COMBINED EXPERIMENTS

BPHY101P

L3-L4

Name: Vidhi Shah

Reg No: 21BCE1297

EXPERIMENT : No. 1 Reg No.: 21BCE1247

Page No | Date 21 02 22

EXP: Determination of refractive index of a dispersing triangular prism for spectroscopic applications

- AIM: Given the angle of prism, aim of the experiment is to determine the angle of minimum deviation of the prism and hence calculate its refractive index.

- APPARATUS REQUIRED: Spectrometer, given prism, Mercury Vapour lamp, etc

- FORMULA USED:

Refractive index (μ) of the prism is given by

$$\mu = \frac{\sin \frac{\alpha+\delta}{2}}{\sin\left(\frac{\alpha}{2}\right)}$$

Where α is the angle of prism
δ is the angle of minimum deviation.

- RESULT:

The refractive index (μ) of given prism is $1.519 \approx 1.52$

TABULATIONS:

TR = MSR + (VSC * LC)

Angle of prism = 60°
Least count of spectrometer = 1°

READING FROM		VERNIER 1			VERNIER 2		
		MSR	VSC	TR	MSR	VSC	TR
Refracted Ray (i)	V	131°	15'	131°15'	311°	2'	311°2'
	G	132°	19'	132°19'	312°	13'	312°13'
	Y	132°	26'	132°26'	312°	29'	312°29'
	R	133°	0'	133°	313°	0'	313°
Direct Ray (ii)		171°	19'	171°19'	351°	12'	351°12'
Difference between (ii) and (i)	V	40°	4'	40°4'	40°	10'	40°12'
	G	39°	0'	39°0'	39°	-1'	38°59'
	Y	39°	-7'	38°53'	39°	-17'	38°47'
	R	38°	19'	38°19'	38°	12°	38°12'
Mean Value (δ)	V	40°8'					
	G	38°29.5'					
	Y	38°50'					
	R	38°15.5'					
Mean Value of D (δm)		38°55.75' = 38.9°					

Calculations:

According to formula, $\mu = \dfrac{\sin\left(\frac{\alpha+\delta}{2}\right)}{\sin(\alpha/2)}$

$$\Rightarrow \mu = \frac{\sin\left(\frac{60+38.9}{2}\right)}{\sin\left(\frac{60}{2}\right)}$$

$$\Rightarrow \mu = \frac{\sin(49.45)}{\sin(30)}$$

$$\Rightarrow \mu = 1.5196 \Rightarrow \boxed{\mu = 1.52}$$

Reg No. 21BCE1297 Name: Vidhi Shah Batch: L3-L4

Dataset 2

EXPERIMENT: No. 2 Sonometer

Page No.

Date 28 02 22

- **AIM:** To study the vibrational modes of a stretched string/wire using sonometer.

- **APPARATUS REQUIRED:** Sonometer, a non-magnetic wire (eg:- stainless steel wire), an electromagnetic coil, an AC source of known frequency (6-8V, 1A), a set of weights.

- **FORMULA:**

$$f = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$$

where, → n=1 corresponds to fundamental mode of vibration while n=2, 3, 4..... correspond to respective harmonics.

→ T is the tension in the wire

→ μ is mass per unit length or linear density of the wire.

→ L is the length of the wire.

- **RESULT:**

Value of frequency of AC source is 50.224 Hz (According to the formula).

OBSERVATION TABLE :

Mass per unit length of the wire, $\mu = 1.9 \times 10^{-3}$ kg/m

Sr. No	Load (M) (kg)	Tension (T) $T = Mg$ (N)	Resonance Length (L) (I)	(II)	Mean (cm)	Mean (L) (m)	Frequency (f) $f = \frac{1}{4L}\sqrt{\frac{T}{\mu}}$ (Hz)
1.	0.1	0.98	15	13.5	14.25	0.1425	39.84
2.	0.2	1.96	16.5	16	16.25	0.1625	49.41
3.	0.3	2.94	19	19.5	19.25	0.1925	51.08
4.	0.4	3.92	20	20	20	0.2	56.77
5.	0.5	4.9	23.5	23.5	23.5	0.235	54.02
						Mean Frequency	50.224

• GRAPH :

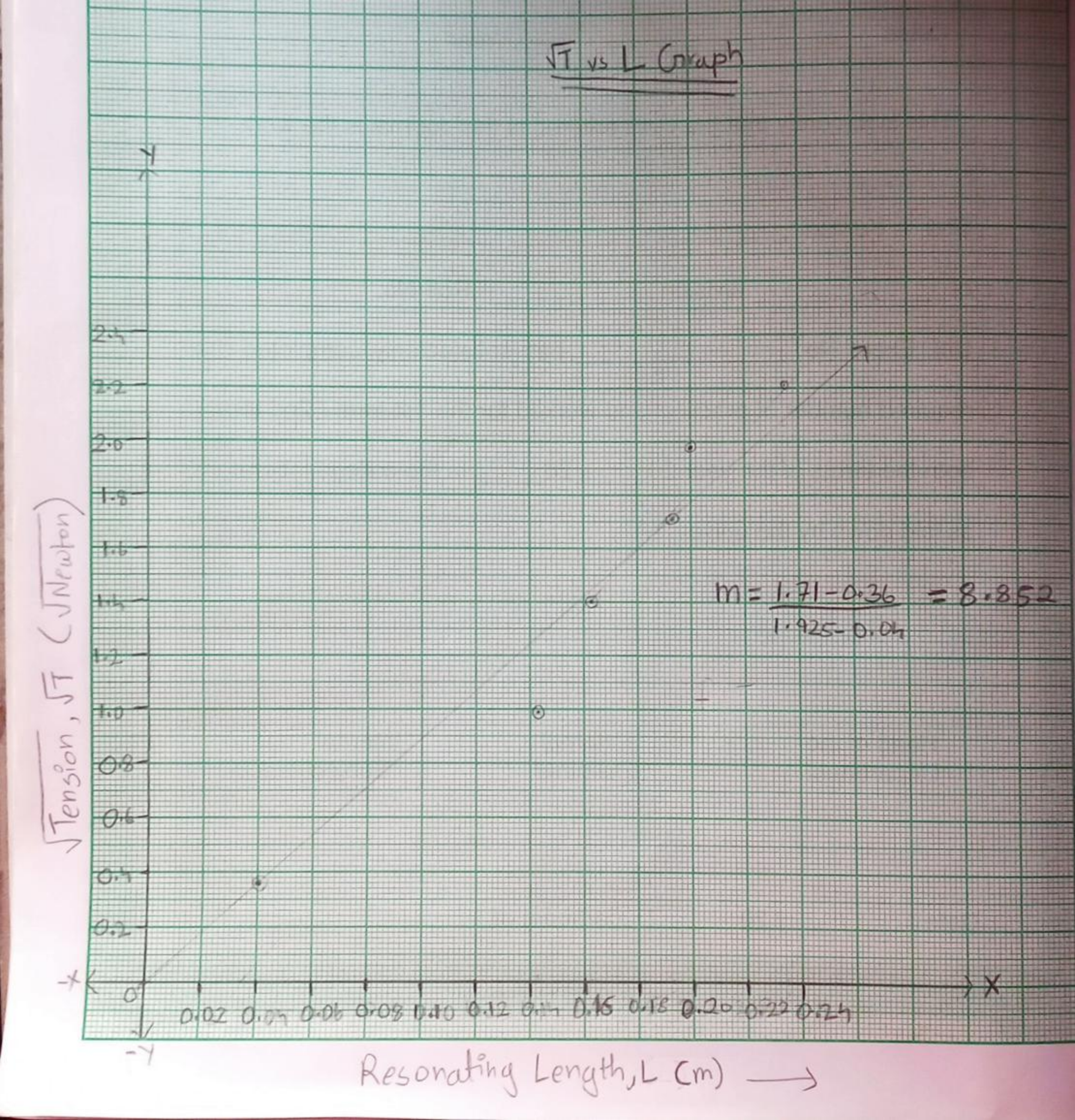
	y	x
	$\sqrt{T}$	L
0.99 =	$\sqrt{0.98}$	0.1425
1.4 =	$\sqrt{1.96}$	0.1625
1.71 =	$\sqrt{2.94}$	0.1925
1.98 =	$\sqrt{3.92}$	0.2
2.21 =	$\sqrt{4.9}$	0.235

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

$$\Rightarrow \sqrt{T} = 4f\sqrt{\mu}\,L$$
$$(y = mx)$$

$$\Rightarrow \text{Slope, } m = 4f\sqrt{\mu} = 8.852 \text{ (from graph)}$$

$$\Rightarrow f = \frac{m}{4\sqrt{\mu}} = 50.772 \text{ Hz}$$



√T vs L Graph
√Tension, √T (√Newton)
Resonating Length, L (m)
Y
-Y
X
-X
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22
0.24
m = 1.71-0.36 / 1.925-0.04 = 8.852

- CALCULATIONS:

$$u = 0.0019 \text{ kg/m}, \quad f = \frac{1}{4L}\sqrt{\frac{T}{\mu}}$$

1) $L_1 = 0.1425\text{m}$

$T_1 = 0.98\text{ N}$

$$\Rightarrow f_1 = \frac{1}{4(0.1425)}\sqrt{\frac{0.98}{0.0019}}$$

$$\Rightarrow f_1 = 39.8438 \text{ Hz}$$

2) $L_2 = 0.1625\text{ m}$

$T_2 = 1.96\text{ N}$

$$\Rightarrow f_2 = \frac{1}{4(0.1625)}\sqrt{\frac{1.96}{0.0019}}$$

$$\Rightarrow f_2 = 49.4126 \text{ Hz}$$

3) $L_3 = 0.1925\text{ m}$

$T_3 = 2.94\text{ N}$

$$\Rightarrow f_3 = \frac{1}{4(0.1925)}\sqrt{\frac{2.94}{0.0019}}$$

$$\Rightarrow f_3 = 51.0865 \text{ Hz}$$

4) $L_4 = 0.2\text{ m}$

$T_4 = 3.92\text{N}$

$$\Rightarrow f_4 = \frac{1}{4(0.2)}\sqrt{\frac{3.92}{0.0019}}$$

$$\Rightarrow f_4 = 56.7774 \text{ Hz}$$

5) $L_5 = 0.235\text{ m}$

$T_5 = 4.9\text{N}$

$$\Rightarrow f_5 = \frac{1}{4(0.235)}\sqrt{\frac{4.9}{0.0019}}$$

$$\Rightarrow f_5 = 54.0248 \text{ Hz}$$

$$\Rightarrow f = \frac{f_1 + f_2 + f_3 + f_4 + f_5}{5}$$

$$\Rightarrow f = \frac{39.84 + 49.41 + 51.08 + 56.77 + 54.02}{5}$$

$$\Rightarrow f = \frac{251.12}{5}$$

$$\therefore \boxed{f = 50.224} \text{ Hz}$$

Name: Vidhi Shah   Reg No: 21BCE1297   Batch: L3+L4
Dataset 2

EXPERIMENT: No. 3   Electron Diffraction - deBroglie Wavelength   Page No.   Date 07 03 22

- **AIM:** ① To observe the diffraction of electrons on polycrystalline graphite and to confirm the wave nature of electrons.
  ② To calculate and compare both the deBroglie's and Bragg's wavelength of electron.

- **APPARATUS REQUIRED:** Electron diffraction tube, tube holder, high voltage power supply, analogue multimeter.

- **FORMULA USED:**

① Bragg's wavelength:

$$\boxed{\lambda = d\frac{D}{2L}}$$

d → the seperation between two adjacent planes
D → diameter of the rings
L → Distance between graphite target and fluorescent screen = 135mm

② deBroglie's Wavelength:

$$\boxed{\lambda = \frac{h}{\sqrt{2meV}}}$$

m → mass of electron
e → charge of electron
h → Planck's constant
V → Applied Voltage, kV

• OBSERVATION TABLE :

S. No.	Voltage 'V' (kV)	Diameter of ring 'D'	MSR (cm)	VSC	TR (cm)	$\theta = \frac{D}{L}$	$\tan(2\theta)$	d (nm)	Braggs (λ), (Å)	deBroglie (λ), (Å)
1.	4	Ring 1	2.3	1	2.31	0.1711	0.3562	0.213	0.182 Å	0.194 Å
		Ring 2	4.3	7	4.37	0.3237	0.7561	0.123	0.199 Å	0.194 Å
2.	4.4	Ring 1	2.2	0	2.20	0.1630	0.3380	0.213	0.173 Å	0.185 Å
		Ring 2	4.1	8	4.18	0.3096	0.7126	0.123	0.190 Å	0.185 Å
3.	4.8	Ring 1	2.1	6	2.16	0.1600	0.3314	0.213	0.170 Å	0.177 Å
		Ring 2	4.1	7	4.17	0.3089	0.7106	0.123	0.189 Å	0.177 Å
							Mean λ		0.184 Å	0.185 Å

• CALCULATION: Braggs (λ) $= d\frac{D}{2L}$, deBroglie (λ) $= \frac{h}{\sqrt{2meV}}$

$L = 13.5\,cm,\ m = 9.11\times10^{-31}\,kg,\ e = 1.6\times10^{-19}\,C,\ h = 6.626\times10^{-34}\,m^2\frac{kg}{s}$

$\Rightarrow me = 14.576\times10^{-50}$

① V = 4 kV :

Ring 1:

$$\text{Braggs}(\lambda) = 0.213\times10^{-9}\left(\frac{2.31\times10^{-2}}{2\times13.5\times10^{-2}}\right)m = 0.0182\times10^{-9}m = 0.182\,Å$$

$$\text{deBroglie}(\lambda) = \frac{6.626\times10^{-34}}{\sqrt{2\times14.576\times10^{-50}\times4\times10^{3}}}\,m = 0.0194\times10^{-9}m = 0.194\,Å$$

Ring 2:

$$\text{Braggs}(\lambda) = 0.123\times10^{-9}\left(\frac{4.37\times10^{-2}}{2\times13.5\times10^{-2}}\right)m = 0.0199\times10^{-9}m = 0.199\,Å$$

$$\text{deBroglie}(\lambda) = \frac{6.626\times10^{-34}}{\sqrt{2\times14.576\times10^{-50}\times4\times10^{3}}}\,m = 0.194\,Å$$

② $V = 4.4\,kV$:

Ring 1:

Braggs (λ) $= 0.213 \times 10^{-9} \left(\frac{2.2}{13.5 \times 2}\right) m = 0.01735 \times 10^{-9} m = 0.1735\,Å$

Ring 2:

Braggs (λ) $= 0.123 \times 10^{-9} \left(\frac{4.18}{13.5 \times 2}\right) m = 0.0190 \times 10^{-9} m = 0.19\,Å$

de Broglie (λ) $= \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 14.576 \times 10^{-50} \times 4400}} m = 0.0185 \times 10^{-9} m = 0.185\,Å$

③ $V = 4.8\,kV$

Ring 1:

Braggs (λ) $= 0.213 \times 10^{-9} \left(\frac{2.16}{27}\right) m = 0.0170 \times 10^{-9} m = 0.170\,Å$

Ring 2:

Braggs (λ) $= 0.123 \times 10^{-9} \left(\frac{4.17}{27}\right) m = 0.01899 \times 10^{-9} m = 0.1899\,Å$

de Broglie (λ) $= \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 14.576 \times 4800}} m = 0.01771 \times 10^{-9} m = 0.1771\,Å$

RESULT:

1. deBroglie wavelength of electron = 0.185 Å
2. Bragg's Wavelength of electron = 0.184 Å

Name: Vidhi Shah **Reg. No: 21BCE1297** **Date: 14/03/22** **Batch: L3-L4**

Experiment 4: Phase and Group velocity of EM waves

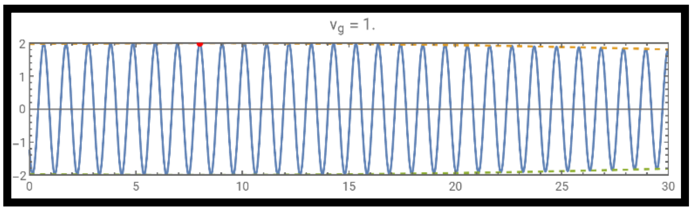
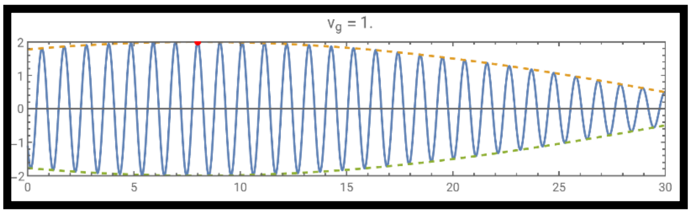
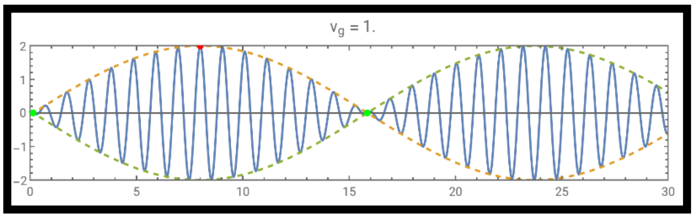
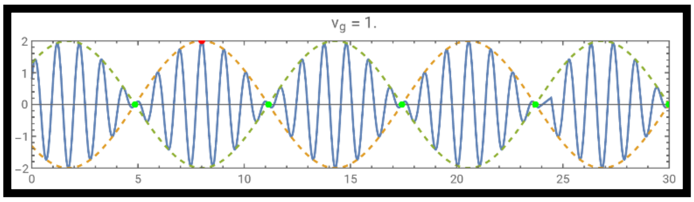
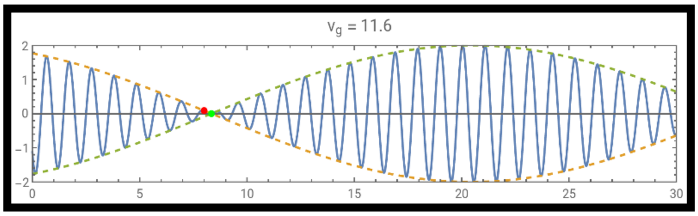
Tools required:

http://demonstrations.wolfram.com/GroupAndPhaseVelocity/

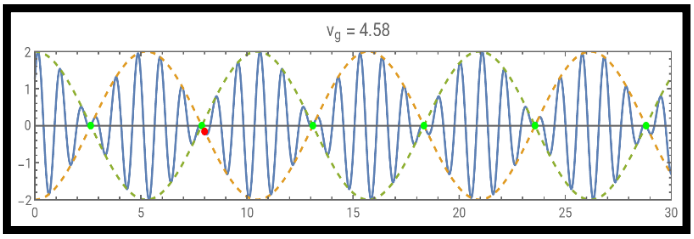
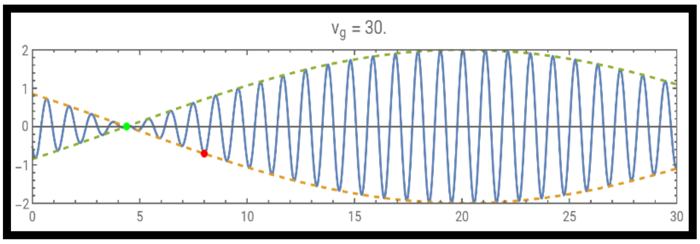
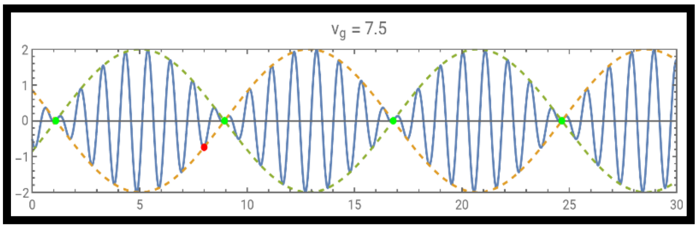
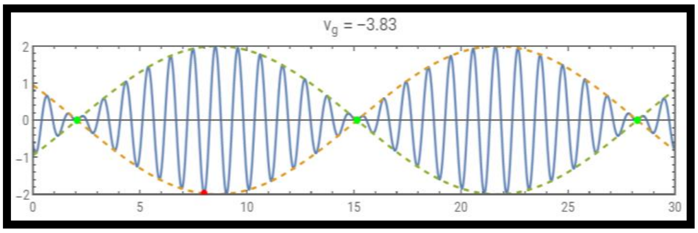
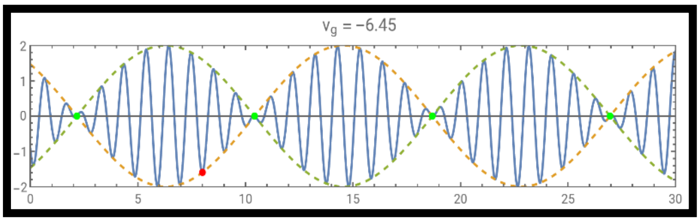
Objective:

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

Observation table:

S. No	Δω	Δk	Wave pattern of the resultant waves	V_g
1	0.02	0.02		1
2	0.06	0.06		1
3	0.2	0.2		1
4	0.5	0.5		1
5	1.51	0.13		11.6

Name: Vidhi Shah **Reg. No: 21BCE1297** **Date: 14/03/22** **Batch: L3-L4**

S. No	Δω	Δk	Wave pattern of the resultant waves	V_g
6	2.75	0.6		4.58
7	3	0.1		30
8	3	0.4		7.5
9	-0.92	0.24		-3.83
10	-2.45	0.38		-6.45

Name: Vidhi Shah **Reg. No: 21BCE1297** **Date: 14/03/22** **Batch: L3-L4**

Inferences:

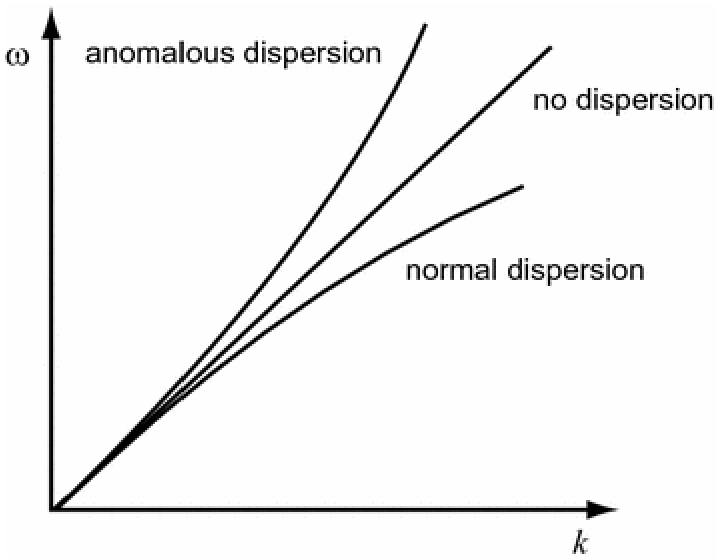
1. **Are the wave patterns for various values of Δω and Δk same? If not, why?**
   No, the wave patterns for various values of Δω and Δk are not same even if V_g is same. The resultant wave formed by the superposition of two waves is dependent on the values of Δω and Δk. The resultant wave of the two waves is:

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

2. **Comment on the Phase velocity (Vp) of the waves for increased values of Δω and Δk.**
   Phase Velocity (V_p) remains the same for a wave in a given medium. It does not get affected by the increased values of Δω and Δk.

3. **When do we see V_p and V_g being the same?**
   If the phase velocity does not depend on the wavelength of the propagating wave, then
   $V_g = V_p$. This happens in non-dispersive media.

4. **Draw a typical dispersion relation curve (ω-k curve) for $V_p = V_g$ and $V_p \neq V_g$ cases.**
   $V_p = V_g$ – No dispersion
   $V_p \neq V_g$ – Anomalous Dispersion and Normal Dispersion



Name: Vidhi Shah Reg. No.: 21BCE1297 Batch: L3+L4 Dataset: 2

EXPERIMENT: No. 5 Diffraction Grating

Page No. | Date 21 03 22

- **AIM:** To determine the number of lines in a given grating using a laser source of light.

- **APPARATUS REQUIRED:** He-Ne laser or semiconducting laser, grating, grating stand, scales.

- **FORMULA USED:**

$$\boxed{N = \frac{\sin\theta}{n\lambda}}$$

where,

N → The density of lines in the grating (lines/meter OR lines/inch)

θ → Angle of diffraction (degree)

n → Order of diffraction

λ → Wavelength of the laser light used in the experiment (nm)

- **RESULT:**

The density of lines in the given grating was determined to be $N = 2449.82 \approx 2450$ lines/inches.

- ## OBSERVATION TABLE :

$\lambda = 660\ nm = 6.6 \times 10^{-7} m = [6.6 \times 39.37] \times 10^{-7}$ inches $= 259.842 \times 10^{-7}$ in
$= 2.59842 \times 10^{-5}$ in

Diffraction Order	D (cm)	2L (cm)	L (cm)	$\tan\theta = L/D$	$\theta = \tan^{-1}\left(\frac{L}{D}\right)$	$\sin\theta$	Mean $\sin\theta$	N (lines/inch)
	30	4	2	0.001164	3.8141	0.06652		
	35	4.6	2.3	0.001157	3.7597	0.06557		
1	40	5.2	2.6	0.001134	3.7190	0.06486	0.0650	2502.56
	45	5.8	2.9	0.001125	3.6873	0.06431		
	50	6.4	3.2	0.001117	3.6619	0.06387		
	30	7.6	3.8	0.002211	7.2190	0.12566		
	35	9.2	4.6	0.002294	7.4874	0.13031		
2	40	10.4	5.2	0.002269	7.4069	0.12892	0.1275	2453.46
	45	11.4	5.7	0.002211	7.2190	0.12566		
	50	12.8	6.4	0.002234	7.2942	0.12696		
	30	11.6	5.8	0.003374	10.9422	0.18982		
	35	13.8	6.9	0.003441	11.1524	0.19342		
3	40	15.6	7.8	0.003403	11.0342	0.19140	0.1905	2444.00
	45	17	8.5	0.003297	10.6965	0.18561		
	50	19.6	9.8	0.003421	11.0894	0.19234		
	30	15.6	7.8	0.004538	14.5742	0.25163		
	35	18.6	9.3	0.004638	14.8805	0.25680		
4	40	21	10.5	0.004582	14.7083	0.25390	0.2534	2438.01
	45	23	11.5	0.004460	14.3354	0.24760		
	50	26.6	13.3	0.004643	14.8957	0.25706		

→

Diffraction Order	D (cm)	2L (cm)	L (cm)	$\tan\theta = \left(\frac{L}{D}\right)$	$\theta = \tan^{-1}\left(\frac{L}{D}\right)$	$\sin\theta$	Mean $\sin\theta$	N (Lines/inches)
	30	19.6	9.8	0.005701	18.0905	0.31052		
	35	23.2	11.6	0.005785	18.3367	0.31460		
5	40	26.6	13.3	0.005803	18.3920	0.31552	0.3132	2411.07
	45	29.4	14.7	0.005701	18.0905	0.31052		
	50	33.2	16.6	0.005795	18.3662	0.31509		
							Mean	2449.82 ≈ 2450

- CALCULATIONS:

$\lambda = 2.59842 \times 10^{-5}$ in, $N = \frac{\sin\theta}{n\lambda}$

① $n=1$:

$N_1 = \frac{0.0650271}{1 \times 2.59842 \times 10^{-6}}$

$= 2502.5620$

$\Rightarrow N_1 = 2502.56$ lines/inch

② $n=2$:

$N_2 = \frac{0.12750250}{2 \times 2.59842 \times 10^{-5}}$

$= 2453.4621$

$\Rightarrow N_1 = 2453.46$ lines/inch

③ $n=3$:

$N_3 = \frac{0.19051611}{3 \times 2.59842 \times 10^{-5}}$

$= 2443.9945$

$\Rightarrow N_3 = 2444.00$ lines/inch

④ $n=4$:

$N_4 = \frac{0.25339891}{4 \times 2.59842 \times 10^{-5}}$

$= 2438.0096$

$\Rightarrow N_4 = 2438.01$ lines/inch

⑤ $n=5$:

$N_5 = \frac{0.31324840}{5 \times 2.59842 \times 10^{-5}}$

$= 2411.0683$

$\Rightarrow N_5 = 2411.07$ lines/inch

$N = (N_1 + N_2 + N_3 + N_4 + N_5) / 5$

$= \frac{12249.1}{5}$

$\Rightarrow \boxed{N = \boxed{2449.82} \approx 2450 \text{ lines/inch}}$

Name: Vidhi Shah Reg. No.: 21BCE1297 Batch: L3+L4 Dataset: 2

EXPERIMENT: No. 6 Optical Fibre

Page No.
Date 11 04 22

- AIM:

1) To determine the Numerical Aperture (NA) and acceptance angle (θ_a) of the given two different (1 meter and 1/2 meter cables) optical fibers to find their suitability in telecommunications applications.

2) Observing the optical power losses, when light is passing through two different (1 meter and 1/2 meter cables) optical fibres during, (a) When they are not coupled with each other and (b) when they are coupled each other through an in-line adaptor.

- APPARATUS REQUIRED:

→ Fiber optic LED light source, Fiber optic power meter, Fiber Optic (FO) cable 1 meter, FO cable 1/2 meter, In-line adaptor (to connect 2 cables), NA - Jig (L-shape with scale on one side and connector on other side).

- FORMULA:

$$NA = \sin\theta_a = \frac{W}{\sqrt{(4L^2+W^2)}} \quad \text{(No unit)}$$

where, W = Diameter of the spot (m)
L = Distance between the fiber end and the screen (m)
θ_a = Acceptance angle (°)

Sundaram

Teacher's Sign.:

- ## OBSERVATION TABLE :

(i) Optical fiber cable with length of $\frac{1}{2}$ m :

Power loss = 37.4 dB

Sr. No.	L (mm)	W (mm)	NA (No unit)	θ_a (deg)
1.	22	30	0.563	34.287
2.	20	25	0.530	32.005
3.	14	20	0.581	35.538
4.	12	15	0.530	32.005
5.	4	10	0.781	51.340
		Mean	0.597	37.035

(ii) Optical fiber cable with length of 1m :

Power loss = 57.4 dB

Sr. No.	L (mm)	W (mm)	NA (No unit)	θ_a (deg)
1.	23	30	0.546	33.111
2.	18	25	0.570	34.778
3.	14	20	0.581	35.538
4.	12	15	0.530	32.005
5.	6	10	0.640	39.806
		Mean	0.574	35.048

- CALCULATIONS:

① 1 meter:

i) $NA_1 = \frac{30}{\sqrt{3016}} = 0.546$

$\theta_{a_1} = \sin^{-1}(0.546) = 33.111°$

ii) $NA_2 = \frac{25}{\sqrt{1921}} = 0.570$

$\theta_{a_2} = \sin^{-1}(0.570) = 34.778°$

iii) $NA_3 = \frac{20}{\sqrt{1184}} = 0.581$

$\theta_{a_3} = \sin^{-1}(0.581) = 35.538°$

iv) $NA_4 = \frac{15}{\sqrt{801}} = 0.530$

$\theta_{a_4} = \sin^{-1}(0.530) = 32.005°$

v) $NA_5 = \frac{10}{\sqrt{244}} = 0.640$

$\theta_{a_5} = \sin^{-1}(0.640) = 39.806$

② 1/2 meter:

i) $NA_1 = \frac{30}{\sqrt{2836}} = 0.563$

$\theta_{a_1} = \sin^{-1}(0.563) = 34.287°$

ii) $NA_2 = \frac{25}{\sqrt{2225}} = 0.530$

$\theta_{a_2} = \sin^{-1}(0.530) = 32.005°$

iii) $NA_3 = \frac{20}{\sqrt{1184}} = 0.581$

$\theta_{a_3} = \sin^{-1}(0.581) = 35.538°$

iv) $NA_4 = \frac{15}{\sqrt{801}} = 0.530$

$\theta_{a_4} = \sin^{-1}(0.530) = 32.005°$

v) $NA_5 = \frac{10}{\sqrt{164}} = 0.781$

$\theta_{a_5} = \sin^{-1}(0.781) = 51.340°$

EXPERIMENT : No. Page No. Date

- RESULTS:

(i) The Numerical Aperture of the given optical fiber (1 meter) = 0.574

(ii) The acceptance angle for the given optical fiber (1 meter) = 35.048°

(iii) The Numerical Aperture of the given optical fiber (1/2 meter) = 0.597

(iv) The acceptance angle for the given optical fiber (1/2 meter) = 37.035°

(v) The optical power loss, when the light is passing through optical fiber cable (1 meter) = 57.4 dB

(vi) The optical power loss, when the light is passing through optical fiber cable (1/2 meter) = 37.4 dB

Name: Vidhi Shah Reg. No: 21BCE1297 Batch: L3+L4 Dataset: 2

EXPERIMENT : No. 7 Planck's Constant

Page No. | Date 18 04 22

- **AIM:** To determine the value of Planck's constant using electroluminescence process

- **APPARATUS:** LEDs, digital voltmeter, micro-ammeter, and ten turn linear potentiometer

- **FORMULA USED:**

$$\boxed{V_0 = \frac{hc}{e} \lambda^{-1}}$$

Where, $V_0 \rightarrow$ Barrier potential
$\lambda \rightarrow$ Wavelength
$c \rightarrow$ Speed of light
$e \rightarrow$ electronic charge
$h \rightarrow$ Planck constant

→ 'h' can be found by obtaining the slope of $V_0 \lambda^{-1}$ curve
→ 'V_0' can be obtained from V-I plot.

- **RESULT:**

The value of Planck's constant was found to be 5.73×10^{-34} J-s

· **OBSERVATION TABLE:**

→ I-V Characteristics

BLUE		GREEN		YELLOW		RED	
V	I (mA)	V	I (mA)	V	I (mA)	V	I (mA)
0	0	0	0	0	0	0	0
0.1	0	0.1	0	0.1	0	0.1	0
0.2	1	0.2	1	0.2	1	0.2	1
0.3	2	0.3	2	0.3	2	0.3	2
0.4	3	0.4	3	0.4	3	0.4	3
0.5	4	0.5	4	0.5	4	0.5	4
0.6	5	0.6	5	0.6	5	0.6	5
0.7	6	0.7	6	0.7	6	0.7	6
0.8	7	0.8	7	0.8	7	0.8	7
0.9	8	0.9	8	0.9	8	0.9	8
1	9	1	9	1	9	1	9
1.1	10	1.1	10	1.1	10	1.1	10
1.2	11	1.2	11	1.2	11	1.2	11
1.3	12	1.3	12	1.3	12	1.3	12
1.4	13	1.4	13	1.4	13	1.4	13
1.5	14	1.5	14	1.5	16	1.5	17
1.6	15	1.6	15	1.6	25	1.6	37
1.7	16	1.7	16	1.7	82	1.62	47
1.8	17	1.8	17	1.74	192	1.64	68
1.9	18	1.9	18	1.77	300	1.66	100
2	19	2	20	–	–	1.68	174
2.1	20	2.1	24	–	–	1.69	224
2.2	22	2.2	38	–	–	1.7	285
2.3	27	2.3	78	–	–	–	–
2.4	73	2.4	211	–	–	–	–
2.42	122	2.41	240	–	–	–	–
2.45	234	–	–	–	–	–	–

→ 1/λ, Barrier Potential

LED Colour	Wavelength (λ)	1/λ (nm⁻¹)	Barrier potential (V_0)
Blue	450	2.22×10^{-3}	2.3
Green	520	1.92×10^{-3}	2.1
Yellow	580	1.72×10^{-3}	1.6
Red	630	1.59×10^{-3}	1.5

• CALCULATIONS:

$$m = \frac{N \Sigma x_i y_i - \Sigma x_i \Sigma y_i}{N \Sigma x_i^2 - (\Sigma x_i)^2}$$
(slope)

$$= \frac{4(10.138 \times 10^6) - (29.68 \times 10^6)}{4 \times (9.5 \times 10^{12}) - (27.88 \times 10^{12})}$$

$$= \frac{(40.552 - 29.68) \times 10^6}{(38 - 27.88) \times 10^{12}}$$

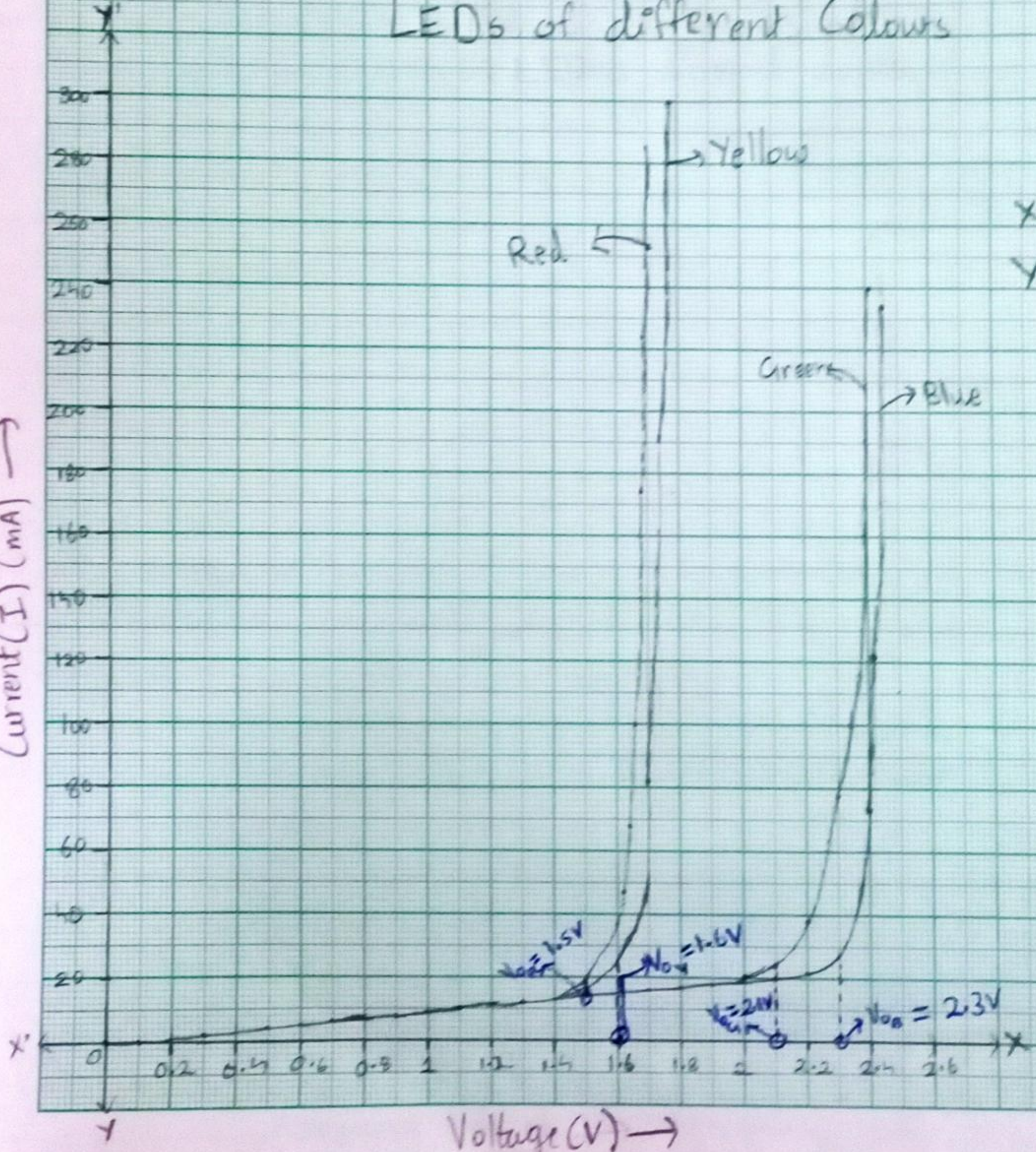
$$= \frac{10.872}{10.12} \times 10^{-6}$$

$$\boxed{m = 1.074 \times 10^{-6}}$$

$$\frac{c}{e} = \frac{3 \times 10^8}{1.6 \times 10^{-19}} = 1.875 \times 10^{+27}$$

$$\frac{m}{4e} = h = \frac{1.074 \times 10^{-6}}{1.875 \times 10^{+27}} = 0.573 \times 10^{-33} \Rightarrow \boxed{h = 5.73 \times 10^{-34} \text{ J-s}}$$

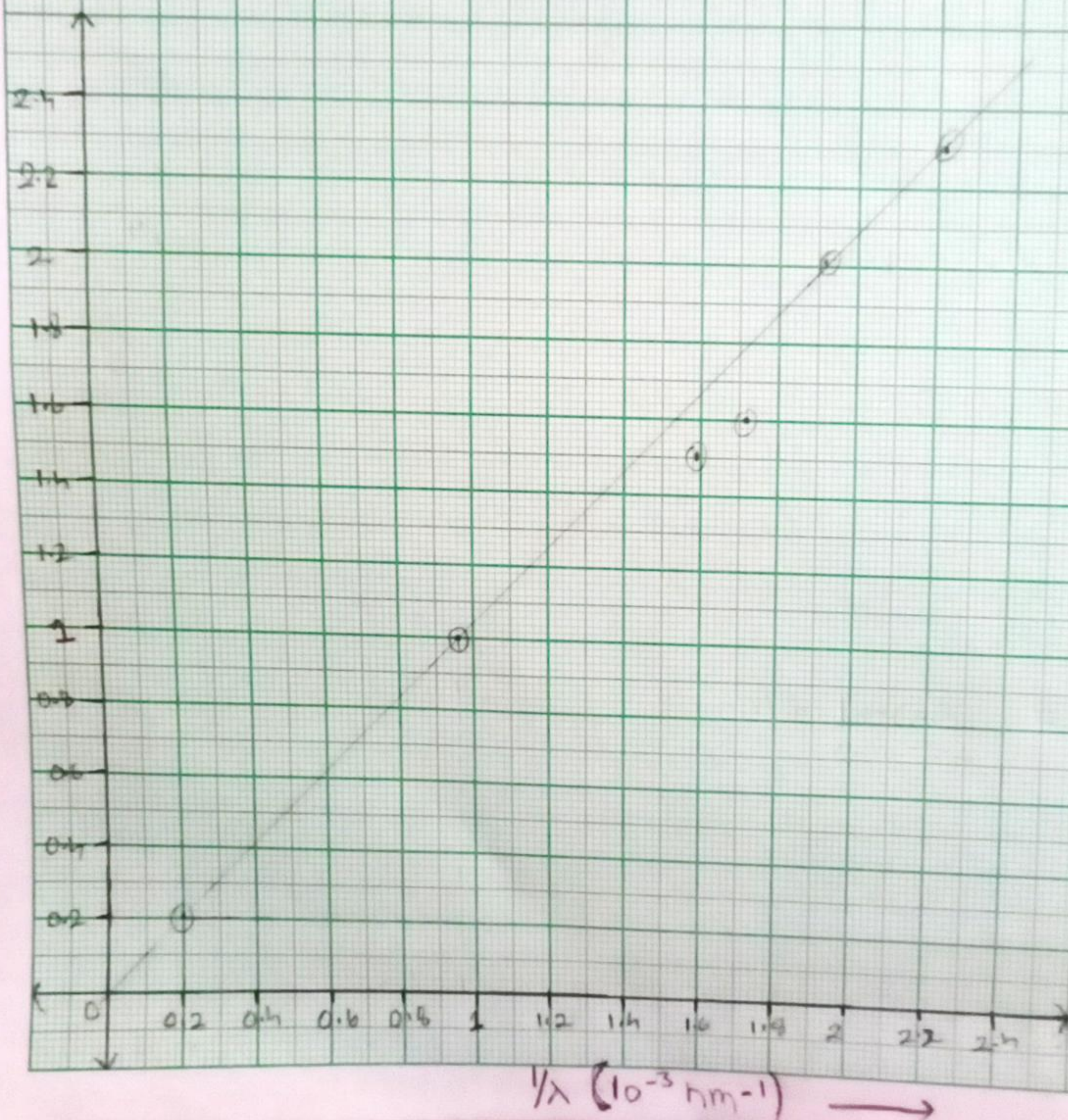
I-V Characteristics of LEDs of different Colours



__Scale__

X-axis → 1 cm = 0.2 V

Y-axis → 1 cm = 20 mA



2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
1/λ (10^-3 nm^-1)

Name: Vidhi Shah Reg. No.: 21BCE1297 Batch: L3+L4 Dataset: 2

EXPERIMENT: No. 8 Solar Cell Characteristics

Page No. | Date 25 04 22

- **AIM:** To determine I-V characteristics and the suitability of the solar cell in electric power generation.

- **APPARATUS:** Solar cell characteristic kit, light source, LEDs

- **FORMULA USED:**

→ $\boxed{P_{max} = I_m \times V_m \text{ (Watts)}}$

P_{max} → Maximum Power [Area of largest rectangle under the I-V curve]

I_m → Maximum Current

V_m → Maximum Voltage

→ $$\boxed{FF = \frac{P_{max}}{V_{oc} \times I_{sc}}}$$ (No unit)

FF → Fill Factor

V_{oc} → Open Circuit Voltage

I_{sc} → Short Circuit Voltage

→ $$\boxed{\eta = \left(\frac{P_{max}}{A \times I_0}\right) \times 100\%}$$

η → Efficieny

A → Area of solar cell (m^2)

I_0 → Intensity of solar light radiation (Watts/m^2)

Maximum efficiency is when power delivered to solar cell is P_{max}

Observation Table:

(i) $d = 10cm$: $I_0 = 11.49 \frac{W}{cm^2}$ $A = 6 \times 10^{-4} cm^2$

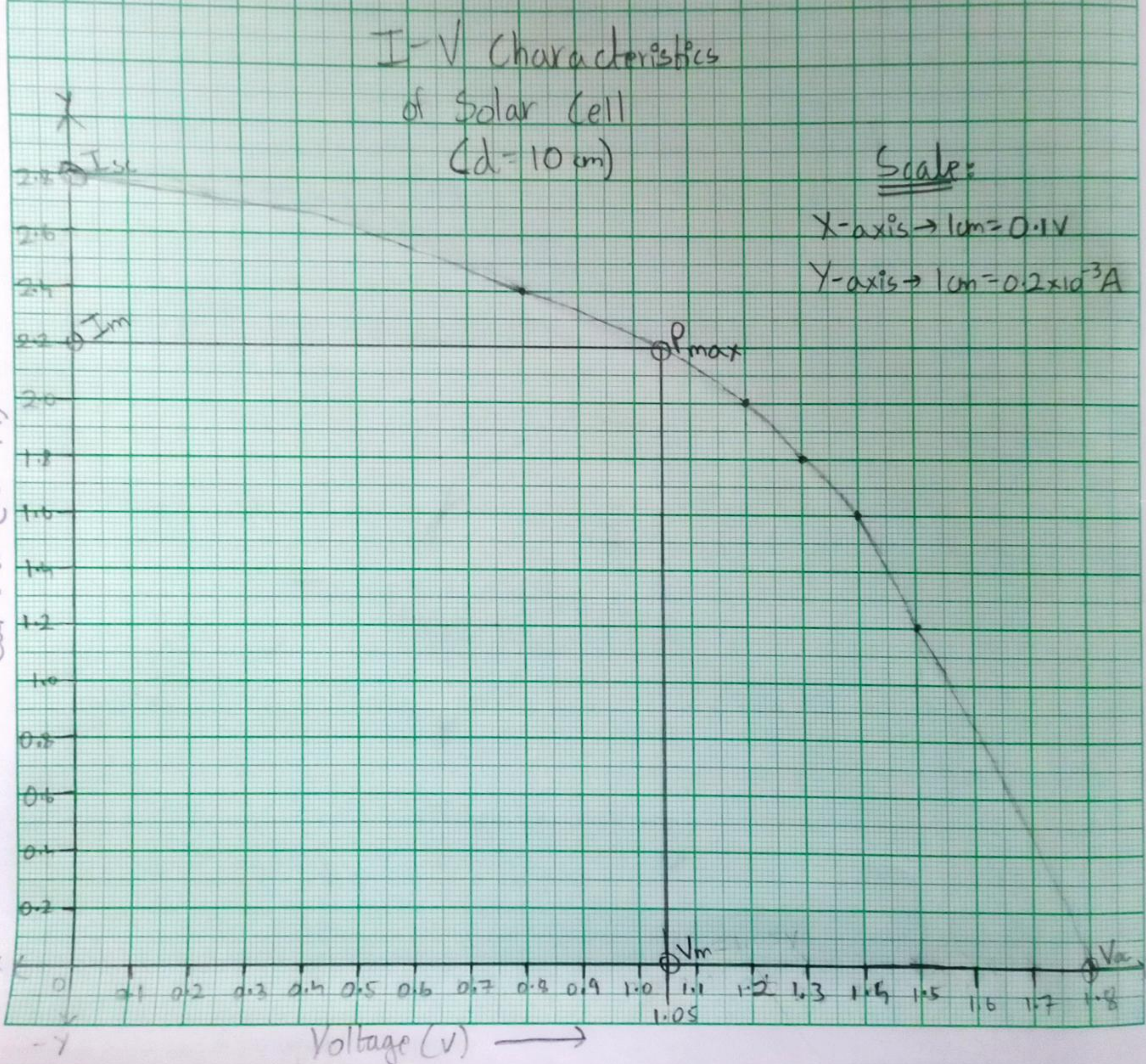
$V_{oc} = 1.8V$ $I_{sc} = 2.8mA$

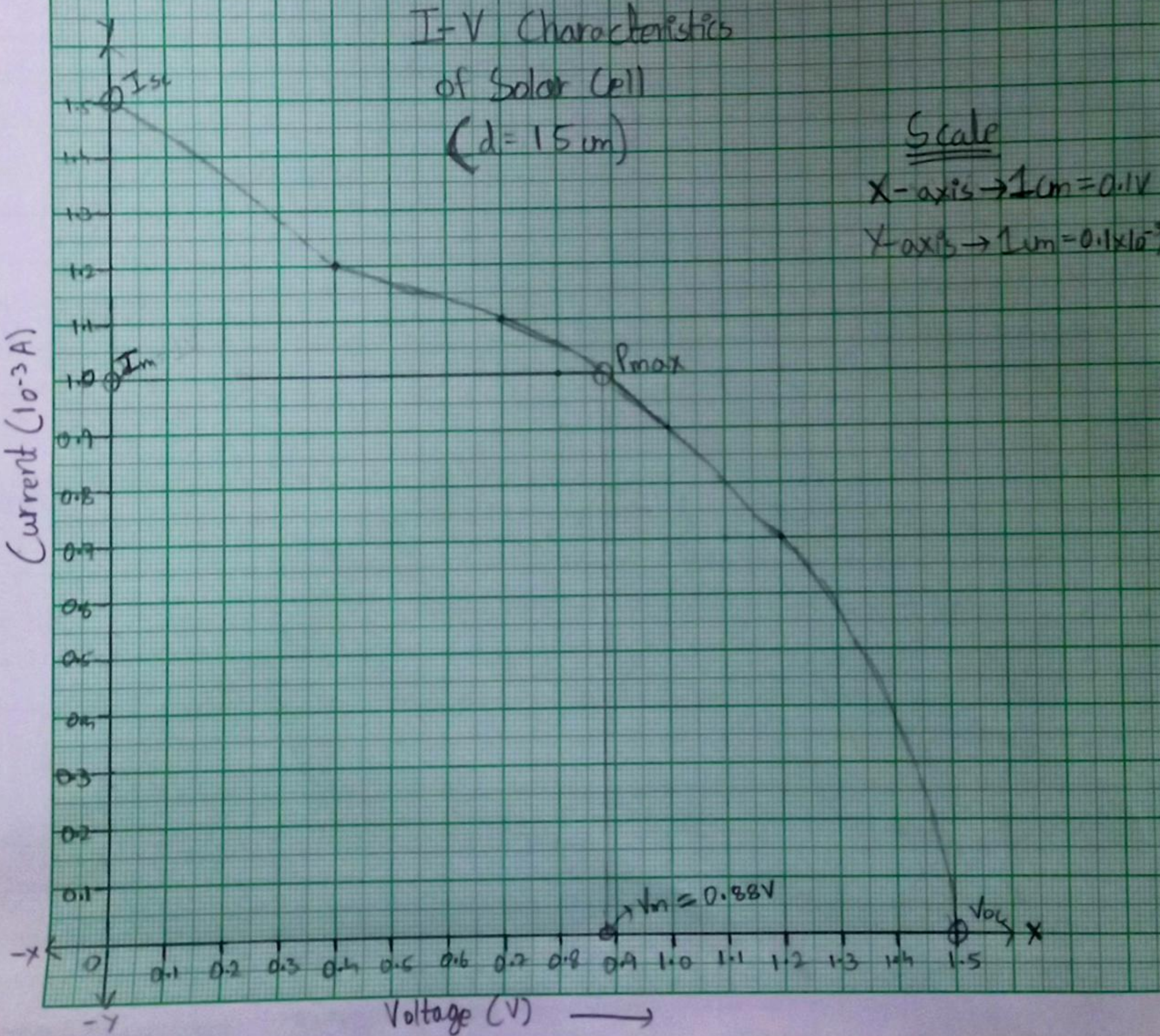
S.No.	Resistance (Ω)	Voltage (V)	Current (mA)	Power (W)
1.	300	0.8	2.4	1.92×10^{-3}
2.	400	1.2	2	2.4×10^{-3}
3.	500	1.3	1.8	2.34×10^{-3}
4.	600	1.4	1.6	2.24×10^{-3}
5.	900	1.5	1.2	1.8×10^{-3}

(ii) $d = 15cm$: $I_0 = 6.12 \frac{W}{cm^2}$ $A = 6 \times 10^{-4} cm^2$

$V_{oc} = 1.5V$ $I_{sc} = 1.5mA$

S.No.	Resistance (Ω)	Voltage (V)	Current (mA)	Power (W)
1.	300	0.4	1.2	0.48×10^{-3}
2.	400	0.7	1.1	0.77×10^{-3}
3.	500	0.8	1	0.8×10^{-3}
4.	600	1	0.9	0.9×10^{-3}
5.	900	1.2	0.7	0.84×10^{-3}


I-V Characteristics
of Solar Cell
(d = 10 cm)
Scale:
X-axis → 1cm = 0.1V
Y-axis → 1cm = 0.2×10⁻³A
Isc
Im
Pmax
Vm
Voc
Current (10⁻³A)
Voltage (V)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.05
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
X
-X
Y
-Y



I-V Characteristics
of Solar Cell
(d = 15 cm)
Scale
X-axis → 1 cm = 0.1V
Y-axis → 1 cm = 0.1×10⁻³ A
Current (10^{-3} A)
Voltage (V)
I_{sc}
I_m
P_{max}
V_m = 0.88V
V_{oc}
Y
-Y
X
-X
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5

· CALLCULATIONS :

① d=10cm: $I_m = 2.2\times10^{-3}$ A, $V_m = 1.05$ V, $I_{sc} = 2.8\times10^{-3}$ A, $V_{oc} = 1.8$ V

$A = 6\times10^{-4}$ cm², $I_o = 11.49\ \frac{W}{cm^2}$

$$P_{max} = (2.2\times10^{-3}A)\times(1.05V)$$

$$\Rightarrow \boxed{P_{max} = 2.31\times10^{-3}\ W}$$

$$FF = \frac{2.31\times10^{-3}}{1.8\times2.8\times10^{-3}}$$

$$\Rightarrow \boxed{FF = 0.46}$$

$$\eta = \left(\frac{2.31\times10^{-3}}{6\times10^{-4}\times11.49}\right)\times100$$

$$\eta = (0.335)\times100$$

$$\Rightarrow \boxed{\eta = 33.5\%}$$

② d=15cm: $I_m = 1\times10^{-3}$ A, $V_m = 0.88$V, $I_{sc} = 1.5\times10^{-3}$A, $V_{oc} = 1.5$ V

$A = 6\times10^{-4}$ cm², $I_o = 6.12\ \frac{W}{cm^2}$

$$P_{max} = (10^{-3}A)\times(0.88V)$$

$$\boxed{\Rightarrow P_{max} = 0.88\times10^{-3}\ W}$$

$$FF = \frac{0.88\times10^{-3}}{1.5\times1.5\times10^{-3}}$$

$$\Rightarrow \boxed{FF = 0.39}$$

$$\eta = \left(\frac{0.88\times10^{-3}}{6\times10^{-4}\times6.12}\right)\times100$$

$$\eta = (0.24)\times100 \Rightarrow \boxed{\eta = 24\%}$$

- **RESULT:**

1. For $d = 10\ cm$:

   a) $P_{max} = 2.31 \times 10^{-3}\ W$

   b) $FF = 0.46$

   c) $\eta = 33.5\%$

2. For $d = 15\ cm$:

   a) $P_{max} = 0.88 \times 10^{-3}\ W$

   b) $FF = 0.39$

   c) $\eta = 24\%$