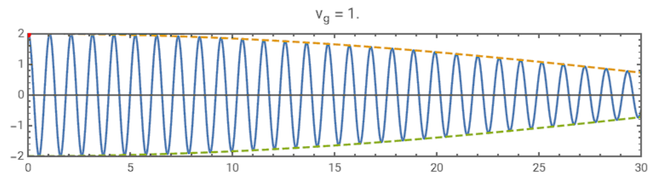
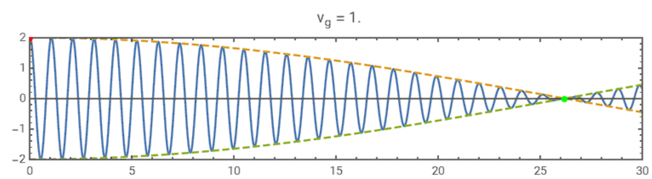
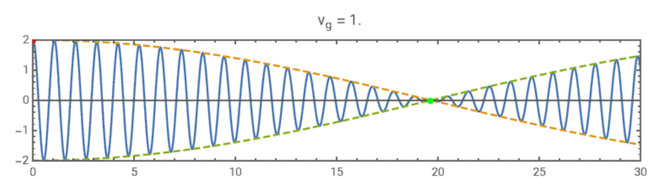
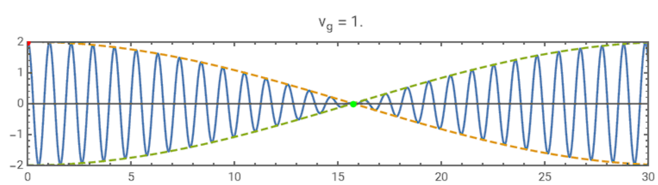
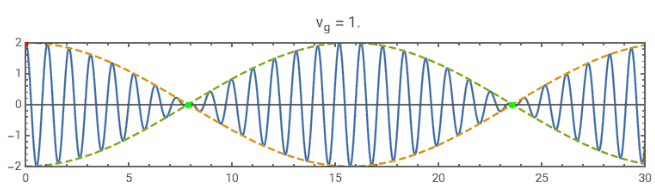
- Any real signal consisting of travelling waves of many different frequencies, which travel together as a group, at a speed that will always be less than or equal to the speed of light in vacuum. To gain some insight into what may happen when a real signal travels through a dispersive medium, we consider adding two waves of equal amplitude. When two waves travelling with amplitudes $f_1(z,t) = \cos(k_1 z - \omega_1 t)$ and $f_2(z,t) = \cos(k_2 z - \omega_2 t)$ are added, we get

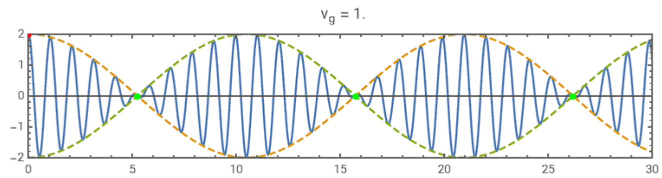
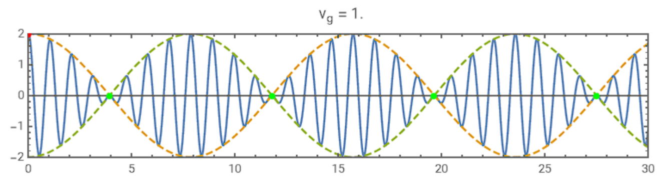
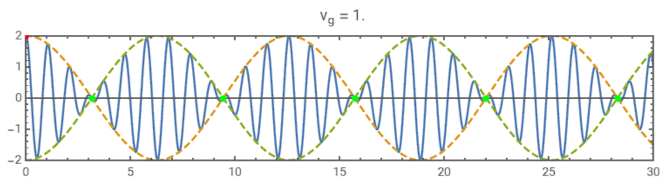
$$f_1(z,t) + f_2(z,t) = \cos(k_1 z + \omega_1 t) + \cos(k_2 z - \omega_2 t)$$

$$= 2\cos\left(\frac{\Delta k \cdot z - \Delta\omega t}{2}\right) \cdot \cos\left(\frac{\bar{k}z - \bar{\omega}t}{2}\right)$$

where, $\Delta k = k_1 - k_2$, $\Delta\omega = \omega_1 - \omega_2$, $\bar{k} = k_1 + k_2$, $\bar{\omega} = \omega_1 + \omega_2$

The result is a fast oscillating wave that travels with a phase velocity $v_p = \frac{\bar{\omega}}{\bar{k}}$ and it's amplitude being modulated by $2\cos\left(\frac{\Delta k z - \Delta\omega t}{2}\right)$ in space and time. This modulated wave moves at the group velocity given by $v_g = \frac{\Delta\omega/2}{\Delta k/2} = \frac{\Delta\omega}{\Delta k}$

S.No	Δw	Δk	Wave pattern of the resultant waves	V_g
1	0.02	0.02		1
2	0.04	0.04		1
3	0.06	0.06		1
4	0.08	0.08		1
5	0.1	0.1		1
6	0.2	0.2		1

7	0.3	0.3		1
8	0.4	0.4		1
9	0.5	0.5		1

<u>Table: Observation of wave pattern on various differences in frequency and wavelength</u>

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Inferences:-

1). Are the wave patterns for various values of $\Delta\omega$ and Δk same? If not, why?

↳ The wave patterns are different for various values of $\Delta\omega$ and Δk. For a given group velocity, (1 in above case), increasing $\Delta\omega$ implies increase in difference in frequency of two waves which means - for a match of crest and trough the waves have to travel shorter distance than before. eventually forming more wavepackets in a given distance.

Mathematically, $F(z,t) = 2\cos\left(\frac{\Delta k}{2}z - \frac{\Delta\omega}{2}t\right)\cos(\bar{k}z - \bar{\omega}t)$.

If $\Delta\omega$ and Δk both increase, the argument of amplitude part will increase with time and distance, as a result the length of an envelope will shorten.

Hence, the wave patterns are not same for various values of $\Delta\omega$ and Δk.

2). Comment on phase velocity (V_p) of the waves for increased values of $\Delta\omega$ and Δk.

↳ In case of a dispersive medium, phase velocity changes with respect to k and $V_p = \frac{\overline{\omega}}{\overline{k}}$.

In a non-dispersive medium ($\mu = 1$). V_p will be constant for all wavelengths. Thus, phase velocity does not depend upon change in $\Delta\omega$ and Δk.

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3). Why do we see V_p and V_g being the same.

↳ We have formula for group velocity and phase velocity:-

$$V_p = V_g - k \, dV_p / dk$$

Since, V_p is constant for non-dispersive medium ·ie. $\Delta V_p = 0$;

ie. $\frac{dV}{dk} = 0$

$$\boxed{\therefore V_p = V_g}$$

Hence, for non-dispersive medium - i.e. vacuum, they are equal

4). Draw a typical dispersion curve (ω-k curve) for $V_p = V_g$ and $V_p \neq V_g$ cases.

↳ Since, ω is a function of k,

For a non-dispersive medium (ie. $\mu = 1$), $\omega \propto k$ and (ω-constant) is proportional to k for dispersive medium. In both cases, V_p is the proportionality constant.

Case I: When $V_g = V_p$,

This case is possible in non-dispersive medium. The relation between ω and k is:- $\omega = ak$; $a = V_p$.

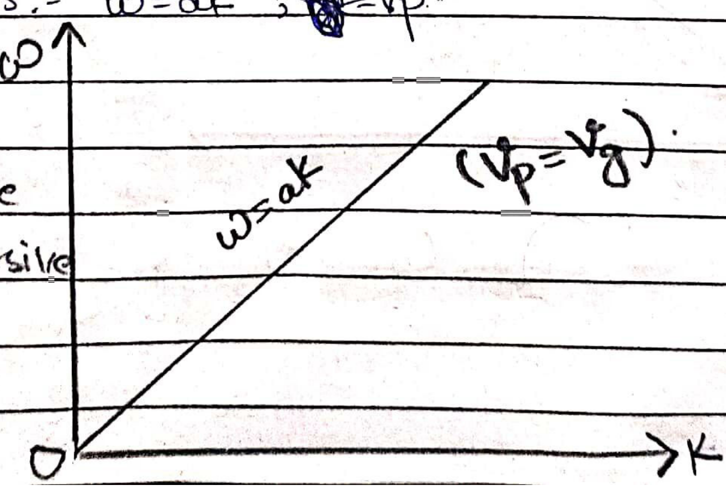

Fig:- ω-k curve for non-dispersive medium.

Case-II : $V_p \neq V_g$:

~~$V_p > V_g$~~. This case is possible in dispersive medium.
The relation between ω and K is :-

ⓐ : For $V_g > V_p$:

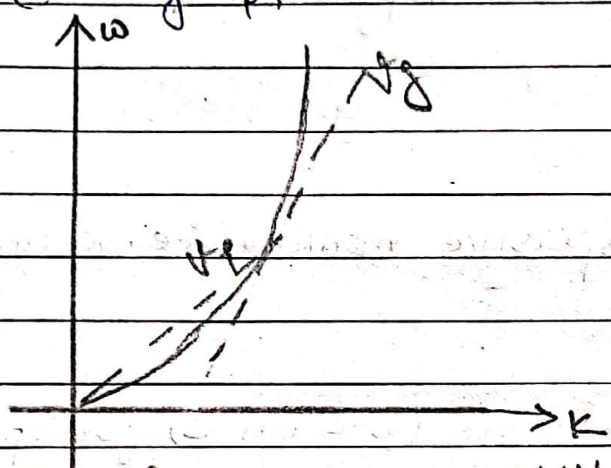

Fig:- Dispersion Curve for $V_g > V_p$

ⓑ : For $V_g < V_p$.

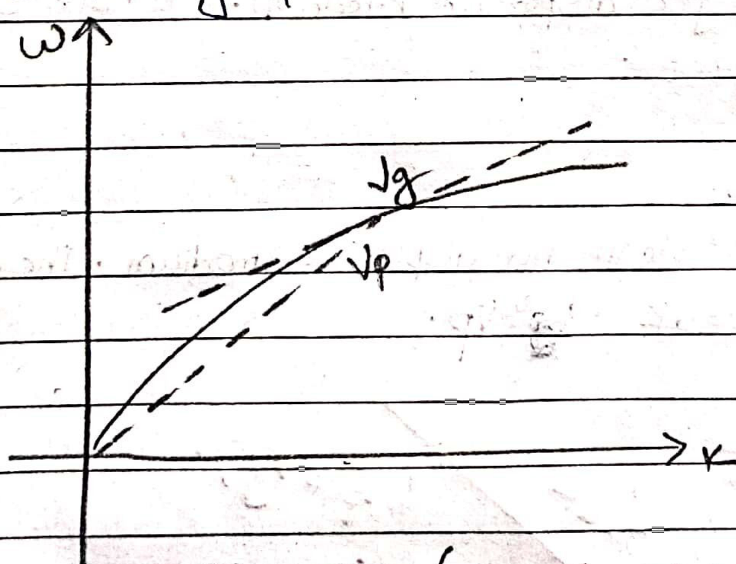

Fig:- Dispersion Curve for $V_p > V_g$.

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OPTICAL FIBER CHARACTERIZATION.

Apparatus Available:-

- Diode Laser
- Optical fiber
- Laser-fiber Coupler
- Optical rail
- Pinhole photo detector
- Power Supply for laser
- Detector Output measurement unit.

SLO:

To determine the numerical aperture of given multimode optical fiber

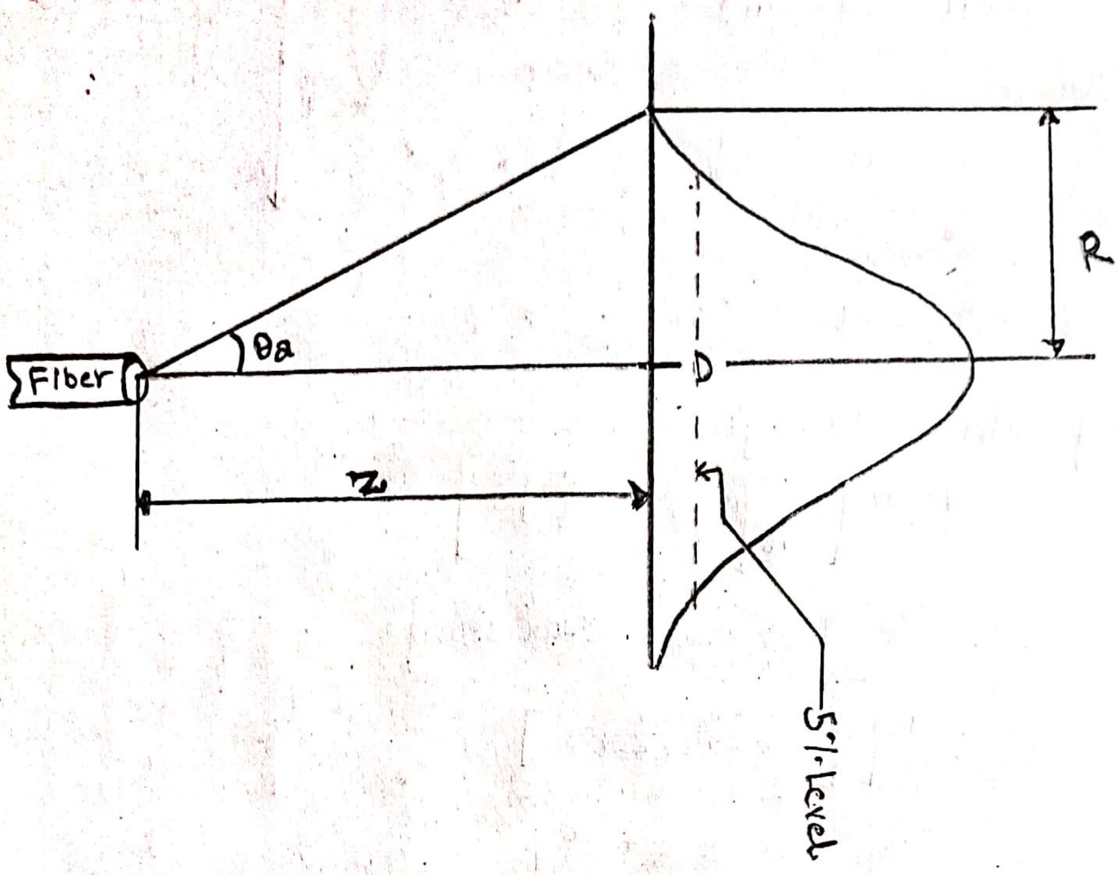
Theory:-

A multi-mode optical fiber will only propagate light that enters the fiber within a certain cone, known as the acceptance cone of the fiber. The half-angle of this cone is called the acceptance angle, θ_a.

$$\text{Acceptance angle } \theta_a = \tan^{-1}(D/z).$$

where, D is the diameter of far field intensity at 5% intensity level of the maximum attainable intensity and z is the distance between the detector and the fiber output end.

$$NA = \sin\theta_a.$$



Z	Micrometer readings (mm)	Detector o/p current	D
1 mm	21.10	0.01	1.9 mm
	20.90	0.01	
	20.70	0.04	
	20.50	2.4	
	20.30	12.5	
	20.10	29.1	
	19.90	55.5	
	19.70	94.1	
	19.50	127.4	
	19.30	138.0	
	19.10	113.4	
	18.90	64.4	
	18.70	22.8	
	18.50	5.1	
	18.30	1.0	
	18.10	0.02	
	17.90	0.01	

Calculation:-

From graph, D = 1.9 mm,

$R = \frac{D}{2} = \frac{1.9\,mm}{2}$

$= 0.95\,mm$

$Z = 1\,mm$

$\theta_a = \tan^{-1}\left(\frac{R}{Z}\right)$

$= \tan^{-1}\left(\frac{0.95}{1}\right)$

$= 43.53^\circ$

Numerical Aperture (NA)

$= \sin(\theta_a)$

$= \sin(43.53^\circ)$

$= 0.689$

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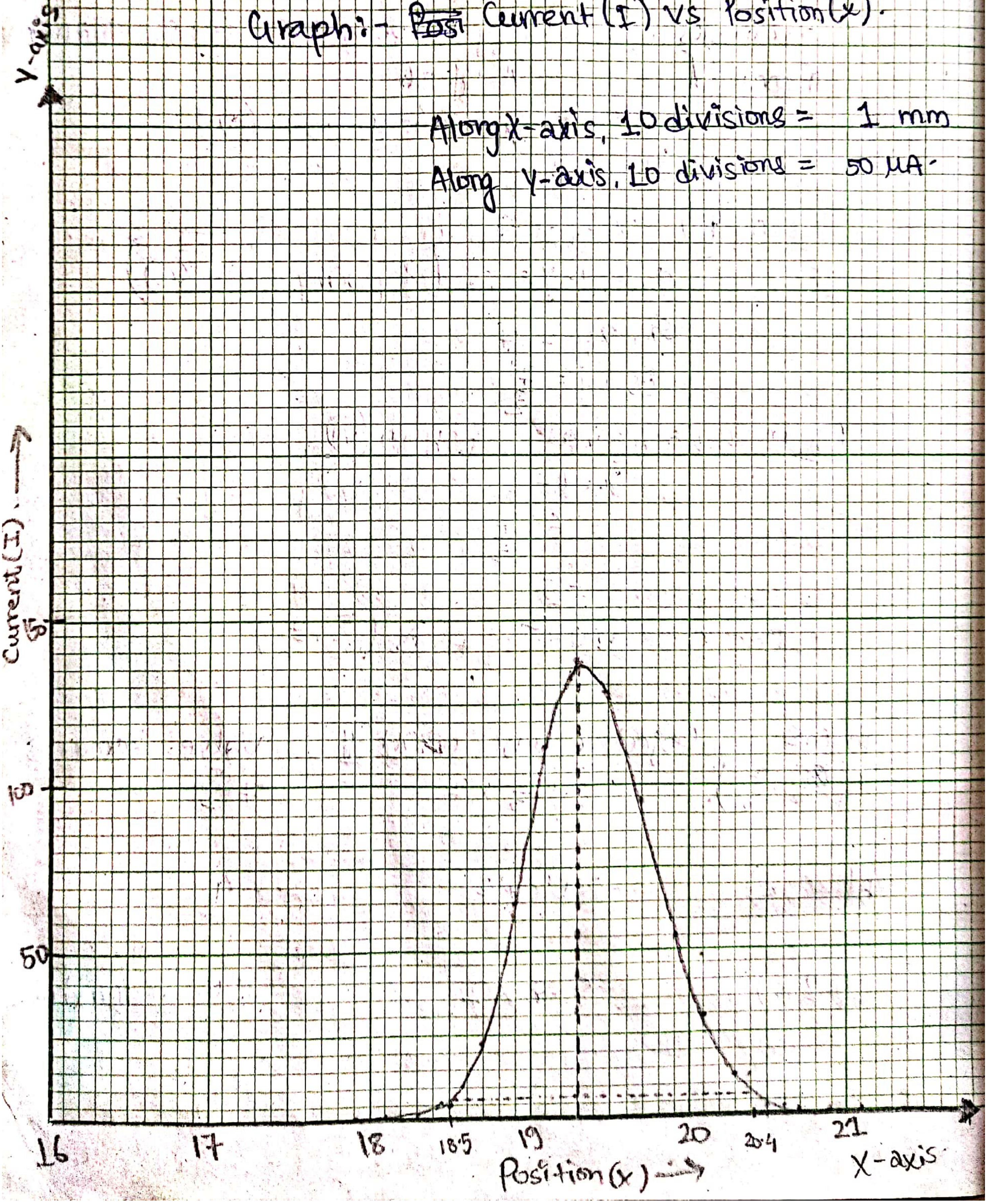
Graph:- ~~Posi~~ Current (I) vs Position (x).

Along x-axis, 10 divisions = 1 mm

Along y-axis, 10 divisions = 50 μA.



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Result:-

Numerical Aperture (NA) of the given multimode optical fiber is 0.689 ~~(units)~~.

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INTEGRATED OPTICS.

APPARATUS AVAILABLE:-

- Spectrometer
- Spirit Level
- Magnifying Glass
- Glass prism
- Sodium Vapour Lamp.

SLO:

✓ To determine the apex angle of given prism using a spectrometer.

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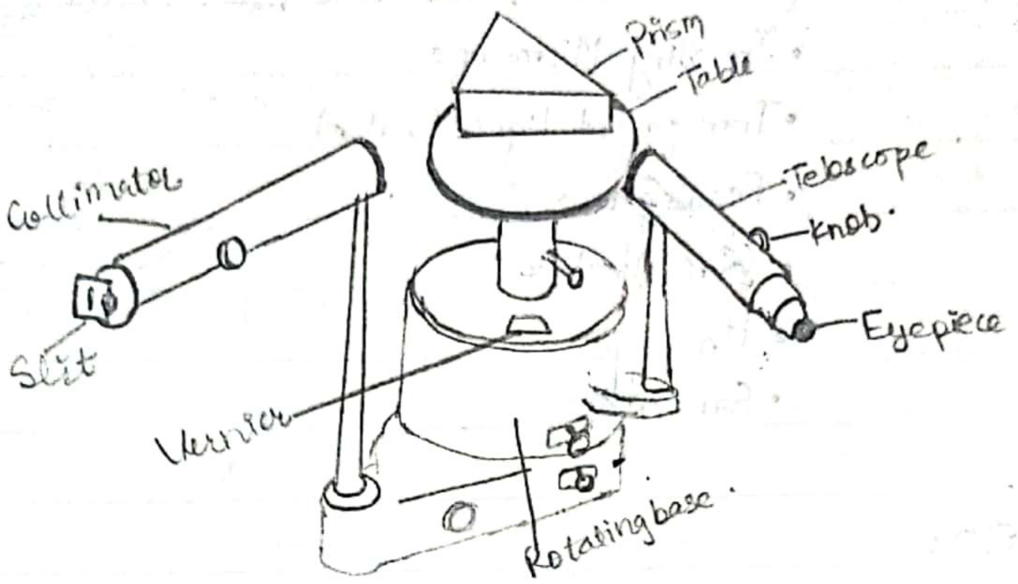

Fig:- Schematic diagram of a Spectrometer.

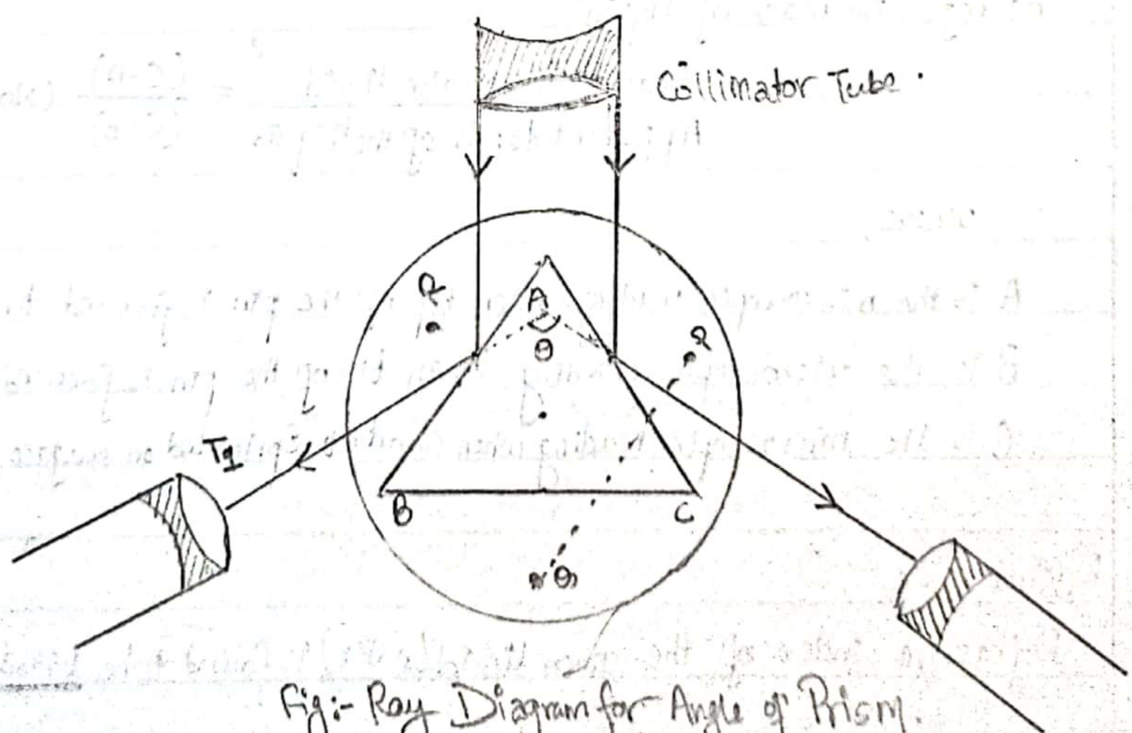

Fig:- Ray Diagram for Angle of Prism.

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Tabulation:-

Least Count = $1' = \left(\frac{1}{60}\right)^\circ$

Reading of reflected ray	Vernier A			Vernier B		
	MSR	VSR	Total	MSR	VSR	Total
Reflection from side AB (a)	293°	17'	293.28°	113°	13'	113.22
Reflection from side AC (b)	55°	12'	55.2° +(360°)	235°	25'	235.42
Difference between 'a' and 'b'		θ_1 =	121.92°		θ_2 =	122.2

~~Mean θ~~

SAMPLE CALCULATIONS:-

For Vernier A, for reflection of ray from AB, MSR = 293°, VSR = 17'

$$\text{Total} = 293 + \frac{17}{60} = 293.28^\circ$$

for reflection of ray from AC, MSR = 55°, VSR = 12'

$$\text{Total} = 55 + \frac{12}{60} = 55.2^\circ + (360^\circ)$$

$$\theta_1 = (360 + 55.2^\circ) - 293.28^\circ = 121.92^\circ$$

For vernier B, for reflection of ray from AB, MSR = 113°, VSR = 13'

$$\text{Total} = 113 + \frac{13}{60} = 113.22^\circ$$

for reflection of ray from AC, MSR = 235°, VSR = 25'

$$\text{Total} = \cancel{MS}\ 235 + \frac{25}{60} = 235.42^\circ$$

$$\theta_2 = (235.42 - 113.22)^\circ = 122.2^\circ$$

$$\text{Mean}(\theta) = \frac{\theta_1 + \theta_2}{2} = \frac{122.2 + 121.92}{2} = 122.06^\circ$$

$$\text{Angle of prism } (A) = \frac{\theta}{2} = \frac{122.06}{2} = 61.03^\circ$$

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RESULT:-

The apex angle of the given equilateral prism is 57.03°

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INTEGRATED OPTICS- REFRACTIVE INDEX.

Apparatus Available:-

- Spectrometer
- Spirit Level
- Magnifying glass
- Glass prism
- Sodium Vapour Lamp.

SLO:

✓ To determine the refractive index of the glass prism using a spectrometer.

Refractive Index of prism:-

$$\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad \text{(No units)}.$$

where $A \rightarrow$ Angle of prism.

$\delta_{min} \rightarrow$ Angle of minimum deviation

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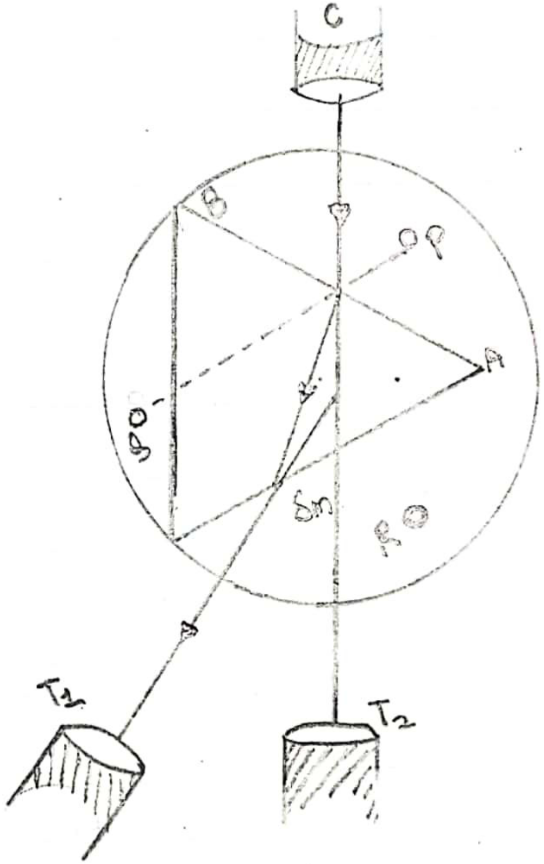

Fig:- Determination of Minimum Deviation.

Tabulation:

Least Count = $1' = \left(\frac{1}{60}\right)^\circ$

Angle of prism, A (as obtained earlier) = 60°

Vernier	Reading for minimum deviation position (R_1)			Reading for direct ray (R_2).			$\delta_m = R_1 - R_2$	μ
	MSR	VSR	TR	MSR	VSR	TR	~~51.76~~	
A	128°	25'	128.42	180°	11'	180.18	51.76	1.656
B	308°	10'	308.17	1°	9'	1.15 =361.15°	52.98°	1.667

Average μ = 1.6615

Sample calculation,

For Vernier A,

For direct ray, MSR = 180°, VSR = 11°, LC = 1'

Total reading = MSR + VSR×LC = $180 + 11 \times \frac{1}{60} = 180.18$

For minimum deviation position, MSR = 128°, VSR = 25'

Total reading = MSR + VSR×LC = $128^\circ + 25 \times \frac{1}{60} = 128.42$

$\delta_m = 51.76^\circ$

$$\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60+51.76}{2}\right)}{\sin\left(\frac{60}{2}\right)} = 1.656$$

For Vernier B,

~~For direct ray, MSR:~~

Similarly,

for B, $\delta_m = 52.98^\circ$

$\mu = 1.667$

$$\text{Mean } \mu = \frac{\mu_A + \mu_B}{2} = \frac{1.656 + 1.667}{2} = 1.6615$$

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RESULT:

The refractive index of the prism is:- 1.66