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DELTA Pg No.

Date / /

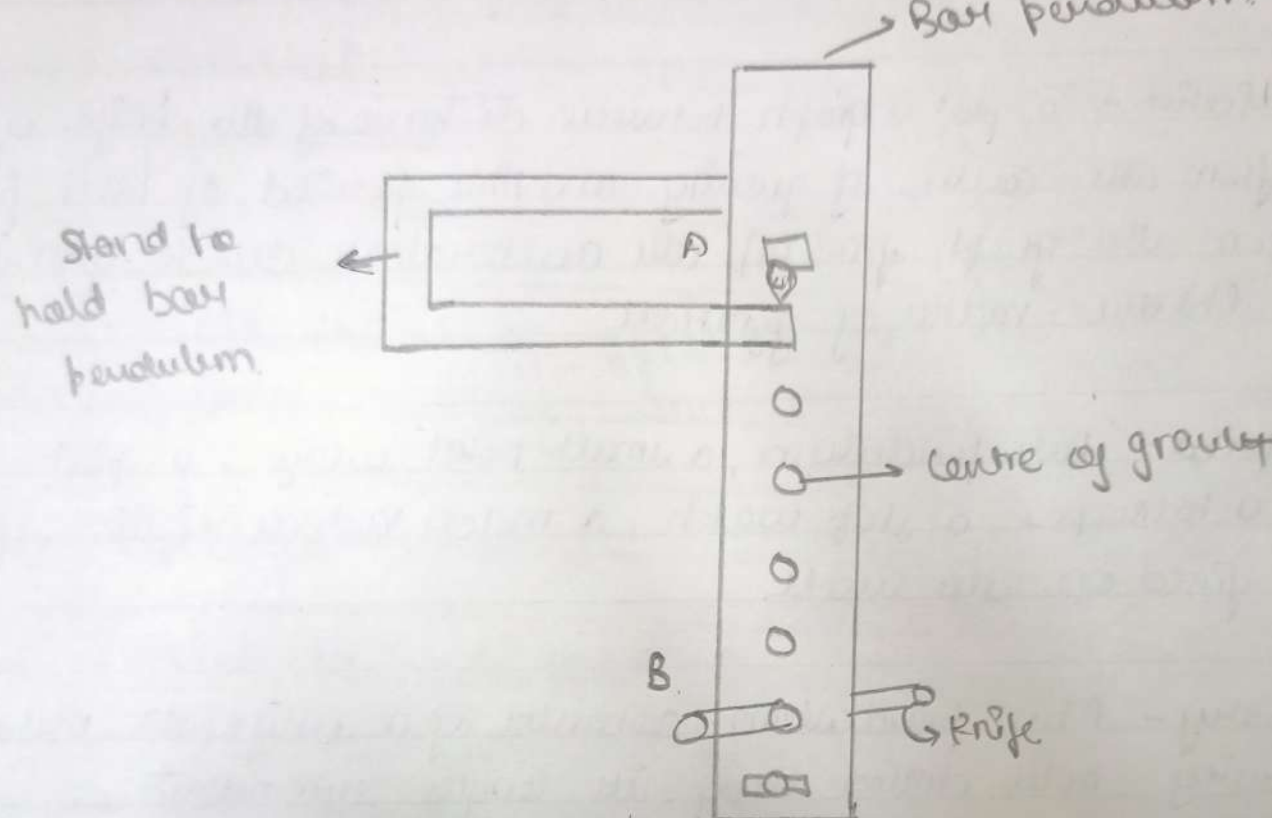
EXPERIMENT-1

Objective - To plot a graph between distance of the knife a edge from the centre of gravity and time period of bar pendulum. From the graph find (a) the acceleration due to gravity (b) the radius of gyration

Apparatus - Bar pendulum, a small metal wedge, a spirit-level a telescope, a stop watch, a meter rod, a rigid-support fixed on the wall.

Theory - A bar pendulum consists of a uniform metal-bar having holes drilled along its length symmetrically on either side of the centre of gravity at intervals of about 5cm. Two knife-edges are placed symmetrically with ~~step~~ respect to C.G as at A and B. The bar is allowed to oscillate about a horizontal knife-edge passing through each of holes in turn beginning with the nearest to one-end and the time period is noted in each-case. If a graph is plotted between the distance of the knife edge from the centre of gravity and the corresponding time period T. it has the shape shown in the figure.

It has a horizontal-line ABCDE is drawn, it cuts the graph in points ABD and E about which the time period is the same for A as the centre of suspension D is the centre of oscillation and for E as the centre of suspension, B is the centre of oscillation.



Bar pendulum
Stand to hold bar pendulum
A
Centre of gravity
B
Knife

Figure.

Date ______
Page ______

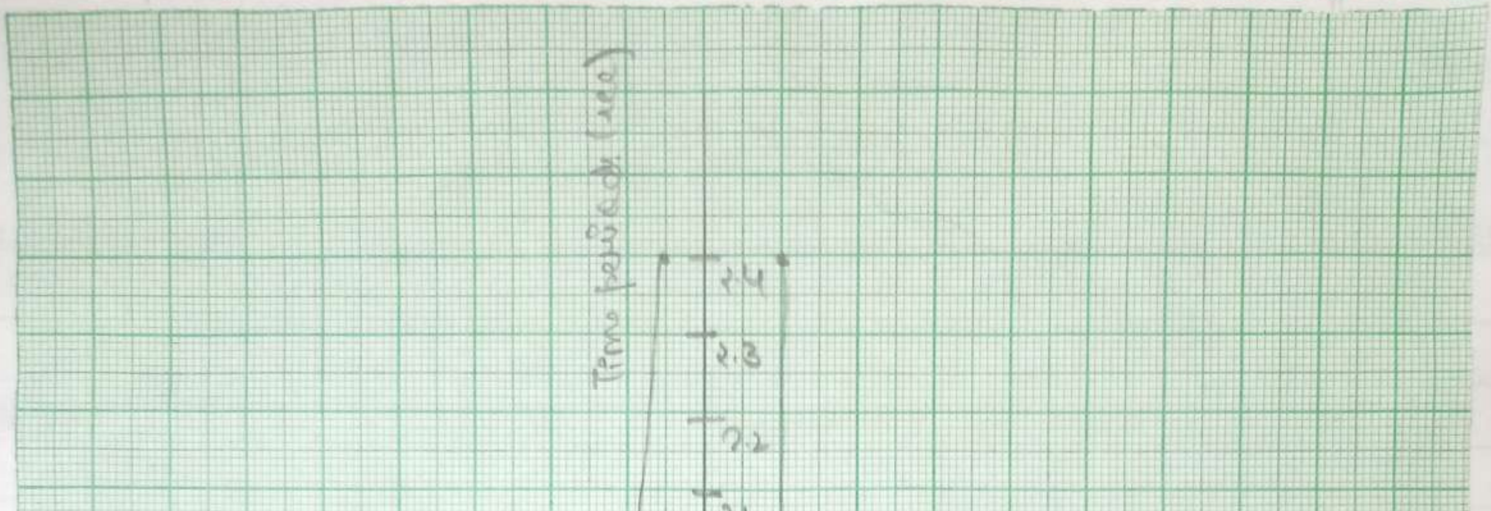
The distance AD and BE then give the length of the equivalent simple pendulum. If T is the corresponding time period, T_1

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \therefore g = \frac{4\pi^2 L}{T^2}$$

The radius of gyration, $K = \sqrt{l l_1}$
where $l = \frac{AE + CE}{2}$ and $l' = \frac{BC + CD}{2}$

Procedure

1. ~~Check/the/spirit level~~ Balance the bar on the sharp wedge mark it ~~G~~ at a.
2. Fix the knife edge in the outermost holes on either end of the bar parallel to each other with their sharp edges pointing towards a.
3. Check the spirit level that the glass plate o fixed on the rigid-bracket on plate a fixed on the rigid-balance on the wall are horizontal. Suspend the pendulum by placing the knife-edge on the side A perpendicular to the slot in the bracket and so that pendulum hangs vertically.
4. Adjust the eye-piece of the telescope so that the cross-wires are clearly visible through it. Focus the telescope on the bar from about one meter distance and see that the point of intersection of the cross wire coincides with the line AB or a



Calculations : From ABCD

(A) Acceleration due to gravity

$$L = \frac{AD+BC}{2} = \frac{0.60+0.60}{2} = 0.60m.$$

$T = 1.57$ sec

$$g = \frac{4\pi^2 L}{T^2} = \frac{4\times(3.14)^2\times 0.60}{(1.57)^2} = 9.6 ms^{-2}$$

(B) Radius of gyration K:

$$l = \frac{AC+CE}{2} = \frac{0.10m+0.10}{2} = 0.10m$$

$$l' = \frac{BC+CD}{2} = 0.70m.$$

$$K = \sqrt{ll'} = \sqrt{(0.10)(0.70)} = \sqrt{0.08} = 0.28m$$

From A'B'C'D'

(A) Acceleration due to gravity

$$L = \frac{A'D' + B'C'}{2} = \frac{0.64+0.64}{2} = 0.64m$$

$T = 1.63$ sec

$$g = \frac{4\pi^2 L}{T^2} = \frac{4\times(3.14)^2\times 0.64}{(1.63)^2} = 9.5 m$$

(B) Radius of gyration K:

$$l = \frac{A'C' + C'E'}{2} = \frac{0.40+0.40}{2}$$

$$l' = \frac{B'C' + C'D'}{2} = \frac{0.15+0.15}{2}$$

$$= 0.15m$$

$$K = \sqrt{ll'} = \sqrt{(0.49)(0.15)}$$

$$= \sqrt{0.07} = 0.27m$$

Result :- 1. The acceleration due to gravity $g = 9.6 ms^{-2}$

2. Radius of gyration, $K = 0.28m$

Date
Page

reference line drawn on the pendulum

5. Displace the bar slightly and release it. It will begin to vibrate. Note the time for 20 vibration and also measure the length from the point upto the bottom of the first hole i.e. upto the point about which the pendulum turns. Distance can also be measured from one end of the bar.
6. Suspend the pendulum on the knife-edge B side of the pendulum and take the observation
7. Now insert the knife-edge in hole 1,2,3 on either side of the C.G and note the time for 20 vibrations in each case and measure the corresponding distances from G.
8 Plot a curve between distance from C.G and the corresponding time period T. (time for one vibration)
9. Draw two horizontal line ABCDE and A'B'C'D'E' and not calculations.
10 Find the mass of pendulum to determine the inertia.

Precaution and sources of Error

1. The knife-edges should be horizontal and the bar pendulum should hang vertically.
2. Amplitude of vibration should be small.
3. The time of oscillation should be noted after 5 or 6 oscillations so that any irregularities of motion subside
4. Time should be noted with the help of a good ~~spot~~ stopwatch

Observation table:

	No.	Distance from (in cm)	Time for 20 vibration / sec.	Time period
For holes on side A.	1	45 cm	32.29	1.61
	2	40 cm	31.2	1.56
			30.94	1.547
	3	35 cm	30.94	1.52
	4	30 cm	30.57	1.52
	5	25 cm	30.44	1.57
	6	20 cm	31.44	1.64
	7	15 cm	32.55	1.89
	8	10 cm	37.97	
			37.97	2.4
	9	5 cm	48	
For holes on side B	1	45 cm	32.20	1.61
	2	40 cm	31.1	1.56
	3	35 cm	30.96	1.541
	4	30 cm	30.60	1.52
	5	25 cm	30.40	1.57
	6	20 cm	31.51	1.52
	7	15 cm	32.82	1.64
	8	10 cm	37.96	1.89
	9	5 cm	48.02	2.4

Least count of stop watch : 0.01 sec.

using a telescope

5. The knife edges should be sharp
6. The support shouldn't be jerky
7. Smooth and good-sized curve should be drawn

Weak-points - The result may be slightly inaccurate on account of

(i) The curvature of the knife edges
(ii) finite - amplitude of the swing
(iii) yielding of the support and
(iv) Resistance of air

Date
Page

20/01/21

EXPERIMENT-2

Aim- To determine the Planck's constant.

Apparatus- A vacuum type photoelectric-cell mounted inside a wooden box with a wide opening on the side opposite to the cathode, volt DC supply, a voltmeter (0-3 volt range) a rheostat, a sensitive moving coil galvanometer with lamp and scale arrangement, a key, a mercury lamp and few light filters.

Theory- When a photon of energy $h\nu$ is incident on the emissive surface of the cathode, almost all of its energy is transferred to the electron inside the metal. If this energy is greater than threshold energy w_0, the electron ~~[illegible]~~ is emitted. w_0 is called the work-function of the metal. Above the threshold energy frequency, corresponding to w_0, photoelectrons have a range of energies from 0 to a certain maximum value and this max increasing frequency. As w_0 remains constant for a given photoelectric-cell E_{max} varies linearly with frequency. In this experiment to find out the maximum kinetic-energy E_{max} of the emitted electron reverse bias the photoelectric-cell i.e. anode is made negative. It therefore repel the emitted electrons and the current decreases. The negative potential on the anode

★ CALCULATION : The graph between the frequency ν, along x-axis and the stopping potential V_s along Y axis is a straight line.

By formula

$$\boxed{V_s = \frac{h}{e}\nu - \frac{W_0}{e}}$$

slope is $\frac{h}{e}$

Hence,

Planck's constant (h);

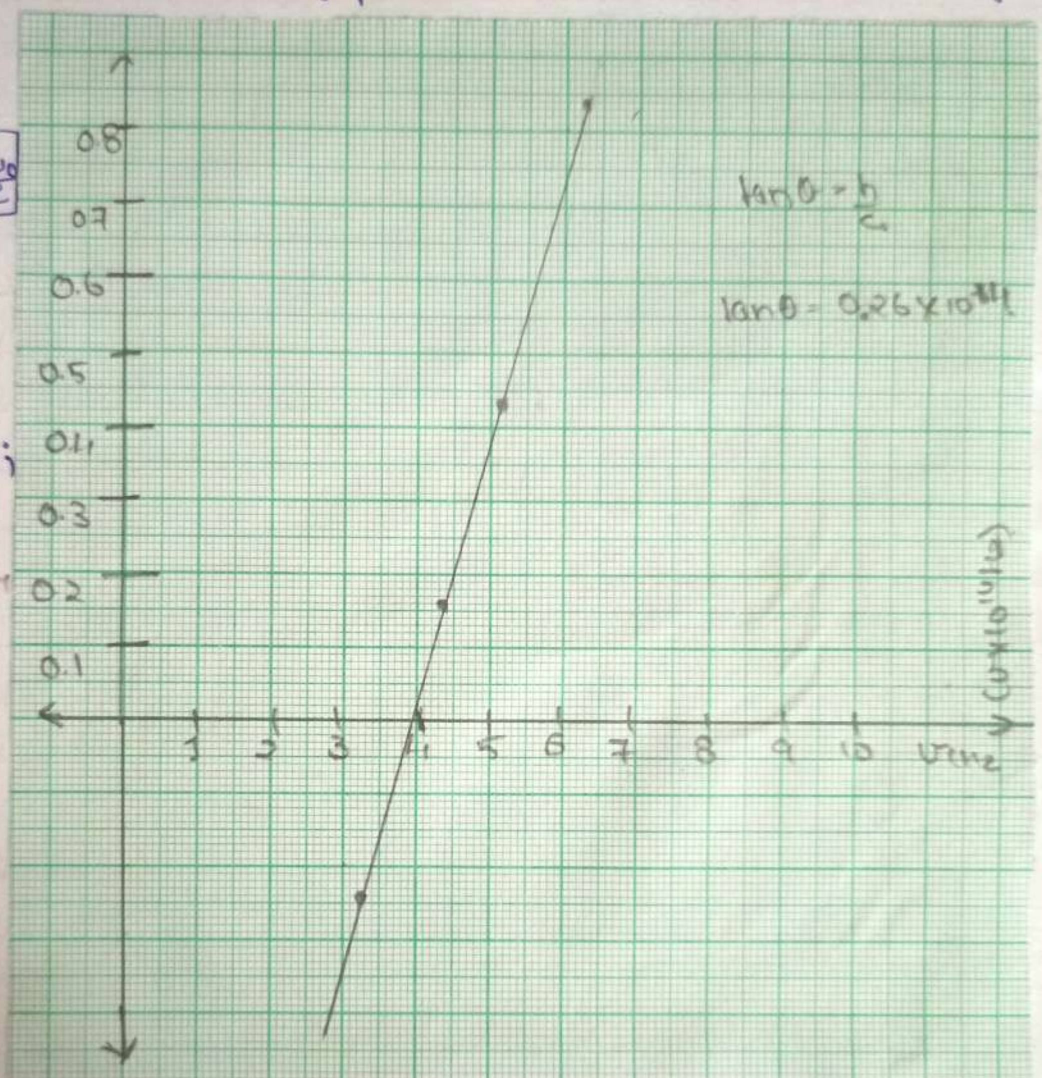
$$\boxed{h = \text{slope} \times e}$$

$h = 1.6 \times 10^{-19} \times 0.26 \times 10^{-14}$

$h = 4.16 \times 10^{-34}$ Js

Now,

Calculation of work function W_0 can be calculated with solving we did; solving them



$W_0 = e(\text{slope} \times \nu) - eV_s = e\,[(0.26 \times 10^{-14} \times 4.34 \times 10^{14}] - 0.185] = 0.9434$ eV.

• Result
- Planck's constant - 4.14×10^{-34} Js
- Actual value of planck's constant - 3.4×10^{-34} Js
- Work function of given photoelectric cell - 0.9434 eV
- Actual value of work function of given photocell - 1.61 eV

is slowly increased till the stopping potential vs is reached, when the current stops.

Formula used - $h\nu = \frac{1}{2} m v_m^2 + w_0$

$E_{max} + w_0$

This is called Einstein's ~~photoelectric~~ photoelectric equation when stopping potential is reached:-

$eV_s = E_{max}$. V_s is called the stopping potential or the cut off potential because it just stops the electrons from leaving the surface.

$h\nu = eV_s + w_0$ & $eV_s = h\nu - w_0$

& $V_s = \frac{h}{e} \nu - \frac{w_0}{e}$

Thus, if we draw a graph with frequency ν along the x-axis, it would be a straight line with slope equal to h/e and negative - intercept on y axis equal to w_0/e.

Procedure.

1. Make the connections as shown in figure. C and A are respectively the cathode and anode of the photocell.
2. Arrange the mercury lamp just in front of the photocell and set the galvanometer so that the spot moves freely.

Date ______
Page ______

(3) With no light falling on the photocell, insert the key in K, adjust the voltage in the voltmeter to zero and adjust spot in galvanometer to zero position. Remove the key.
(4) Fit the violet filter in front of the photocell
(5) Increase the potential on anode slowly by the rheostat. The deflection in the galvanometer decreases. Go on increase the negative potential applied to anode till the spot of light in the galvanometer comes back to zero position.
(6) Repeat the process and take three readings with the same filter.
(7) Change the filter one by one from violet to red and repeat the experiment
(8) Make a graph with frequency of the filter v along x-axis and stopping potential along y-axis

Precaution and sources of error
1 Care should be taken to ensure that when no-light is falling on the cathode, the deflection in the galvanometer is zero.
2. The position of the mercury lamp should not be changed during the experiment.
3. Care should be taken to note down the stopping potential. The voltage across the photocell should be increased very slowly and three-readings

should be taken. for each filter.

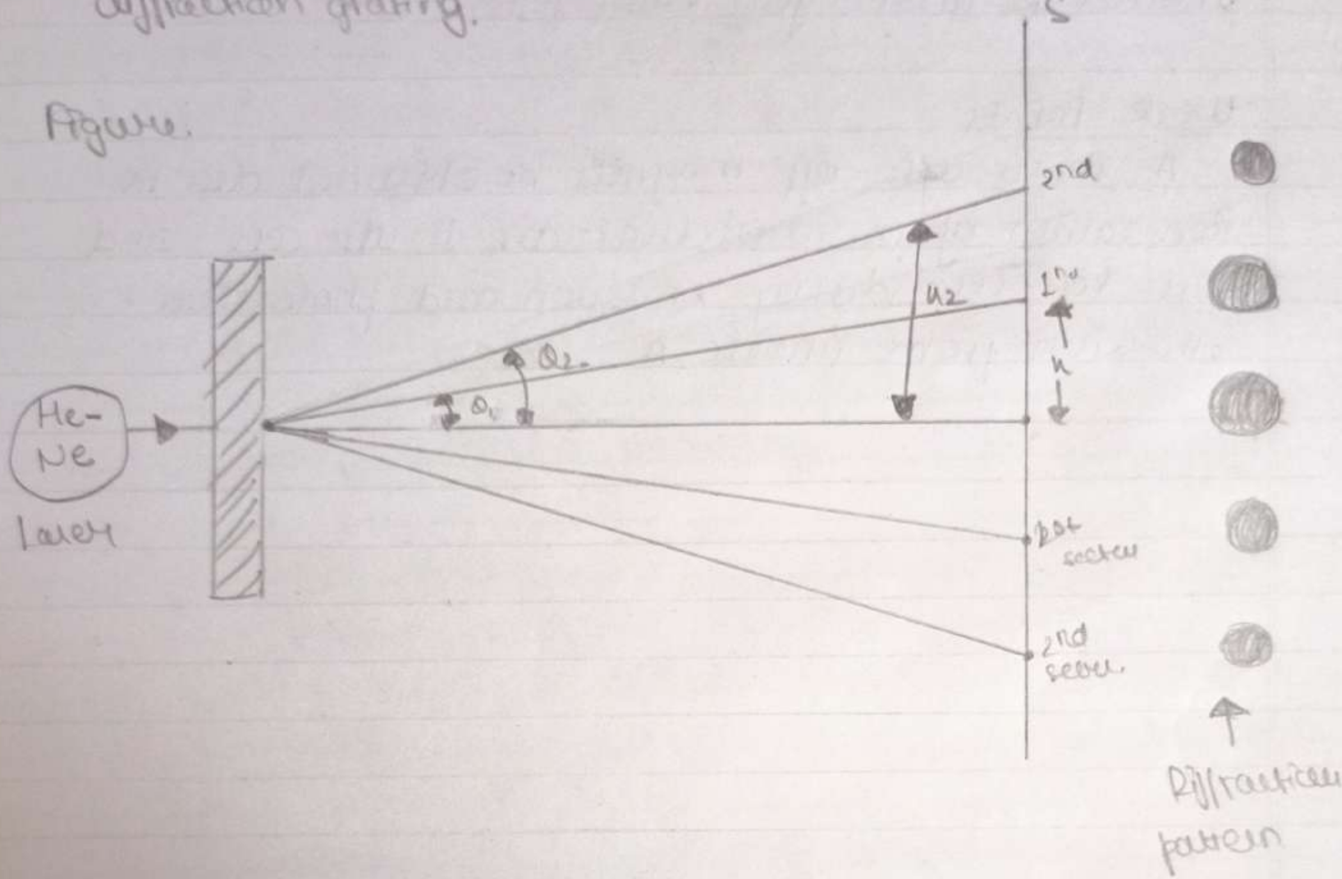
Weak - Points

A sharp cut - off may not be obtained due to ionisation of the residual air in the cell and due to secondary emission and photoelectric emission from anode A.

Aim:

To find the wavelength of He- Ne LASER source using transmission diffraction grating.

Figure.



27/01/21

Date ____
Page ____

EXPERIMENT - 3

Aim:

To find the wavelength of He-Ne LASER source using transmission diffraction grating.

Apparatus:

He-Ne Laser, Diffraction, Optical bench with four stands a screen with a graph paper pasted on it, metre scale and a travelling microscope

Formula used:

When a monochromatic beam of wavelength λ is diffracted by a diffraction grating, the n^{th} order principle maxima is formed at an angle θ_n given by

$$(a+b) \sin\theta_n = n\lambda$$

where $(a+b)$ is the grating constant and

$$\lambda = \frac{(a+b)\sin\theta_n}{n}$$

When laser light is incident on the diffraction grating and diffraction pattern is obtained on the screen formed by a graph paper, $\sin\theta_n$ can be obtained for different order maxima.

From fig. we have

$$\sin\theta_n = \frac{x_n}{\sqrt{L^2+x_n^2}} = \frac{x_n}{L} \text{ if } L >> x_n$$

Observations

Distance of screen from the grating "L" = 61.7cm

at N = 100 lines cm

Order of Diffraction (n)	Distance of Maxima from central upper (x_n) (cm)	$\sin\theta_n = \frac{x_n}{\sqrt{L^2+x_n^2}}$	λ (cm)
1.	4.8	0.291	7700
2.	9.8	0.256	7800
3	14.5	0. 228	7600
4.	19.6	0.302	7550

at N = 300 lines / cm

Order of Diffraction (n)	Distance of Maxima from central spot	$\sin\theta_n = \frac{x_n}{\sqrt{L^2+x_n^2}}$	λ (cm)
1	14	0. 221	7300
2	29.5	0.431	7190
3	59	0.537	7070

Mean = 7458 A°

Result :

The wavelength of He - Ne Laser light λ = 7458 A°

Actual Value = 6328 A°

% Error = 17%.

Date
Page

Precautions and sources of Error:

1. Do not see the laser source directly as it may cause damage to eye
2. The graph used at the screen should be vertically straight
3. The diffraction grating should be very near to the laser source

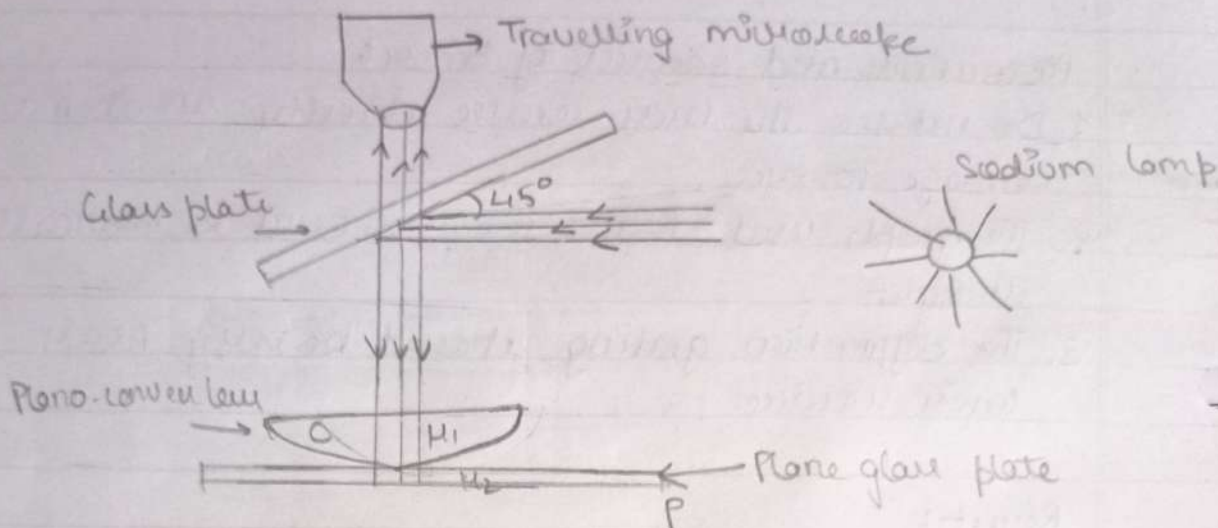
Result:

The wavelength of He-Ne laser light $\lambda = 7458 A^{\circ}$

Actual error = $6328 A^{\circ}$

% error = 17 %

• **Aim:** To determine the wavelength of sodium light by newton's rings



• **Observations table**

• Measurement of diameter of rings, Dn and D_n^2
• Vernier constant reading of microscope 0.01 mm.

S.NO	Number of bright fringes	Microscope reading with cross wire		Diameter of the ring x-y =Dn	(Dn)^2 (mm)^2
		On right x(mm)	On right y (mm)		
1	2	42.54	46.20	3.66	13.40
2	4	42.03	46.71	4.68	21.9
3	6	41.78	47.23	5.45	29.70
4	8	41.50	47.60	6.10	37.21
5	10	41.19	47.95	6.76	45.69
6.	12	40.90	48.25	7.35	54.02

03/02/2021

Date ______
Page ______

EXPERIMENT-4

Objective- To determine the wavelength of sodium light using newton's ring.

Apparatus- Newton's ring apparatus (i.e planoconvex lens) and an optically plane glass plate placed on a wooden stand having a plane glass plate, a travelling microscope, sodium lamp, a convex lens and a spherometer.

Theory- Newton's ring are formed as a result of interference between the waves reflected from the top and bottom of air-film surface formed between the lower convex surface and top of the plane P.

By proper analysis we will have following results

$$\boxed{\lambda = \frac{D^2_{n+m} - D^2_n}{4mR}}$$

where, D_{m+n} is the diameter of $(n+m)^{th}$ bright ~~ring~~, ring, D_n is diameter of n^{th} bright ring
R is radius of curvature of the curved surface of plano-convex lens.

- The radius of curvature R is calculated with the

★ Calculation:

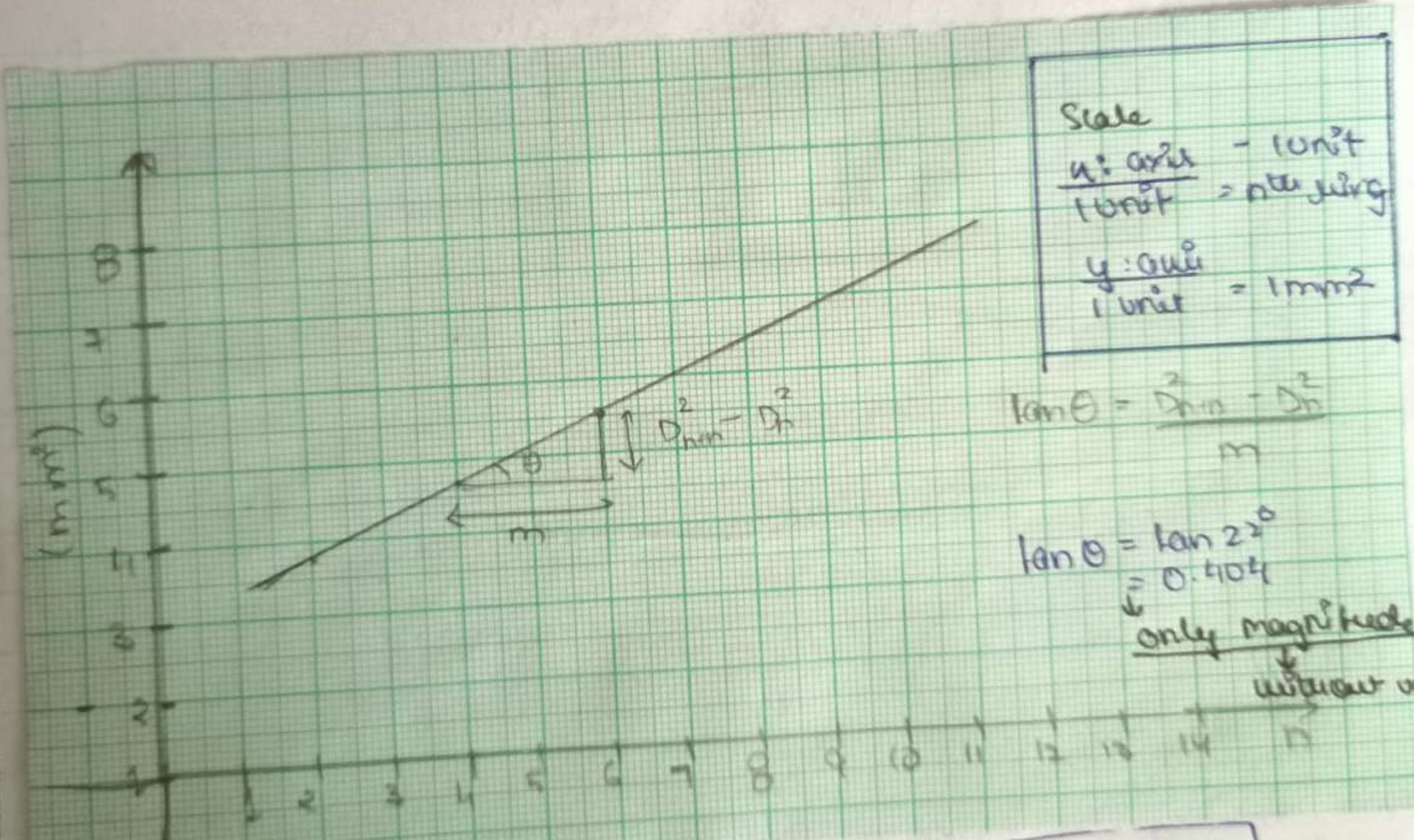
- The radius of the convex surface of the plano-convex lens is 170cm

- Wavelength by this method calculated equals the

$\lambda = \dfrac{D^2_{n+m} - D^2_n}{4mR}$ also $\tan\theta = \dfrac{(D^2_{n+m} - D^2_n)}{m}$ mm^2

$\therefore \lambda = \dfrac{\tan 22^\circ}{4R} = \dfrac{0.404 \times 10^{-6} m^2}{4 \times 170 \times 10^{-3} m} = 0.0005942 \times 10^{-3} = 594.2 \times 10^{-9} m$

$\boxed{\lambda = 594.2 nm}$



- Result
  - Wavelength of sodium light obtained $\boxed{594.2 nm}$
  - Actual wavelength of sodium light is $\boxed{589nm}$
  - Percentage error $= \left| \dfrac{594.2 - 589}{589} \right| \times 100 = \boxed{0.88\%}$

help of spherometer, i.e. using the formula as

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

where l is the distance between the outer legs of the spherometer & h is the elevation of tip of the central leg as compared to the outer legs when placed on the convex lens.

Precaution and source of error:

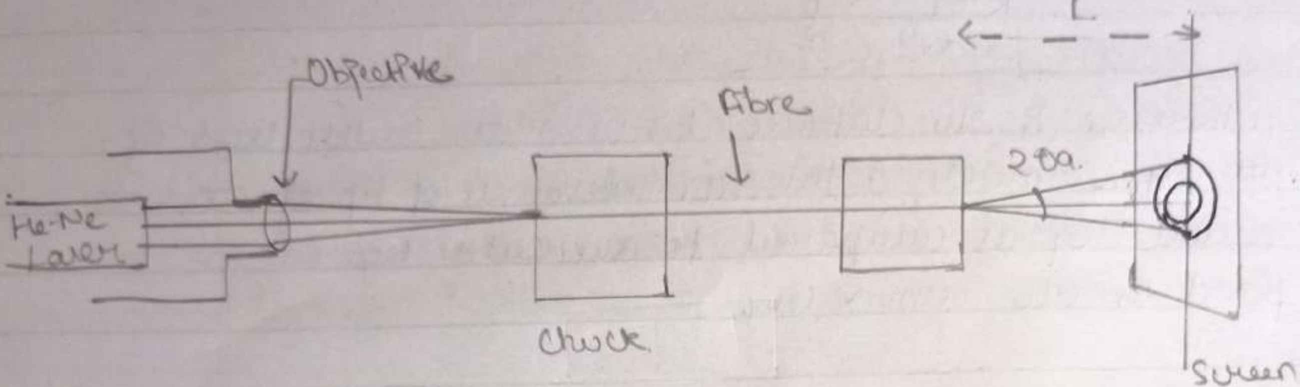
1. The surface of plano-convex lens and plane glass plate should be optically spherical and plane respectively.
2. The plano-convex lens and the glass plate should be cleaned.
3. The convex surface of the plano-convex lens should be large in aperture.
4. The sodium light should have an extended source
5. Before starting the measurement for diameter of the rings, slow motion of the microscope only in one direction should be ensured for whole range of observation only to avoid back lash error
6. Cross-wire should be adjusted on the bright fringes tangentially
7. The value of 'h' in the measurement of radius was measured

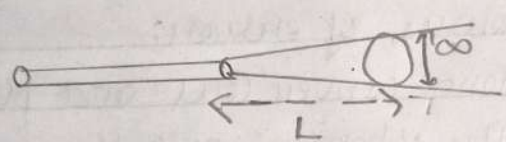
Result: • Wave length of sodium light obtained: $\boxed{594.2\ nm}$

• Percentage error: $\left|\frac{594.2 - 589}{589}\right| \times 100 = \boxed{0.88\%}$

· **Objective** To determine the numerical aperture (NA) of an optical fibre.

· **Setup**·





· **Observation**

S.NO	Distance betw output end of optical fibre and screen L (mm)	Diameter of circular spot D (mm)	$NA = \frac{D}{\sqrt{D^2+4L^2}}$
1	1.18	4	0.8613
2	2.66	8	0.8377
3	5.00	12	0.7682
4	6.80	16	0.7619
5	8.70	20	0.7544

Date
Page

14/02/2025

EXPERIMENT - 05

Objective - To determine the numerical aperture (NA) of an optical fibre.

Apparatus - Optical fibre, two fibre optic chucks, He-Ne laser a microscopic objective and a screen with a graph paper pasted on it.

Theory - Numerical aperature (NA) of the optical fibre is a measure of light gathering ability of the fibre and is an important parameter which determines the angle of the "light acceptance cone" at the input end of the fibre. The numerical aperture is ~~at~~ defined as the sine angle of the acceptance cone. It is given as

$$NA = \sin\theta_a = \sqrt{\mu_1^2 - \mu_c^2}$$

where, μ_f and μ_c are refractive indices of core and cladding respectively. Thus to determine the numerical aperture, the acceptance angle θ_a of the fibre should be known.

In case of experiment setup the numerical aperture can be calculated by the following formulae

$$\sin\theta = \frac{D/2}{\sqrt{(D/2)^2 + L^2}} = \frac{D}{\sqrt{D^2 + 4L^2}}$$

• Calculation

Mean value of NA = $\frac{0.8613 + 0.8327 + 0.7682 + 0.7619 + 0.7544}{5}$

$$NA = \frac{3.9785}{5} = \boxed{0.7957}$$

• Result

NUMERICAL APPERTURE OF GIVEN OPTICAL FIBRE:-

$\boxed{0.7957}$

Date
Page

where D is diameter of optical fibre by screen and L is distance between optical fibre and screen.

Precautions • Optical fibre should not bend when the light is being ~~it~~ propagated.

• Light should be coupled properly into the fibre so that a bright spot of light is obtained.

• Losses due to bending, leakage, dispersion etc should be minised.

• we should ensure accurate measurement of diameter of the spot.

• Optical fibre axis should be parallel to optical bench.

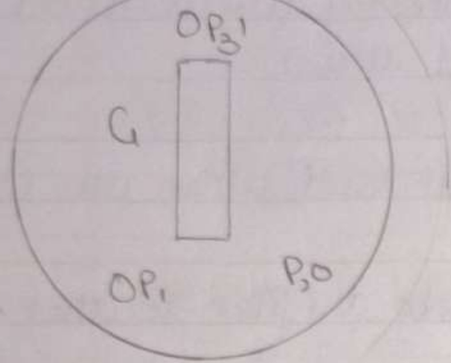
Sources of Error - There may be losses due to bending radiation and leakage, etc.

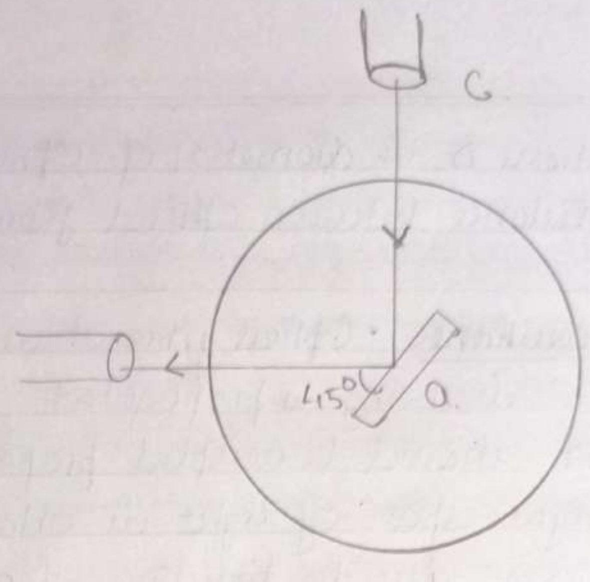
• The edges or ends of optical fibre might not be exactly sharply cut and the bright spot may not be exactly circular.

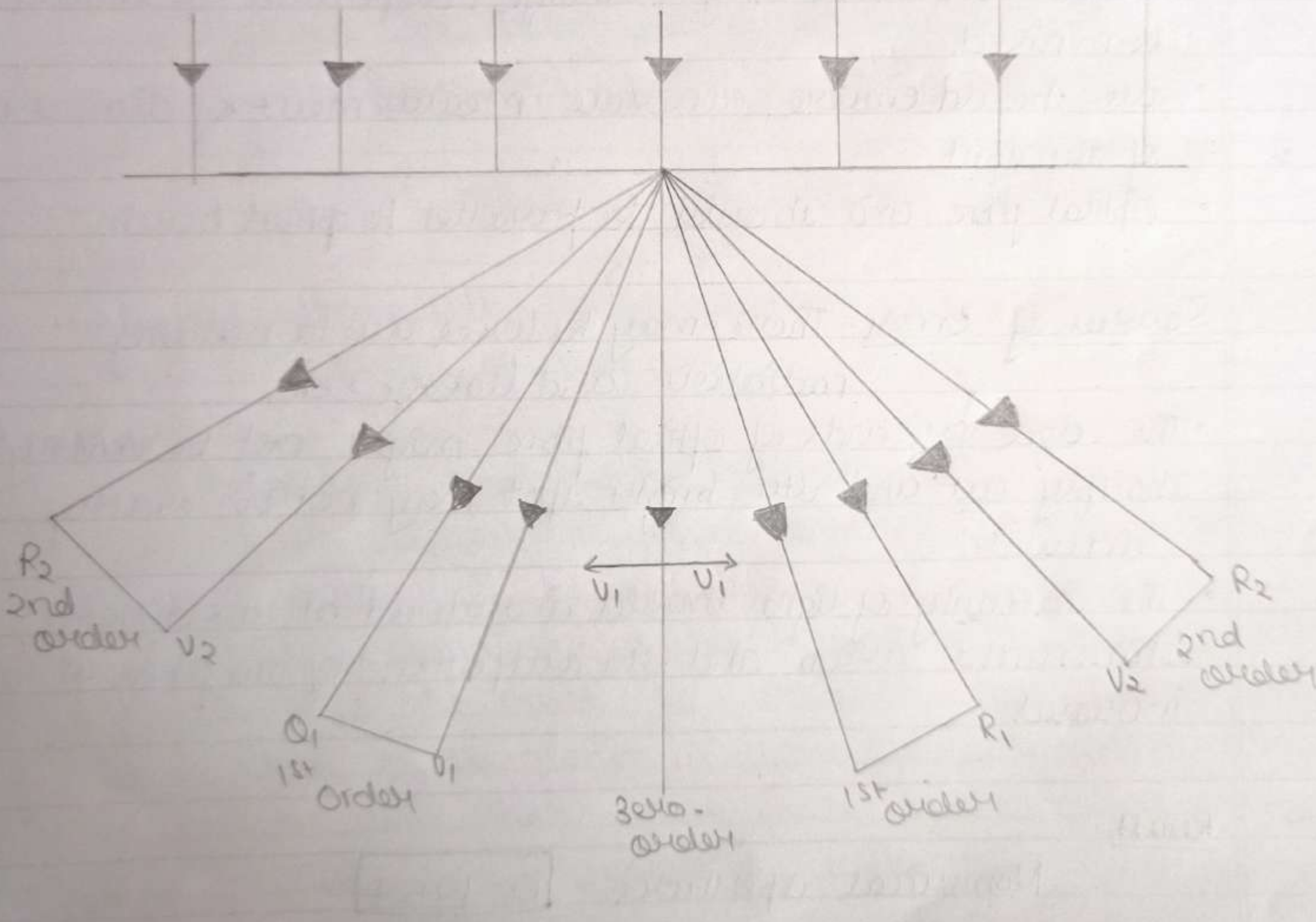
• The intensity of light should is reduced at the distance between the screen and the output end of the fibre is increased.

Result -

Numerical aperture = $\boxed{0.7957}$


OP3'
G
OP1
P2O


G
45°
O.


R2
2nd order
V2
Q1
1st order
V1
V1
V1
zero-order
1st order
R1
R2
V2
2nd order

EXPERIMENT - 6

Aim- To determine the wavelength of sodium light using diffraction-grating.

Apparatus- A plane diffraction-grating, spectrometer mercury-lamp, prism, spirit-level and magnifying glass.

Theory: The wavelength of any spectral-line can be calculated as:-

$$(a+b)\sin\theta = n\lambda \quad \therefore \lambda = \frac{(a+b)\sin\theta}{n}$$

where $a+b$ = grating-element, θ = angle of diffraction
n = order of spectrum.

Precautions and sources of error:-

1. All adjustments of spectrometer must be correctly done
2. The readings of the two grating must be vertical.
3. The light must be incident on the unruled-side of the grating. Otherwise refraction occurs at the thick-glass plate after diffraction and the angle measured will not correspond diffraction.
4. The grating should be as narrow as possible and parallel to the readings.

Observations & Calculations

Vernier constant of spectrometer = 1°

No° of lines per inch of grating N = 15000

Grating element $(a+b) = \frac{25.4}{5000} = 0.00169$ mm.

ORDER OF SPECTRUM	VSR Telescope L.H.S	Telescope R.H.S		Half - angular width, θ_n.	Average angle, θ_n.
0th Order	180°. 66° 364°	198.8° 359.86°	V_1 V_2	$\frac{2.58}{2} = 1.29$ $\frac{4.14}{2} = 2.07$	1.08
1st Order	156. 66° 333. 83°	1.90° 370. 66°	V_1 V_2	21.17 18. 66	19. 91

For 1st Order

$n = 1,\ \theta_n = 19.91,\ \sin\theta_n = 0.340,\ (a+b) = 0.00169$ mm.

$\lambda = (a+b)\sin\theta_n = 0.00189 \times 0.340$

$= 5755 Å$

Result - Mean value of $\lambda = 5755 Å$

DELTA Pg No.
Date / /

(5) The slit should be narrow as possible and parallel to the ruling of the grating.
(6) While reading of the telescope, the turntable should be clamped and vice-versa.
(7) Readings should be taken in both the vernier to eliminate the error due to non-coincidence of the centre of the graduated-scale with axis of rotation of the spectrometer.
(8) Light should be incident normally on the grating surface. Otherwise the angle of incidence would not be zero which is a condition for the derivation of the formula $(a+b)\sin\theta = n\lambda$. Further small change cause ~~a large~~ ~~error~~ in the angle of incidence cause a large error in the angle of diffraction.
(9) Apart from experimental errors, the grating itself may have following errors

(a) Error due to curvature and non-parallelism of the prism. of ~~the~~ the rulings

(b) The errors due to variation of the rulings

Observation & Calculation:-

vernier constant of spectrometer = 1°.

No. of lines per inch on grating, N = 15000

Grating element (a+b) = $\frac{25.4}{5000}$ = 0.00169 mm

ORDER OF SPECTRUM	USR Telescope L.H.S	Telescope R.H.S		Half angular width, θ_n	Average angle θ_n
0th Order	180.66° 364°	198.8° 359.86°	V_1 V_2	$\frac{2.58}{2}$ = 1.29 $\frac{4.14}{2}$ = 2.07	1.08
1st order	156.66° 333.83	199° 370.66°	V_1 V_2	21.17 18.66	19.91

For 1st Order:-

$n = 1$, $\theta_n = 19.91$, $\sin\theta_n = 0.340$, $(a+b) = 0.00169$ mm

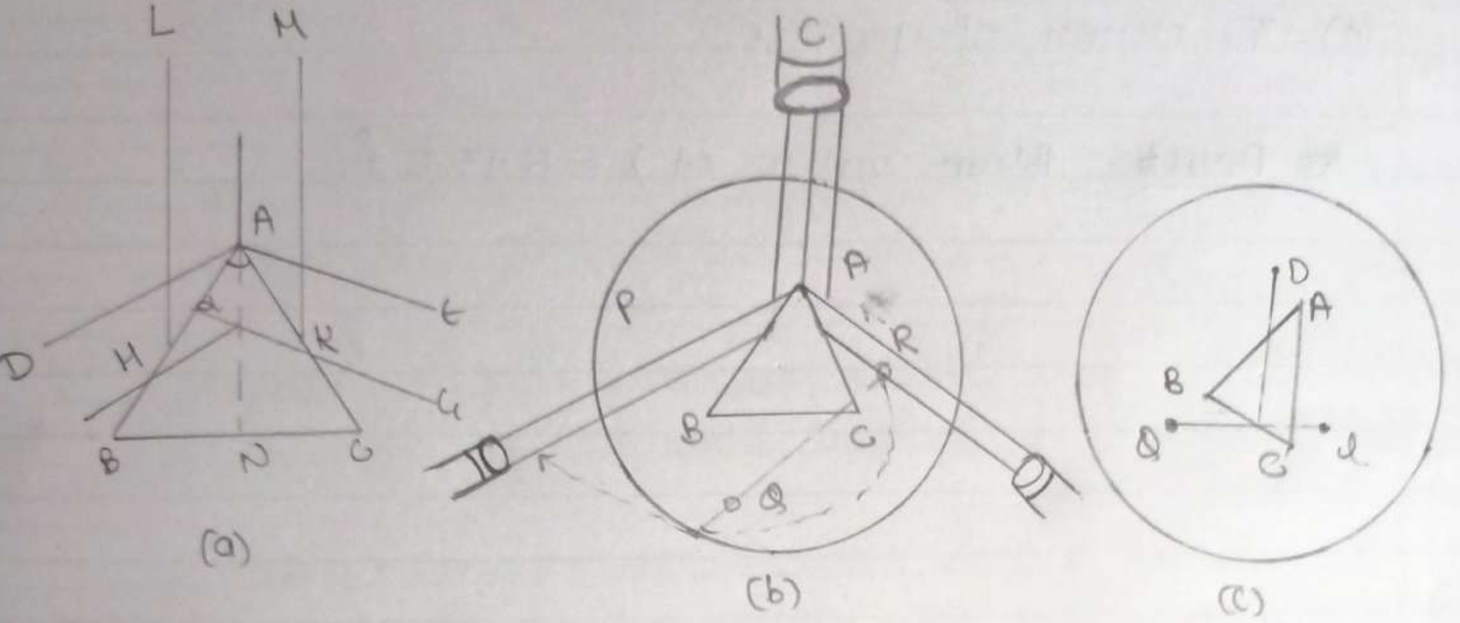
$\lambda = (a+b)\sin\theta_r = 0.00189 \times 0.340$

$= 5755$ Å

Result: Mean value of $\lambda = 5755$ Å.

(c) The errors of spacings.

~~Re~~ <u>Result</u>. Mean value of $\lambda = 5755$ Å.



(a) A parallel beam of light falling on the edge of prism (b) measuring angle of prism with spectrometer (C) Adjustment of the prism on the turn table.

DELTA Pg No.
Date / /

EXPERIMENT - 7

Aim. To determine the refractive - index of the material of the prism using spectrometer

Apparatus- A spectrometer, an electric-lamp, a glass prism, a magnifying, an electric lamp and a source of light.

Theory - Let a narrow parallel beam of light comming from the collimator fall on the edge A of prism. It gets partly reflected from the face AC. If we place a telescope with its axis parallel to KG or AE and image of the slit screen is seen in it, if we ~~knock~~ rotate the telescope so that it's axis lies parallel to HF or AD, the image of the slit will be seen again in it. The angle of prism A is equal to half angle ~~in it~~ θ through which the telescope is rotated i.e $\angle A = \frac{\theta}{2}$

Formula used- If Dm is the angle of minimum- deviation of a ray refracted through a prism, the refractive - index of the material of the prism is

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

Precautions - ① In finding the angle of the prism, the prism -

Observation

Value of circular-scale division

Vernier - constant of the spectrometer = 30"

S.NO.	Vernier scale-reading M.S.R + (V.S.R×LC)		Difference 2θ (Degree)	Mean 2θav (Degree)	Prism angle $A = \frac{2\theta}{2n}$ (degree
	Telescope on LHS (light through left face of prism	Telescope on R.H.S (light through light face of prism			
(•)	$V_1 = 98.33$ $V_2 = 278.38$ $= 360 - 278.38$ $= 81.62$	$V_1 = 218.95$ $V_2 = 38.38$	$\theta_1 = 120.12$ $\theta_2 = 120$	$\theta_{av} = 120.06$	$A = 60.03$.

Angle of minimum Deviation (δm)

Line	Vernier-scale reading M.S.R + V.S.R × L.C		Difference θav (degree)	Refractive index for different colour (μ)
	For minimum deviation-ray V_1	For direct-ray V_1		
Violet	132.5	183.59	51.19	1.650
Indigo	133.375	183.69	50.315	1.6414
Blue	134.35	183.69	49.34	1.6316
Green	135.0833	183.69	48.6067	1.624
Yellow	135.42	183.69	48.27	1.620
Orange	135.5833	183.69	48.1067	1.619
RED	135.75	183.69	47.94.	1.617.

DELTA Pg No.
Date / /

(2) If vernier pass in the zero of the scale or telescope is coated, this face should be taken into account in determining the angle turned.

(3) Eyepiece should be adjusted so that the cross-wire are clearly visible.

(4) Ensure that the plane of the prism-table is horizontal and axes of the telescope and collimator lie in the same horizontal plane.

(5) The slit of the collimator should be narrow and adjust its position w.r.t the collimator-lens so that the image of the slit is sharply focussed.

(6) Both the vernier-scales should be read to ~~avoid~~ avoid error due to eccentricity.

(7) The telescope should be focused for infinity and collimator is adjusted to give a parallel-beam of light.

Sources of error-

(1) Backlash - error may arise during rotation of telescope or prism-table.

(2) Axes of telescope and collimator mayn't lie in the same horizontal-plane

(3) The telescope mayn't be properly set for infinity

(4) The prism-table mayn't be exactly horizontal

Calculation-

Angle of deviation for violet = 51.19

$$\mu_{violet} = \frac{\sin\left(\frac{A+\delta_v}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60+51.19}{2}\right)}{\sin(30^\circ)} = \frac{0.82}{0.50} = 1.64$$

$$\text{Percentage - error} = \frac{1.65-1.64}{1.64} \times 100 = 0.6\%$$

Refractive index (standard-value) of the material of given-prism from table $= \frac{\mu_v + \mu_R}{2}$

$$= \frac{1.650+1.617}{2} = 1.6335.$$

DELTA Pg No.
Date / /

Experiment - 8

Aim- To determine the dispersive - power of the prism using spectrometer and measuring - source

Apparatus- Spectrometer, prism, a spirit-level a magnifying-lens, mercury - lamp and sodium - lamp

Theory- The angular dispersion is defined as the produced in the extreme - colours of the spectrum.

If D_r and D_v are the deviation for violet and red-colours respectively, then angular - dispersion $\alpha = D_v - D_r$

$= (\mu_v - 1) A - (\mu_r - 1) A = (\mu_v - \mu_r) A.$

where μ_v and μ_r are the refractive indices of violet and red- light, A is the angle of prism.

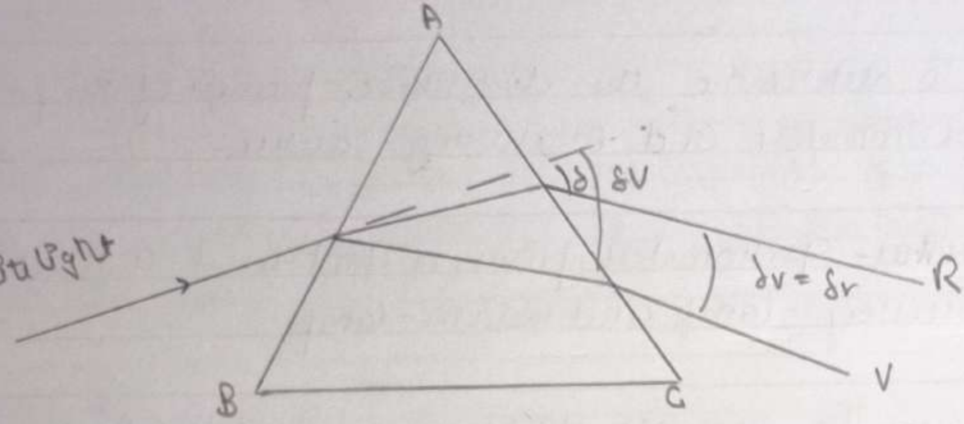
The mean- deviation is the deviation produced for the mean - colour for the spectrum. The mean colour is generally taken as the yellow - colour.

Mean deviation $= (\mu_y - 1) A$

where μ_y is the refractive index of yellow - light. The dispersive power of the material of the prism is defined as the ratio of angular - dispersion to mean deviation.

Dispersive - power $\omega = \dfrac{(\mu_v - \mu_r) A}{(\mu_y - 1) A}$

Aim- To determine the dispersive - power of the prism using spectrometer and mercury source.



Dispersive power.

DELTA Pg No.
Date / /

$$= \frac{\mu_v - \mu_r}{(\mu_r - 1)}$$

The dispersive power ~~μ~~ $= \omega$ depends upon the nature of the ~~material~~ material of the prism and is independent of ~~the~~ prism

Precaution -

1. In finding the angle of prism, the prism-table should be kept throughout
2. If vernier pass the zero of the scale as the telescope is rotated, this fact should be taken in account in determining the angle turned.
3. Eyepiece should be adjusted so that the cross wire are clearly visible
4. Ensure that the plane of the prism table is horizontal and the axes of the telescope and collimator lie in same horizontal plane.
5. The slit of the collimator should be narrow and adjust its position w.r.t the collimator - lens so that the lens image of the slit is sharply focused
6. Both vernier - scale should be read to avoid errors due to eccentricity
7. The telescope should be focused for infinity and collimator is adjusted to give a parallel - beam of light.

Observation - Vernier - constant of spectrometer = Angle of prism, A.

S.NO.	Reading of the vernier V_1			Reading of vernier V_2		
	For position of telescope through		Difference (θ)	For position of telescope through		Difference (θ)
	First-face	Second-face		First-face	Second face	
1	98.33	218.45	120.12	81.02	38.38	120.
2	—	—	—	—	—	—
3	—	—	—	—	—	—

Mean - value of θ = 120.06.

Angle of prism, $A = \theta/2 = 60.03$.

Angle of minimum - deviation

S.NO.	Line	Vernier-reading	Minimum - deviation ray	Direct Ray	Difference D_m
1.	Violet	—	132.5	183.59	Mean DV = 51.19
2.	Yellow	—	135.92	183.69	Mean DY = 48.27
3.	Red	—	135.75	183.69	Mean Dr = 47.94

DELTA Pg No.
Date / /

Source of error:-

1. Back lash error may arise during rotation of telescope or prism-table.
2. Axes of telescope and collimator mayn't be in the same horizontal plane.
3. The telescope mayn't be properly set for infinity.
4. The prism-table ~~stand~~ mayn't be exactly horizontal.

Calculation :- $\mu = \dfrac{\sin\left(\frac{A+Dm}{2}\right)}{\sin(A/2)}$

$$\mu_v = \frac{\sin\left(\frac{60.03+51.19}{2}\right)}{\sin(60.03/2)} = \frac{\sin(55.61)}{\sin(30.015)} = \frac{0.8252}{0.5}$$
$$= 1.6504.$$

$$\mu_r = \frac{\sin\left(\frac{60.03+48.27}{2}\right)}{\sin(0.03/2)} = 1.62$$

Dispersive power $\omega = \dfrac{\mu_v - \mu_r}{\mu_y - 1}$

$$= \frac{1.6504 - 1.616}{1.62 - 1} = \frac{0.0344}{0.02} = 0.05548.$$

Dispersive power of material of prism $= 0.05548$.

DELTA Pg No.
Date / /

Innovative - Experiment - 1

Aim - To determine the cauchy's constant of the given - prism

Apparatus - Spectrometer prism, prism - clamp, magnifying glass, mercury vapour lamp etc.

Theory - Cauchy's equation is an imperical relationship between the refractive index and wavelength of light for a particular transparent material. The most general form of cauchy's equation is

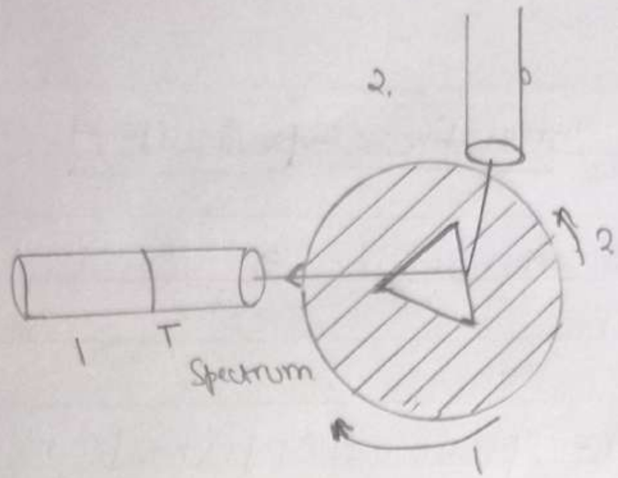
$$n(\lambda) = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \text{---} \quad (1)$$

where n is refractive index, λ is the wavelength, B, C, D etc are coefficient that can be determined for a material by fitting the eq^n to be measured refractive indices at known - wavelength.

The refractive index of n of the material of the prism for a wavelength λ is

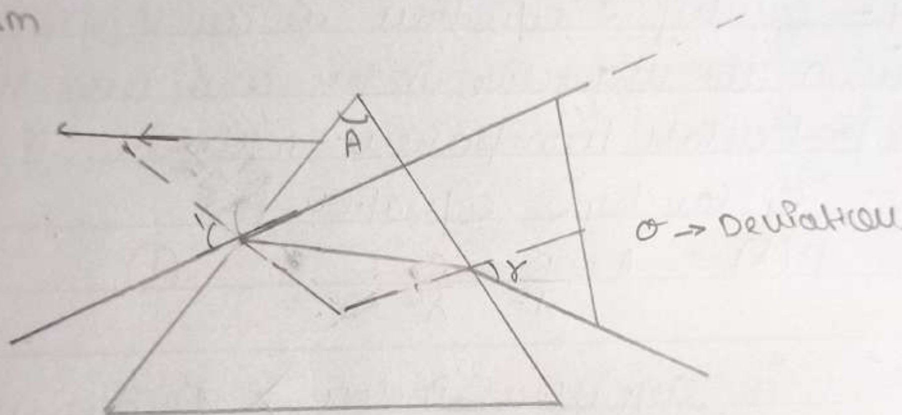
$$n = A + \frac{B}{\lambda^2} \quad \text{---} \quad (2)$$

where A & B are called cauchy's constant for prism. If refractive - index n_1 & n_2 for any two wavelength λ_1 and λ_2 are determined by spectrometer the cauchy's constant A and B can be calculated



Top view of the setup.

Angle of prism

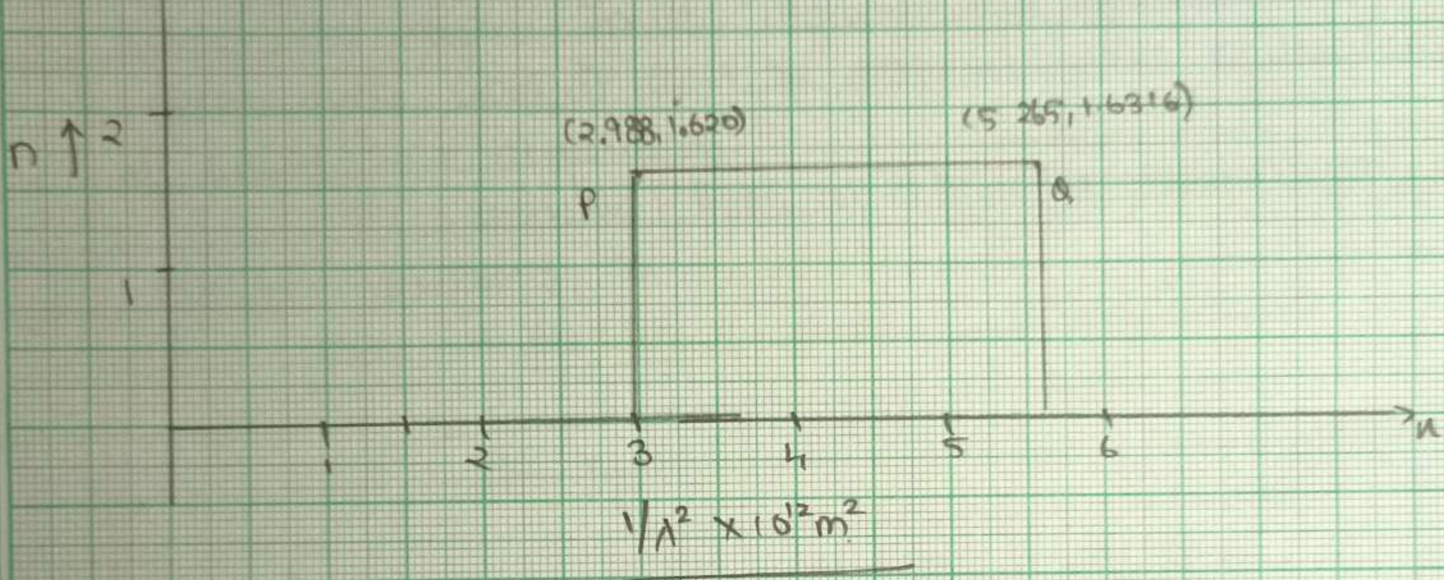


Prism

Scale: x-axis : 2 units = 1 m^2
y-axis : 2 units : 1 unit of R-I

Yellow → 2.988 → $1/\lambda^2$

Blue → 5.265 → $1/\lambda^2$



DELTA Pg No.
Date / /

from the above eqn. In particular, the equation is valid for region of normal-dispersion in the visible wavelength region. In the infrared the eqn becomes inaccurate, and it can't be representative of regions of anomalous dispersion.

The refractive-index at different wavelength can be calculated as:-

$$\mu = \frac{\sin\frac{A_0 + D_m}{2}}{\sin\frac{A_0}{2}}$$

A_0 is the angle of prism and D_m is the angle of minimum deviation of prism.

~~Precaution~~ Precautions- ① Care ~~of~~ should be taken to ensure proper setting of the spectrometer.

② It should be ensured that the setting of the telescope and collimator aren't touched during the course of taking various readings

Sources of error-

① The slit should be sharp and vertical

② The refractive-surfaces of the prism shouldn't be touched with fingers

③ The position of angle of minimum-deviation should be accurately determined

Pair of colours	$\lambda_1 \times 10^{-9}$ m	$\lambda_2 \times 10^{-9}$ m	n_1	n_2	A	B
Yellow & Blue	580	436	1.620	1.6316	1.620	9.48×10^{-3}
Green & violet	546	405	1.624	1.650	1.620	5.03×10^{-3}

Calculation - B is the slope of graph.

For B, after plotting graph, according to values,

For 1st pair of light, yellow & blue

$$B = \frac{1.050 - 1.024}{6.103 - 3.353} = \frac{0.026}{2.75} = 9.43 \times 10^{-3} = B$$

$n = A + \frac{B}{\lambda^2}$, $A = 1.620$ as $\frac{B}{\lambda^2}$ is too small

For 2nd pair of light green & violet

$$B = \frac{1.6316 - 1.620}{5.265 - 2.988} = \frac{0.0116}{2.277}$$

$$= 5.09 \times 10^{-3}$$

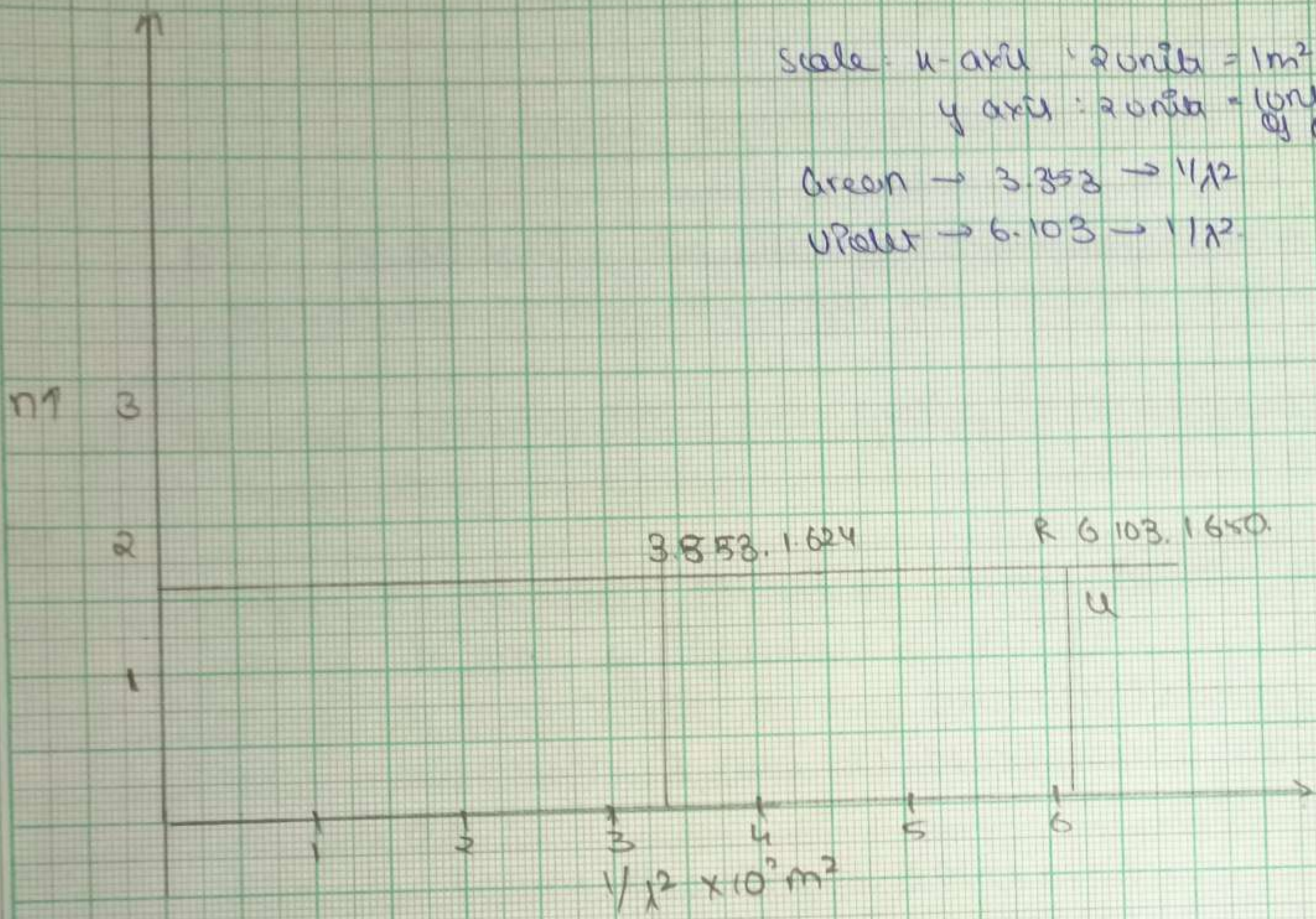
$n = A + \frac{B}{\lambda^2}$, $A = 1.620$ as $\frac{B}{\lambda^2}$ is too small.

PAGE NO. : DATE : SIGNATURE :

Scale: u-axis : 2 units = 1 m²
y axis : 2 units = unit of 0.1

Green → 3.853 → 1/λ²

Violet → 6.103 → 1/λ²



DELTA Pg No.
Date / /

Innovative Experiment - 2

Aim - To determine the dispersive power of a plane transmission grating arranged for normal incidence.

Apparatus - Spectrometer, given grating, mercury vapour lamp etc.

Principle - The dispersive power of grating is the ratio of change in angle of diffraction to the corresponding change in wavelength of any two neighbouring lines. Let 2 wavelength λ and $d\lambda$ be diffracted through θ and $d\theta$.

Dispersive power of grating $= d\theta/d\lambda$

For a grating for normal incidence,

$$\sin\theta = N\lambda n \quad \text{--- (1)}$$

where θ is the angle of diffraction, n is order of spectrum, N is the no. of lines per unit length and λ is the wavelength of light.

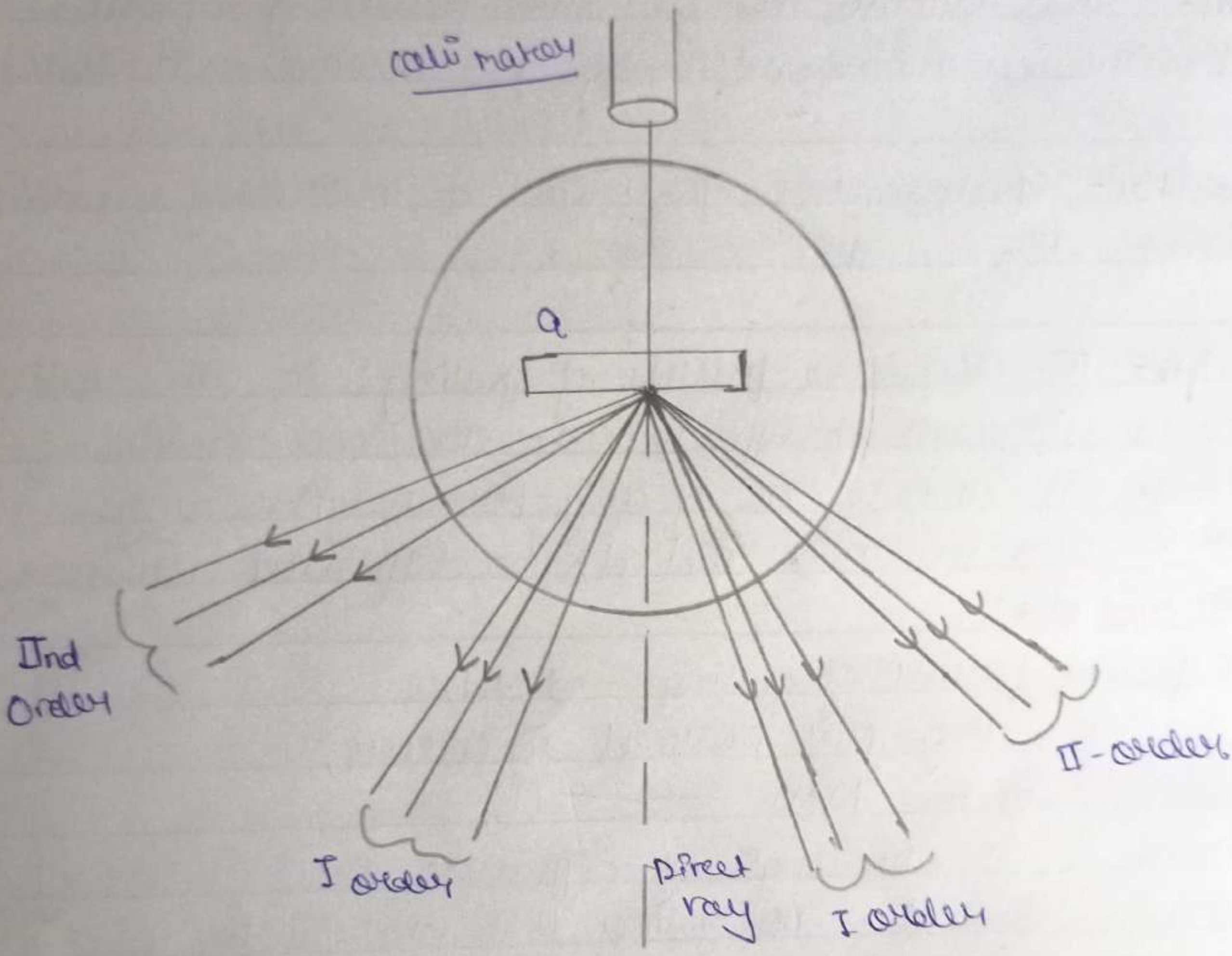
~~Differentiating~~ Differentiating, $\cos\theta\, d\theta = N d\lambda n$

$$\frac{d\theta}{d\lambda} = \frac{Nn}{\cos\theta}$$

Result -

(1) Mean dispersive power of grating in violet region = 636.94 degree/m

Aim - To find the diffraction for a grating.



DELTA	Pg No.
Date	/ /

(2) Mean dispersive - power of grating in yellow - region
= 636.94 degree /m.

Precautions -

(1) Care should be taken to ensure proper setting of the spectrometer and other settings of the telescope and the collimator aren't touched during the course of taking the various readings

(2) The position of the grating adjusted to be normal to the incoming - light from collimator should n't be disturbed.

(3) It is necessary to point the slit toward the brightest - part of the source in order to obtain reasonable intensity of the lines of different - colours especially in high order spectra reduces sharply with decrease in order.

Observation & Calculation

Vernier constant of spectrometer = 10

No. of lines per inch on grating, N = 15000.

Grating element $(a+b) = \frac{25.4}{15000} = 0.00169\,mm$

ORDER OF SPECTRUM	USR Telescope LHS	Telescope RHS		Half angular width , θ_n	Average angle θ_n
0^{th} Order	180.66°	198.8°	V_1	$\frac{2.58}{2} = 1.29$	1.08.
	364°	359.86°	V_2	$\frac{4.14}{2} = 2.07$	
	156.66°	199	V_1	21.17	19.91
1st Order	333.83°	370.66°	V_2	18.66	

Calculation $(a+b)\sin\theta = n\lambda$

$$(a+b)\cos\theta = n\frac{d\lambda}{d\theta} \Rightarrow \frac{d\theta}{d\lambda} = \frac{n}{(a+b)\cos\theta}$$

For $n=0$, $\frac{d\theta}{d\lambda} = 0$

For $n=1$, $\frac{d\theta}{d\lambda} = \frac{1}{(a+b)\cos\theta}$

$$= \frac{1}{(a+b)\cos(20.8)}$$

$$= \frac{1}{0.00169 \times 0.934825}$$

$$= \frac{1}{0.00157} = 636.942675159$$

Result - Dispersive power of grating is 636 94 degree / m.