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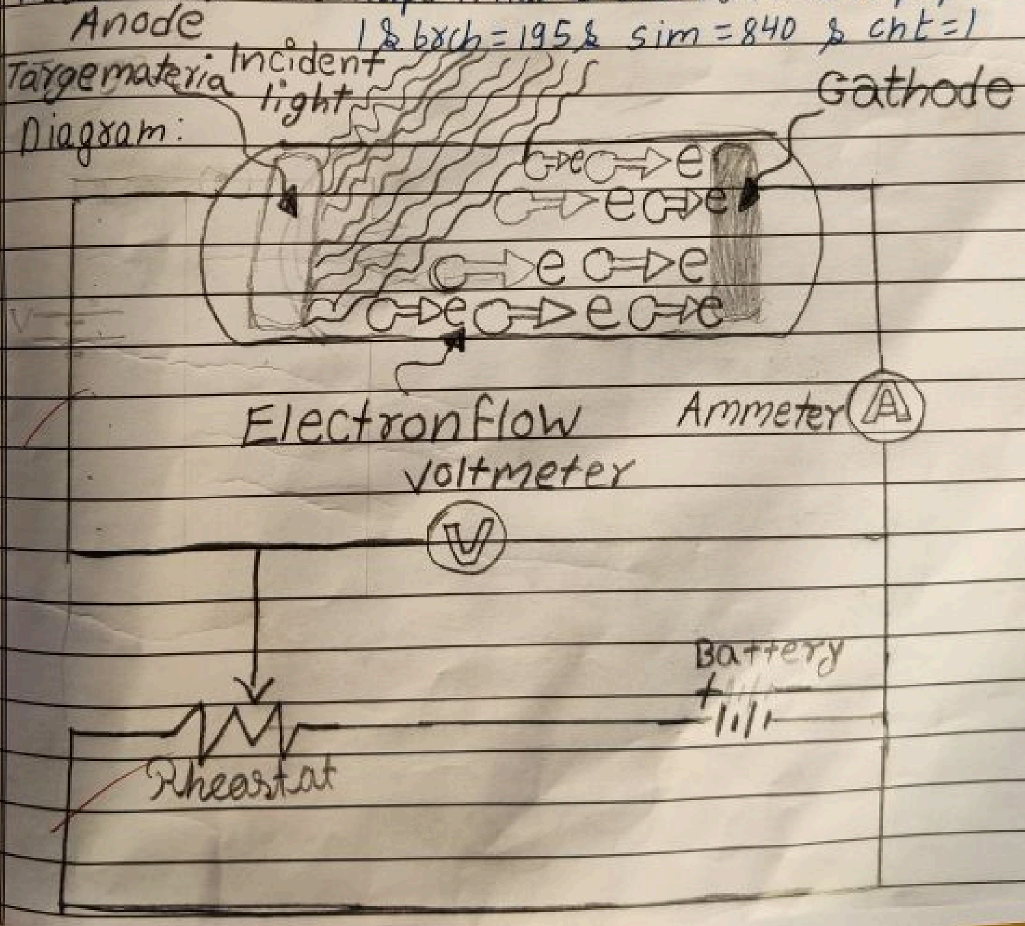
Experiment NO 1 :-

Aim : To understand the phenomenon of the photoelectric effect as a whole.

Apparatus : Material plate, Ammeter, Voltmeter, variable power supply, light source.

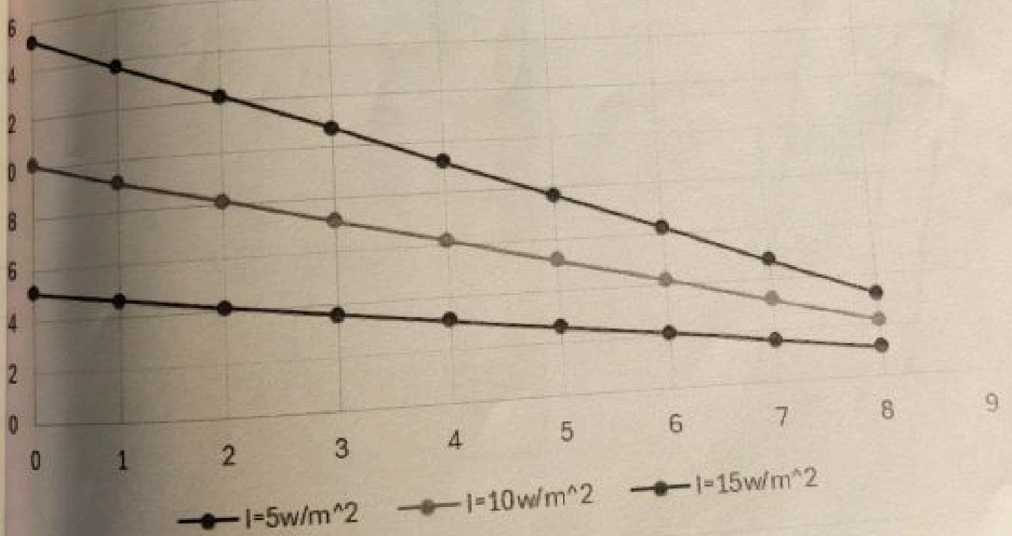
Virtual lab link: https://vlab.amrita.edu/index.php?sub=1&brch=195&sim=840&cnt=1

Diagram:

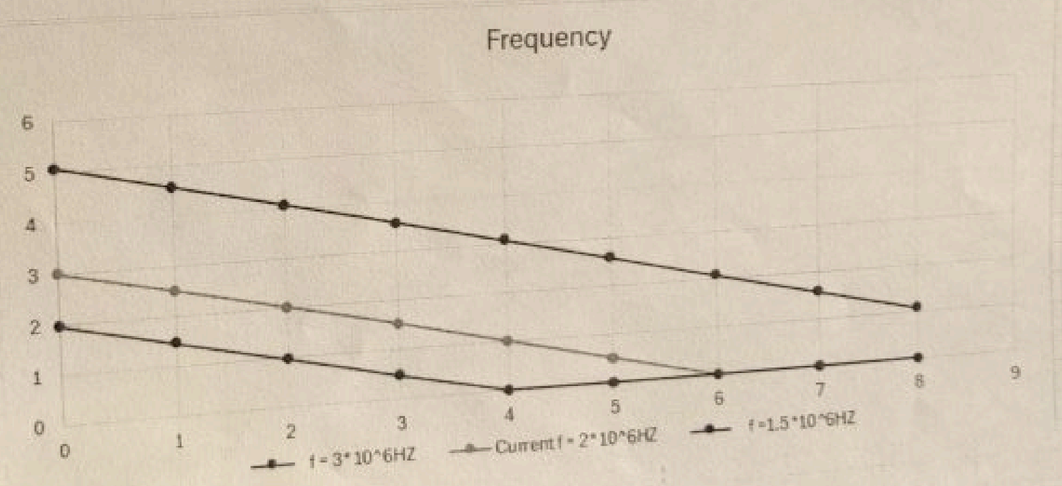


Obv No	Voltag		current	
		I=5w/m^2	I=10w/m^2	I=15w/m^2
1	0	5.07	10.14	15.2
2	1	4.57	9.14	13.7
3	2	4.07	8.14	12.2
4	3	3.57	7.14	10.7
5	4	3.07	6.14	9.2
6	5	2.57	5.14	7.7
7	6	2.07	4.14	6.2
8	7	1.57	3.14	4.7
9	8	1.07	2.14	3.2

intensity vs



Obv No	Voltage		Current	
	(v)	f = 3*10^6HZ	f = 2*10^6HZ	f=1.5*10^6HZ
1	0	5.07	3	1.96
2	1	4.57	2.5	1.46
3	2	4.07	2	0.96
4	3	3.57	1.5	0.46
5	4	3.07	1	0
6	5	2.57	0.5	0
7	6	2.07	0	0
8	7	1.57	0	0
9	8	1.07	0	0



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- Observation from Graph:

1. On increasing intensity at constant frequency, photocurrent increases.

2. On frequency variation at constant intensity, Stopping potential increases (more negative potential require to stop photocurrent)

- Result:

1. The phenomenon of photoelectric effect is studied.

2. A graph is plotted between photocurrent and applied for various intensities at constant frequency.

3. ~~A graph is plotted bet~~

- Procedure:

1. Start the virtual lab simulation using the link below and connect all the connections given in the diagram.

Link: https://mpv-au.vlabs.ac.in/modern-physics/photo_Electric-Effect/index.html

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2. Select the material for studing photoelectric effect.

3. Select area of material, wavelength, intensity of incident light.

4. ~~Sw~~ Switch on the light source.

5. Measure the reverse current for various reverse voltages.

6. Plot the current-voltage graph and determine the threshold voltage.

7. Repeat the experiment by varying the intensity for particular wavelengths of incident light.

• Theory:

The photoelectric effect is the phenomenon where electrons are ejected from a material, typically a metal, when it is exposed to light or other electromagnetic radiation. It was first observed by Heinrich Hertz in 1887 and explained by Albert Einstein in 1905, providing crucial evidence for the particle nature of light.

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When light of a certain frequency strikes the metal surface, photons tranfer energy to electrons. If the photon's energy is greater than the work function (the minimum energy needed to release an electron), the electron is ejected as a photoelectron.

i. Threshold frequency is the minimum frequency of light (or EM radiation) required to emissions of electrons from a material.

ii. Energy of ejected electrons occurs immediately when the light frequency is above the threshold.

Einstein's explation of the photoelectric effect earned him the Nobel Prize in 1921.

When a photon strikes the surface of a metal, it transfers its energy to an electron. If the energy of the photon is greater than or equal to the work function (ϕ) of then material (the minimum energy required to release an electron), the electron is ejected. The Kinetic enegy (K.E) of the emitted electron is given by:

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course code :- ML102

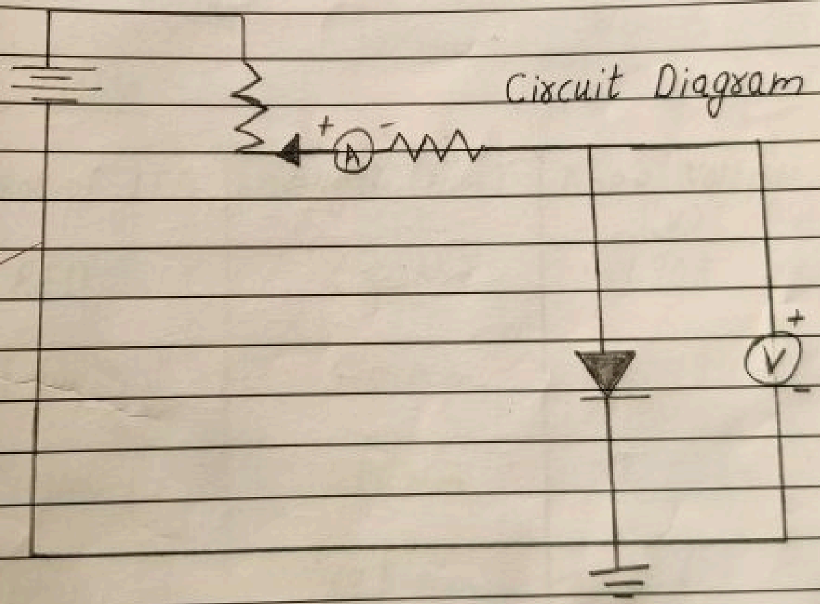
course name :- Engineering physics Lab-1

Experiment NO 2 :-

- **Aim** :- To determine Planck's constant using photoelectric effect.

- **Apparatus** :- 0-10v power supply, a one way key, a rheostat, a digital milliammeter, a digital voltmeter, a 1K resistor and different known wavelength LED's.

- **Diagrams** :-



Circuit Diagram

Formula : Planck's Constant 'h'

$$h = \frac{e}{c} \lambda V$$

Where,

e = charge on electron = 1.6×10^{-19} C

c = speed of light = $3 10^{8}$ m/s

λ = Wavelength of incident light

V = Knee voltage

Observation Table :-

Obs NO.	color of LED	Wavelegth (nm)	Knee Voltage (V)
1	RED	650 Nm	1.908
2	Green	510 Nm	2.434
3	Yellow	570 Nm	2.178
4	Blue	475 Nm	2.615

Calculation :-

Red :- $h = \frac{\lambda e V}{c}$

$$= \frac{650 \times 10^{-9} \times 1.6 \times 10^{-19} \times 1.908}{3 \times 10^{8}}$$

$$= \frac{6.5 \times 10^{-7} \times 1.6 \times 10^{-19} \times 1.908}{3 \times 10^{8}}$$

$$= \frac{\cancel{19.84}\ 6.61}{\cancel{3}\ 1}$$

$$\boxed{= 6.61 \times 10^{-34}\ JS.}$$

Green :- $h = \frac{\lambda e V}{c}$

$$= \frac{5.1 \times 10^{-9} \times 1.6 \times 10^{-19} \times 2.434}{3 \times 10^{8}}$$

$$= \frac{9.86}{3 \times 10^{8}}$$

$$\boxed{= 6.62 \times 10^{-34}\ JS}$$

Yellow :- $h = \frac{\lambda e V}{c}$

$$= \frac{5.7 \times 10^{-9} \times 1.6 \times 10^{-19} \times 2.178}{3 \times 10^{8}}$$

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$= \frac{19.863}{3}$

$\boxed{= 6.62 \times 10^{-34}\ JS}$

Blue :- $h = \frac{\lambda e v}{c}$

$= \frac{4.75 \times 10^{-9} \times 1.6 \times 10^{-19} \times 2.178}{3 \times 10^{8}}$

$\boxed{= 5.51 \times 10^{-34}\ JS.}$

- Result :-

The value of Planck's constant is

Red :- 6.61×10^{-34} JS.
Green :- 6.62×10^{-34} JS.
Yellow :- 6.62×10^{-34} JS.
Blue :- 5.51×10^{-34} JS.

- Procedure :

1. Start the virtual lab Simulation using the link below and connect all the connections given in the diagram.
Link :
https://mpv-au.vlabs.ac.in/modern-physics/Determination_of_Plancks_Constant/

2. Choose a photocell or photo-detector and connect it to the ammeter or voltmeter in the circuit. Position the photocell to receive light from the LED.

3. Connect the LED light source to an adjustable power supply. Use the power supply to change the current, which in turn adjusts the wavelength (color) of the emitted light.

4. Choose LEDs of differents colors (e.g., red, green, blue, or ultraviolet) in the virtual lab. Each color corresponds to a specific wavelength.

5. Gradually increase the voltage supplied to the LED and monitor the voltage across the photocell. The knee voltage is the point where measurable photocurrent is detected.

6. Note the knee voltage for each LED wavelength when photoelectrons are ejected from the photocell.

7. Repeat the process for different LED colors (wavelengths). Record the knee voltage for each color to gather data for multiple wavelengths.

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8. Determine the Planck's constant for each wavelength.

• Theory:

The experiment aims to determine Planck's constant (h) by studing the photoelectric effect using LEDs of different colors (wavelengths). When light of a certain wavelength strikes a photocell, it can eject electrons if the energy of the photons is greater than the work function of the material. The Knee Voltage is the minimum voltage at which photoelectrons are ejected, marking the threshold energy needed. By measuring the Knee voltage for various wavelengths, the relationship between the photons energy and the Knee voltage can be used to calculate Plancks constant, using the equation

$$\left[eV = \frac{hc}{\lambda} \right]$$

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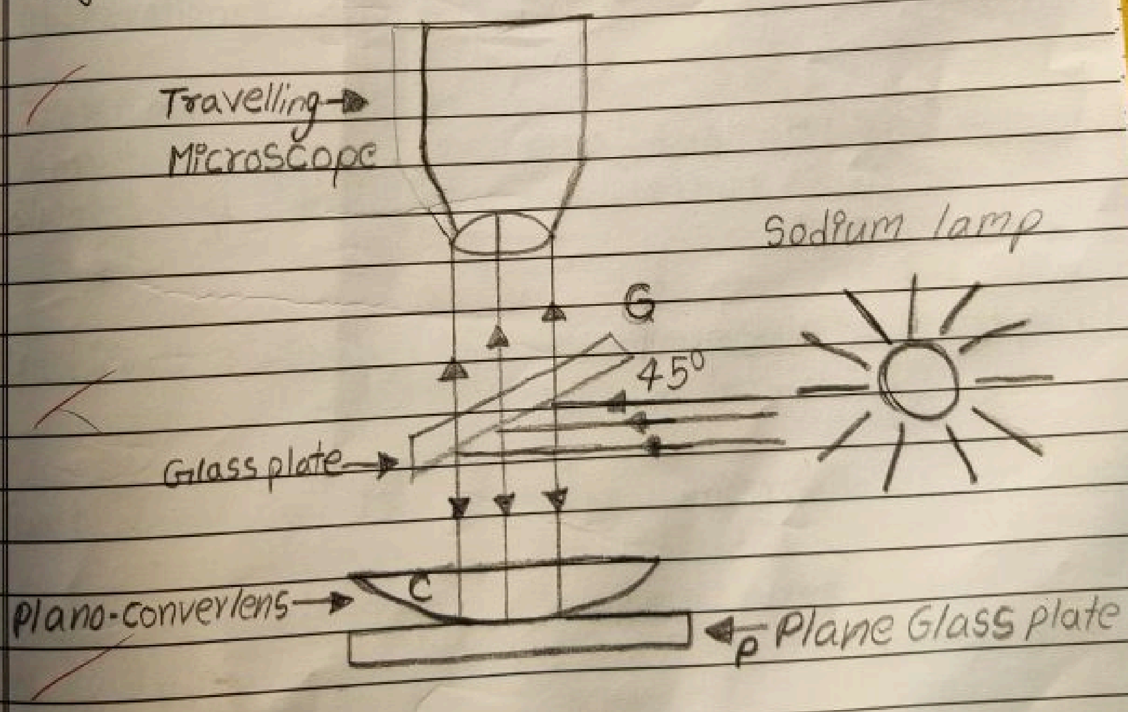
Experiment no : 3

- Aim : To determine wavelength of monochromatic light by Newton's Ring experiment.

- Apparatus : A plano - convex lens of large radius of curvature, optical arrangement for Newton's rings, plane glass plate, Sodium lamp and travelling microscope.

- Diagram :



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• Formula : The wavelength λ of light is given by the formula :

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

Where,

D_{n+m} = diameter of $(n+m)^{th}$ ring,
D_n = diameter of n^{th} ring,
m = an integer number (of the rings)
R = radius of curvature of the curved face of the plano-convex lens.

Observations :

1. Travelling Microscope :
Smallest division on main scale = 0.1 cm
Number of divisions on vernier scale = 50

Least count = $\frac{\text{Smallest divisions on main scale}}{\text{Smallest of divisions on vernier scale}}$ = ~~0.0~~ 0.1 cm / 50 = ~~0.001~~ cm

Least count of the travelling microscope is = $\frac{0.1}{50}$ = 0.002 cm

2. Radius of curvature of the curved face of the plano-convex lens ~~of~~ = R = ~~0.00 km~~ 100 cm

3. m = 2

- Observations table:

Obs. No.	oder No. of rings (n)	Left side (x) (cm) M.S.R	V.S.R	T.R	Right side (y) (cm) M.S.R	V.S.R	T.R	Diameter of rings (Dn = l-y) (cm)	$D^2_{n+m} - D^2_n$ (cm^2)
1	12	2.25	15.	2.265	2.65	41	3.06	-0.795	0.632
2	10	2.3	25	2.325	2.6	28	2.88	-0.555	0.3080
3	8	2.3	48	2.345	2.6	9	2.69	-0.342	0.427
4	6	2.35	21	2.371	2.6	34	2.94	-0.569	0.2010
5	4	2.35	42	2.392	2.55	14	2.69	-0.298	0.7620
6	2	2.4	26	2.426	2.455	30	2.85	-0.424	0.3120

Calculation:-

use the formula : $\lambda = \frac{(D^2_{n+m} - D^2_n)}{4mR}$

$$\lambda = \frac{(1.44 - 1.0)}{4 \times 2 \times 100}$$

$$\lambda = \frac{0.44}{800}$$

$$\lambda = 0.000555$$

$$\lambda = 5.5 \times 10^{-4} m$$

Result :- The wavelength (λ) of the used monochromatic is $5.5 \times 10^{-4} m$ 550 nm

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- ~~Prod~~ Procedure :

1. Start the virtual lab Simulation using the link below.
Link : https://lo-au.vlabs.ac.in/laser-optics/Newtons_Rings_wavelength_of_light/

2. Choose "Air" as the medium and "sodium Lamp" as the light source.

3. Adjust the radius of the plano-convex lens to 100 cm.

4. Use the focus controls to make the Newton's Rings patterns of sharp and clear.

5. Switchs the light sources on to create the interference pattern of Newton's Rings.

6. Look at the concentic rings formed on the surface, starting with the ~~cut~~ central dark ring.

7. Move the microsope to position that flood allows you to clearly view the rings.

8. Adjust the microsope's zoom and focus to ensure clear and sharp image of the rings.

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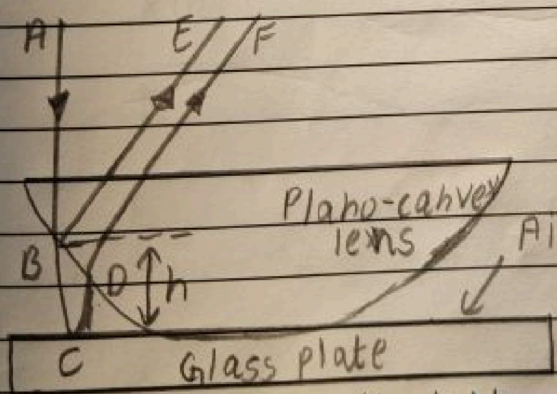
9. Measure the diameters of the rings using the virtual ~~for wavelength~~ measuring tool.

10. Record the ~~measurement~~ measurements and ~~analyse~~ the data for wavelength calculation.

- Theory:

Newton's Rings is an optical interfence phenomenon that occurs when monochromatic ligh is reflected between two surfaces - typically a plano-convex lens and an optically flat glass plate. A thin air film with varying thickness is formed between the lens and the plate. when monochromatic light (such as from a sodium lamp) is incident on this setup, it produces a pattern of concentric circular fringes, Known as Newton's Rings, alternating between dark and bright bands.



Schematic diagram of the light rays in Newton's ring

Newton's ring

Interferce occurs between the light rays reflected from the upper and lower surfaces of the air film. This interference produces a series of concentric circular fringes - Newton's Rings. The central spot is dark because at the center, the lens is in contact with the plate, making the air film thickness zero. At this point, light undergoes destructive interference due to a phase shift caused by reflection at the lower surface of the film (from a denser to a rarer medium).

The diameter of the nth dark ring (Dn) is related to the wavelength of the light by the formula:

$$D_n^2 = 4nR\lambda$$

Where: Dn is the diameter of the n^{th} dark ring.

n is the ring number,

R is the radius of curvature of the plano-canvex lens,

λ is the wavelength of the light.

This formula comes from the interfernce condition, where the path difference between the two reflected light rays causes destructive interference for dark rings.

Due to imperfections in the surfaces of the lens or the plates, the center may not be perfectly dark. To minimize this error, the diameters of two rings, say the n^{th} and $(n+m)^{th}$ dark rings, can be measured, and the wavelength can be calculated using:

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

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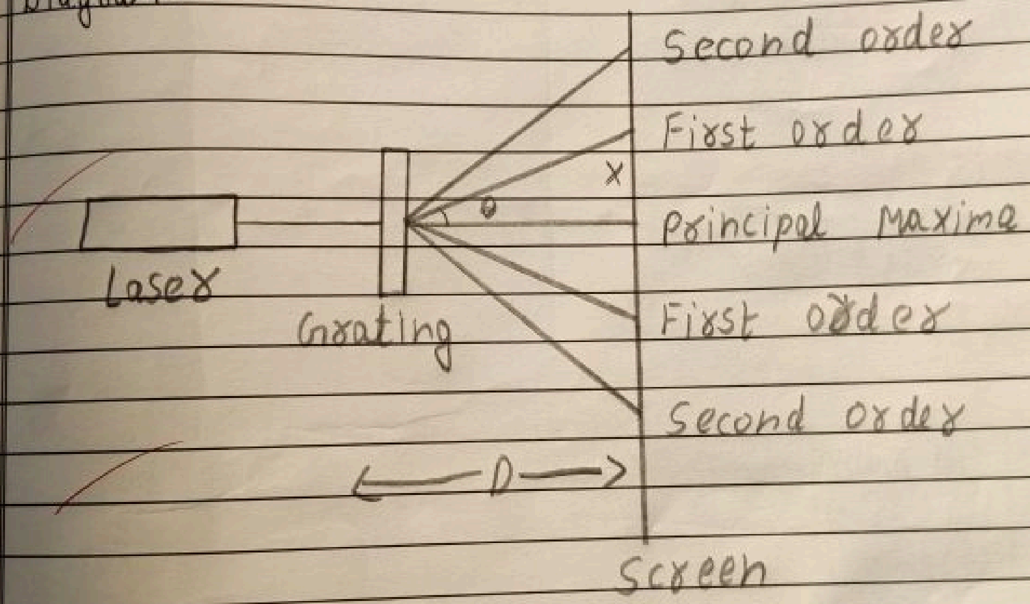
Experiment NO - 4

- **Aim**: To determine laser wavelength using multiple slits (Diffraction Grating).

- **Apparatus**: Laser source, grating plate, screen, scale.

- **Diagram**:



- **Formula**: Condition for diffraction maxima is given by

$$d \sin \theta_n = n\lambda \ \& \ d = \frac{1}{N}$$

Where,

d = Grating element

θ_n = Angle of n^{th} order diffraction

λ = Wavelength of incident light

n = Diffraction order

N = Number of lines on gratting

• Observation :

400 lines per mm

Number of lines on grating = N = 600 lines per mm

$N = 600 \times 10^{-6}$ per cm

$\frac{400}{0.4}$ lines per cm

• Observation Table :

Obs. NO.	Distance between grating System (D)	order (n)	Distance between centers & right maximum (a) (m)	Distance bet^n center & left maxima (b) (cm)	mean dist $x = \frac{a+b}{2}$ (cm)
1	100	1	3.0	3.2	3.1
2	100	2	0.2	6.4	6.3
3	100	3	9.5	6.6	9.55

1.78 3.59 5.43

Calculation :-

$$d\sin\theta = n\lambda$$

1) $d\sin\theta = n\lambda$

$\lambda = \frac{d\sin\theta}{n} = \frac{0.1\times\sin(0.2064)}{400}$

$\lambda = \frac{0.1\times 0.2054}{400\times 1}$

$= 0.5125$

$= 5.12\times10^{-7}\,cm$

$= 512\times10^{-4}$

$\therefore \lambda = 512\,nm$

2) $d\sin\theta = n\lambda$

$\lambda = \frac{d\sin\theta}{n}$

$\lambda = \frac{0.1\times\sin(0.363)}{400\times 2}$

$= \frac{0.0355}{800}$

$= 0.4439$

$= 4.43\times10^{-7}\,cm$

$\therefore \lambda = 443\,nm$

3) $d\sin\theta = n\lambda$

$\lambda = \frac{d\sin\theta}{n}$

$= \frac{0.1\times\sin(0.5\ldots)}{400\times 3}$

$= \frac{0.0532}{1200}$

$= 0.441$

$= 4.44\times10^{-7}\,cm$

$\therefore \lambda = 444\,nm$

$$\lambda_{mean} = \frac{512 + 443 + 444}{3} = 466\,nm.$$

Result :- The laser wavelength (λ) is 466 nm

- Procedure :-

1. Start the virtual lab simulation using the link below.
   Link : https://ophysics.com/l5b.html
2. Set the diffraction grating to 400lines per mm.
3. Set the distance between the grating and the screen to 6 m.
4. Choose the wavelength of the laser to be 700nm.
5. Confirm the grating is in place and all settings are correct.
6. Measure the distance from the principal maximum to various diffraction orders.
7. Record reading for different diffraction orders (1st, 2nd, etc.).
8. Use the diffraction equation to calculate the wavelength or confirm it.

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• Theory :

A diffraction grating consists of closely spaced lines that cause light to diffract, or spread out, into various angles. when monochromatic light (such as a laser) passes through or reflects off the grating, it produces a diffraction pattern on a screen. The light waves interfere with each other, leading to constructive at specific angles, forming bright spots called diffraction maxima.

The angles at which these maxima occur are governed by the grating equation:

$$d \sin\theta_n = n\lambda \ \& \ d = \frac{1}{N}$$

By measuring the angles at which the maxima occurs for diffraction orders and Knowing the setup geometry, the wavelength of the incident light can be determined. This experiment demonstrates the wave nature of light and allows precise measurement of wavelengths, such as that of a laser, by analyzing the diffraction pattern produced on a screen.

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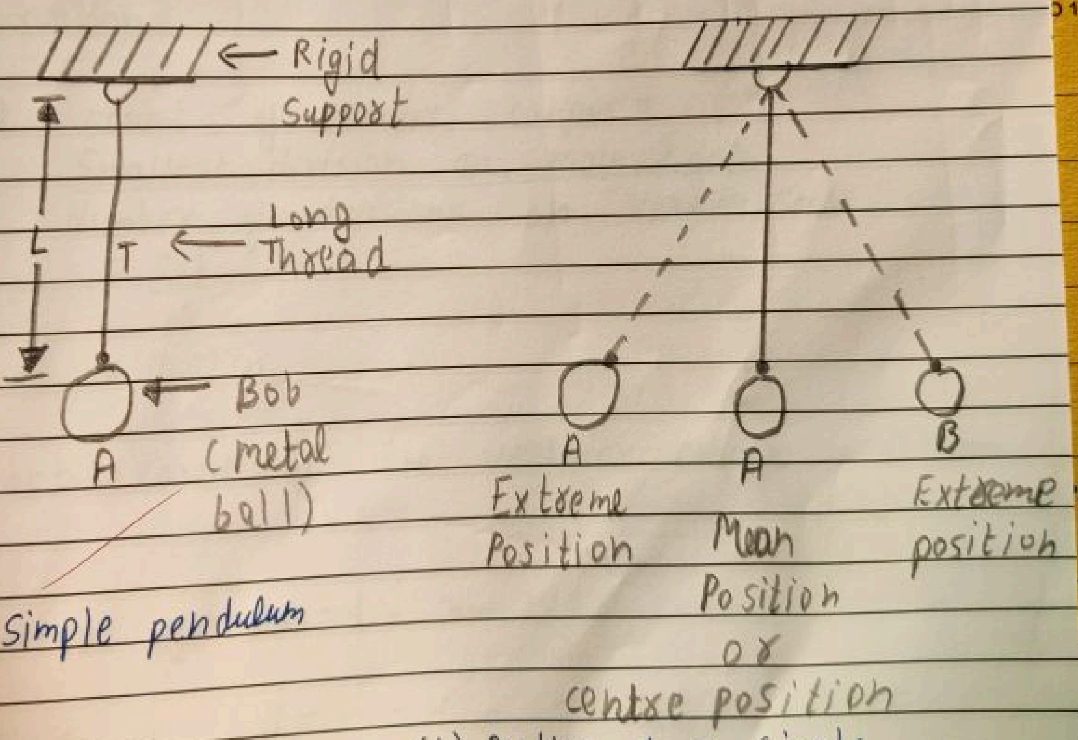
Experiment NO 5 :-

- Aim : To determine the acceleration due to gravity (g) by measuring the period of a simple pendulum.

- Apparatus :- Bob, thread, restort, stand, stop watch, vernier caliper, measing Scale.

- Diagram :-



a) Simple pendulum

(b) Motion of a Simple Pendulum

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- Formula: The time period (T) of simple pendulum is given by

$$T = 2\pi \sqrt{\frac{L}{g}}$$

Where,

L = length of simple pendulum
g = acceleration due to gravity

Therefore,

$$g = 4\pi^2 \frac{L}{g}$$

- Observation:

1. Least count of vernier caliper = $\frac{\text{Smallest division on main scale}}{\text{Number of divisions on vernier scale}}$

$= \frac{0.1}{10}$

$= 0.01$ cm

Least count of the vernier caliper is 0.01cm

2. Diameter of bob = d = ~~2~~ 1.97cm

3. Radius of bob = r = $\frac{d}{2}$ = $\frac{1.97}{2}$ = 0.985

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Obs NO	Length of String (l)(cm)	Effective length (L=l+r) cm	Time for Osillation (s) t_1	t_2	tmean	Time Period $T = \frac{t_{mean}}{20}$ (s)
1	30.5	31.44	23.04	23.04	23.04	1.15
2	35.5	36.44	24.44	24.09	24.09	1.20
3	40.5	41.44	41.44	25.1	25.1	1.25

calculation :-

g 1) $4\pi 2 \times \frac{L}{T^2}$

$= \frac{4 \times 9.86 \times 31.44}{1.32}$

$= 939.38 \ cm/s^2$

g 2) $4\pi 2 \times \frac{L}{T^2}$

$= \frac{4 \times 9.86 \times 36.44}{1.44}$

$= 998.05 \ cm/s^2$

g 3) $4\pi^2 \times \frac{L}{T^2}$

$= \frac{4 \times 9.86 \times 4144}{1.56}$

$= 1047.68 \ cm/s^2$

$g \ mean = \frac{g_1 + g_2 + g_3}{3}$

$= \frac{939.38 + 998.05 + 1047.68}{3}$

$= 995.03 \ cm/s^2$

• Procedure :-

1. Attach the bob to one end ~~t~~of the string and other end to a fixed point. Measure and record the length from the pivot to the center of the bob.

2. Displace the pendulum to a small angle (less than 15°) to ensure the motion is simple harmonic.

3. Using a stopwatch, measure the time it takes for the pendulum to ~~colo~~ complete 20 oscillations. Find the period T of the pendulum.

4. Repeat the experiment for different lengths of the pendulum (eg., 35cm, 40cm, 45cm) and measure the corresponding periods for each length.

5. Calculate the accelaration due to gravity for each length.

Result :- The acceleration due to gravitg (g) is 995.03 cm/s^2

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• Theory:

A Simple pendulum consists of a mass (bob) attached to a string or rod of fixed length, Swinging under the influence of gravity. The motion is of a simple pendulum is periodic, meaning it repeats itself in a regular cycle. This motion is a type of simple harmonic motic (SHM) when the displacement is small.

The period T of a simple pendulum (the time taken for complete Oscillation) depends on the length of length of the pendulum L and the acceleration due to gravity. for Small angles of displacement (less than 15^0), the motion of the pendulum can be approximated by the following formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

This formula shows that the period is independent of the mass of the bood and depends only on the length of the string and the gravitational constant. The acceleration bue to gravity is $9.8 m/s^2$ on Earth.

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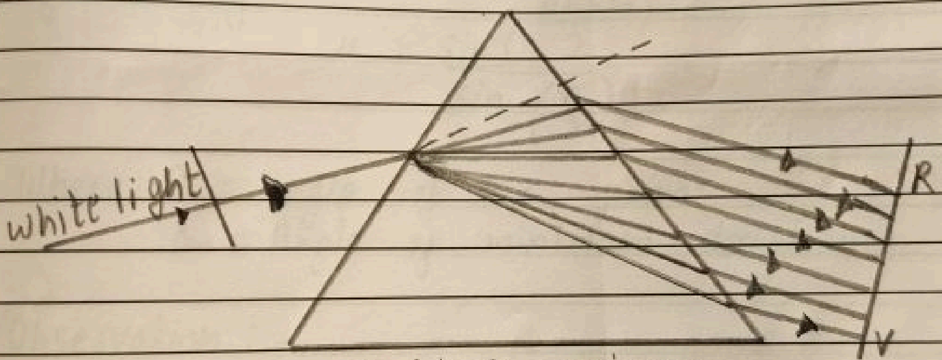
Experiments NO - 6

- **Aim** :- To determine the dispersive power of the material of the prism.
- **Apparatus** : Spectrometer, prism, mercury source and reading lens.
- **Diagram** :



Glass prism

Formula :

The dispersive power (ω), of the material of the prism is given by the formula

$$\omega = \frac{\mu_v - \mu_r}{\mu - 1}$$

Where,

μ_v = refractive index for violet light,

μ_y = refractive index for yellow light

$$\mu = \frac{\mu_v + \mu_y}{2}$$

The refractive index of the prism is given by

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

Where A = Angle of the prism
δm = Angle of minimum deviation

Observation :

1. Least count of Spectrometer

$$= \frac{\text{Smallest division on main scale}}{\text{Number of divisions on vernier Scale}}$$

$$= \frac{0.5^\circ}{30} = 0.0167^\circ \times 60 = 1 \text{ minute}$$

Least count of the Spectrometer is 1 minute.

2. Angle of prism = A = 60°

Observation table :-

Obs NO.	Color	telescope reading at the minimum deviation position (a)			Direct reading of the telescope (b)			Angle of minimum deviation ($\delta m = a-b$)
		MSR	VSR	TR	MSR	VSR	TR	
1.	yellow	177°	0 2	$177^\circ 2'$	125°	4	$125^\circ 4'$	$177^\circ 2' - 125^\circ 4$ $= 51^\circ 58'$
2.	violet	$180^\circ 3'$	20	$180^\circ 50'$	125°	4	$125^\circ 4'$	$= 55^\circ 46'$

calculations :-

1. $T.R = M.S.R + (V.SR + L.C)$

$= 177^\circ + (2 \times 1')$

$T.R = 177^\circ 2'$

2. $T.R = MSR + (VS.R + L.C)$

$= 180^\circ 30' + (20 \times 1')$

$T.R = 180^\circ 50'$

3. $T.R = MSR + (VS.R \times L.C)$

$= 125^\circ + (4 \times 1')$

$= 125^\circ 4'$

Calculation :-

Refractive Index (μ_Y) = $\frac{\sin\left(\frac{60°+51°58'}{2}\right)}{\sin\left(\frac{60}{20}\right)}$

$= \frac{\sin\left(\frac{60°+51°58'}{2}\right)}{\sin(30°)}$

$= \frac{\sin\left(\frac{60°+51°58'}{2}\right)}{\frac{1}{2}}$

$= \frac{0.77}{0.5}$

$\therefore \boxed{\mu_Y = 1.54}$

Refratctive index (μ_V) =

$\mu_V = \frac{\sin\left(\frac{60°+55°46'}{2}\right)}{\sin 30°}$

$= \cancel{0.86}$

$\frac{0.81915}{0.5}$

$= 1.6383$

Now, we know :-

Dispersive power (ω) = $\frac{\mu_V - \mu_Y}{\mu - 1}$

$\therefore \omega = \cancel{1.707\ 1.660}$

$\frac{1.6383 - 1.54}{\mu - 1}$

$\therefore \mu = \frac{\mu_V + \mu_Y}{2}$

$\therefore \omega = \frac{1.6383 - 1.54}{1.585 - 1}$

$\therefore \omega = \frac{1.6383 - 1.54}{0.585}$

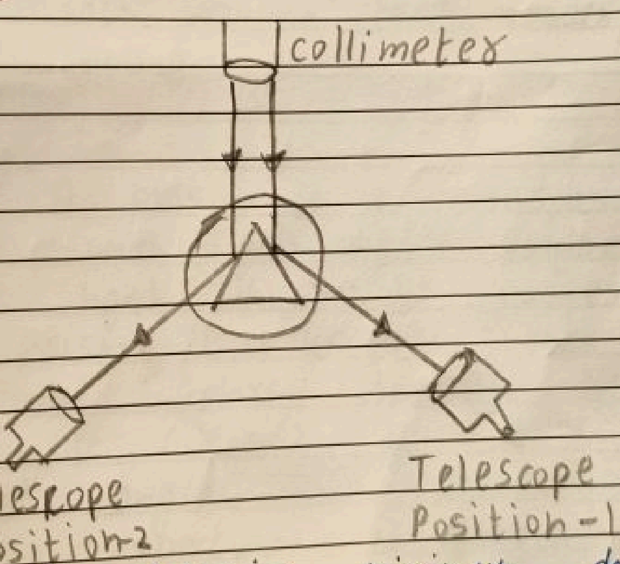
$\boxed{\omega = 0.167}$

- Praduxe :-

1. Finding the prism angle:

a. Place the prism on the prism table as depicted in the following figure.

b. See the ~~angle~~ images of the slit formed due both images at two different positions of thelescope (Positon-1 and Position-2).



2. Finding the following minimum derviation angle source of the light:

a. Move the spectrometer to get sharp and intense special lines. Do not disturb the focusing and alignment of the telescope.

b. Adjust the minimum deviation angle for the yellaw Spectral line and record both readigs.

c. Repeat (b) for other observed spectral lines and record the special

d. Remove the prim without both disturbing the primas table. More the telescoop to to get direct light from the colliqhat. Record both verniear ~~fussh~~ reading a ~~cite~~. direct reading.

- Theory:

A prism is a transparent optical element with flat, angled surfaces that refract light. when light passes through a prism, it is dispersed into its constituent colors because different wavelengths (colors) of light refract at different angles. This separation of light into a specturm is known as dispersion. The dispersive power of a prism is a measure of how effectively it can spead different colors of light apart.

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To adjust the spectrometer for accurate measurements using sodium using yellow light, start with leveling the telespoe by ensuring is horizontally aligned using the leveling screws and spirit level. the focus crosshairs for clarity: Next, level the collimator by adjusts its screws until it is hontrizatial and its light beam is ~~path~~ ~~palle~~ parallel to the optical axis. After that, medanically level the prism the table using its leveling screws and confirm its horizonal alignment with a spirit level.

Bangar
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