Date: July-1-2020
Experiment-1

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CSE 4.

DIFRACTION GRATING-MINIMUM DEVIATION

Aim: Determination of wavelength of light by using plane diffraction grating - minimum deviation method.

Apparatus: Plane diffraction grating, spectometer, reading lens and mercury vapour lamp.

Formula:

$$\lambda = \frac{2 \sin\left(\frac{D}{2}\right)}{Nn} \text{ cm}$$

where, D is the angle of minimum deviation.
n is the order of the spectrum.
N is the number of lines per cm.

Procedure:

(1) Switch the mercury lamp.

(2) Focus the telescope towards a distant object. Adjust rack and pinion screw to get clear and sharp images.

(3) Adjust the rack and pinion screw of the collimator and micrometer screw to get sharp and narrow slit.

(4) Main scale and vernier scale are adjusted for direct reading, i.e -0-0 and 0-180 on vernier 1 and vernier 2 respectively.

(5) The levelling screws of grating table are adjusted with the help of spirit level to make it horizontal.

(6) Grating is kept on its stand so that the incident light with the help of spirit level to make falls approximately normal to the grating.

Observations :-

Least count of spectrometer = $\frac{\text{Value of 1 M.S.D}}{\text{No. of divisions on V.S.}}$

Calculations

Green $x_1 = 344°18'$

$x_3 = 164°14'$

$$\text{Mean} = \frac{(x_1 \sim x_2) + (x_3 \sim x_4)}{2} = 2D$$

$$2D = \frac{(376° - 344°18') + (196°26' - 164°14')}{2}$$

$$2D = \frac{31°1' + 32°12'}{2} = 32°6'30''$$

$2D = 32°6'30''$

$D = 16°3'15''$

$$\lambda = \frac{2\sin(D/2)}{N(n)} = \frac{2 \times 0.13964178}{5118.110(1)} = 5456.75Å$$

$$\boxed{\lambda = 5456.75Å}$$

% Error, λ for green

$$\%\ \text{error} = \frac{5461 - 5456}{5461} \times 100 = \frac{5}{5461} \times 100 = 0.091\%$$

$$\boxed{\therefore \text{for green } \lambda = 5456.765Å \ \& \ \%\ \text{Error} = 0.091\%}$$

Violet :

$x_1 = 167°38'$ $x_3 = 347°2'$

$x_2 = 192°35'$ $x_4 = 372°41'$

$$\text{Mean} = \frac{(x_1 \sim x_2) + (x_3 \sim x_4)}{2} = 2D.$$

(7) Rotate the telescope towards the left untill the spectral lines whose wavelengths are to be determined is approximately in the center of the field of view.

(8) Rotate the grafting table in the same direction (towards left). You will notice that the spectral lines also rotate in the same direction first and then in the opposite direction (towards right) for a short distance and then on further rotation of the grating, the line moves in the same direction (towards left)

(9) Set and lock the grating table at the point of reversal which is callect as position of minimum deviation.

(10) Set the cross wire of telescope at one of the spectral lines by fine adjustment.

(11) Note the reading on vernier 1 and vernier (2) (left)

(12) Repeat the procedure on right side also.

(13) Take the difference of left and right reading of vernier 1 and vernier 2. This will give the value of 2θ.

(14) Take the average of 2θ and find θ.

(15) use the formula to find wavelength (λ) of desired spectral line.

Precautions:

(1) The initial arrangement of the spectrometer should

$$= \frac{(192°35' - 167°38') + (372°41' + 347°2')}{2}$$

$$2D = \frac{24°57' + 24°20'}{2} = \frac{48°79'}{2}$$

$$D = 12°19'15''$$

$$\lambda = \frac{2\sin(D/2)}{N(n)} = \frac{2 \times 0.104528463}{5118.110(1)} = \frac{0.20905}{5118.110} \text{ cm}$$

$$\boxed{\lambda = 4084.645 \text{Å}}$$

$$\% \text{ error} = \frac{4084 - 4078}{4084} \times 100 = \frac{6}{4084} \times 100 = 0.147\%$$

$$\boxed{\therefore \text{ for violet } \lambda = 4084\text{Å} \quad \& \quad \% \text{ error} = 0.147\%}$$

__Observations:__

Least count of spectrometer $= \frac{\text{value of 1 MSD}}{\text{no. of divisions on V.S.}}$

$$= \frac{30}{30} = 1'$$

No. of lines per cm on the grating (N) =

15000 $\longrightarrow$ 2.54 cm

? $\longrightarrow$ 1 cm

$$= \frac{15000}{2.54} = 5118 \text{ lines/cm.}$$

Observation table

Order of spectrum	Colour of spectral line	Spectrometer readings												2θ			θ	λ Å
		Ver - I						Ver - II										
		Left (x_1)			Right (x_2)			Left (x_1)			Right (x_2)			Ver I $(x_1 \sim x_2)$	Ver II $(x_3 \sim x_4)$	Mean		
		M.S.R	V.C × L.C	T.R	M.S.R	V.C × L.C	T.R.	M.S.R	V.C × L.C	TR	MSR	VC × LC	TR					
1	Green	344	18'	344° 18'	376	19'	376°19'	164	14'	164°14'	196	26'	196°26'	32°1'	32°12'	32°6' 30"	16°3' 15"	5456.75 Å
1	Violet	167.5	3'	167°38'	192.5	85'	192°35'	347	2'	347°2'	372.5	11	372° 41'	24°57'	24°20'	24°38' 30"	12°19' 15"	4084 Å

be done before starting the experiment.

(2) The reading should be taken in systematic order.

Results:

The wavelength of Green = 5456.75 Å

The wavelength of violet = 4084.65 Å.

Experiment - 2.

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DIAGRAM:

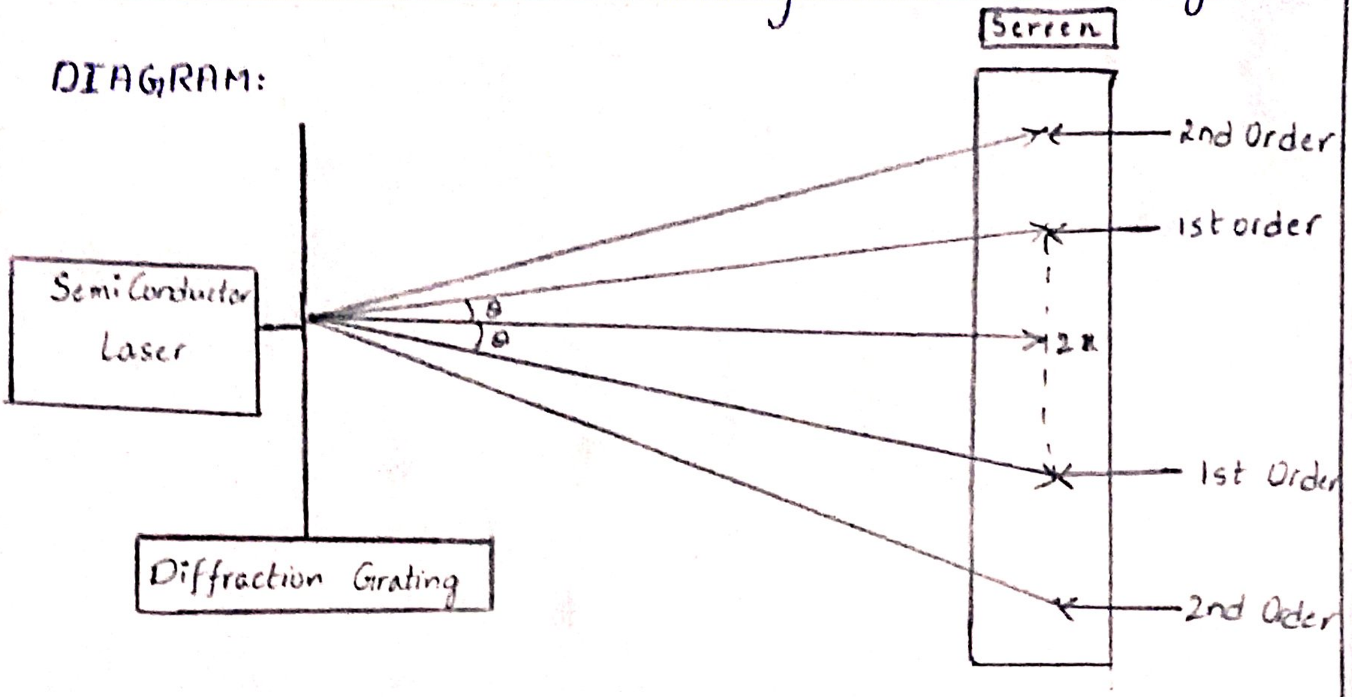

Table:

SNo	Order	r(cm)	x (cm)	$\tan\theta = (\frac{x}{r})$	$\sin\theta$	$\lambda = \frac{\sin\theta}{nN}$
1	1	59.5	0.8	0.0134	0.0566	6807Å
2	2	59.5	1.6	0.0268	0.867	6807Å
3	1	81.0	1.0	0.0123	0.0123	6248Å
4	2	81.0	2.1	0.0259	0.0259	6578Å.

WAVE LENGTH OF LASER LIGHT USING GRATING

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

Apparatus: Semiconductor diode laser, grating, screen, optical bench.

Formula:

Wavelength λ of a source of light incident normally on a transmission grating is

$$\lambda = \frac{\sin\theta}{nN} \ \mathring{A}.$$

where λ = wavelength of light.
θ = angle of diffraction
N = number of lines per cm on the grating.
n = order of spectrum.

Procedure:

1. The grating is mounted on the optical bench & the light beam from He-Ne laser is made to fall normally on it.
2. The screen is mounted at a distance 'r' from the grating to observe diffraction spots (max) of different orders.
3. The distance (2x) between the first order maxima on either side of central maximum is measured. From this the distance 'x' is noted. Similarly, x is determined for the second order also.
4. Now, 'r' is changed and corresponding 'x' measured for first & second order diffraction pattern

Calculations :

$$N = \frac{500}{2.54} = 196.850$$

$$\lambda = \frac{\sin\theta}{nN}$$

1) $\lambda = \frac{0.0134}{1\times196.850} = 6.8072\times10^{-6}\,cm = 6807\,\mathring{A}$.

2) $\lambda = \frac{0.0268}{2\times196.850} = 6.8072\times10^{-6}\,cm = 6807\,\mathring{A}$

3) $\lambda = \frac{0.0123}{1\times196.850} = 6.24841\times10^{-6}\,cm = \cancel{6578\,\mathring{A}}$ $6248\,\mathring{A}$

4) $\lambda = \frac{0.0259}{2\times196.850} = 6.57866\times10^{-6}\,cm = 6578\,\mathring{A}$

$$\text{Mean}\ (r) = \frac{6807+6807+6248+6578}{4}$$

$$= 6610\,\mathring{A}$$

$$\theta = \tan^{-1}(x/r)$$

1) $\theta = \tan^{-1}\left(\frac{0.8}{59.5}\right) = 0.767^\circ$

2) $\theta = \tan^{-1}\left(\frac{1.6}{59.5}\right) = 1.535^\circ$

3) $\theta = \tan^{-1}(1/81) = 0.704^\circ$

4) $\theta = \tan^{-1}(2.1/81) = 1.483^\circ$

$\sin(0.767) = 0.0134$

$\sin(1.535) = 0.0268$

$\sin(0.704) = 0.0123$

$\sin(1.483) = 0.0259$.

5. Assuming N, the value of λ is calculated using the formula $\lambda = \frac{(\sin \theta)}{Nn}$.

Precautions:

1) Do not look into the laser light directly.
2) Take the reading without any parallax error.

Result:

The wavelength of the laser light used is found to be 6610 Å

Experiment - 3

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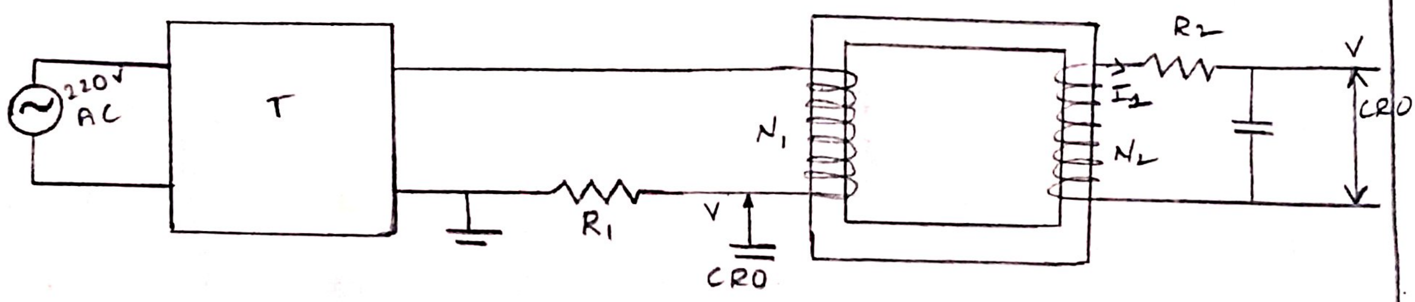
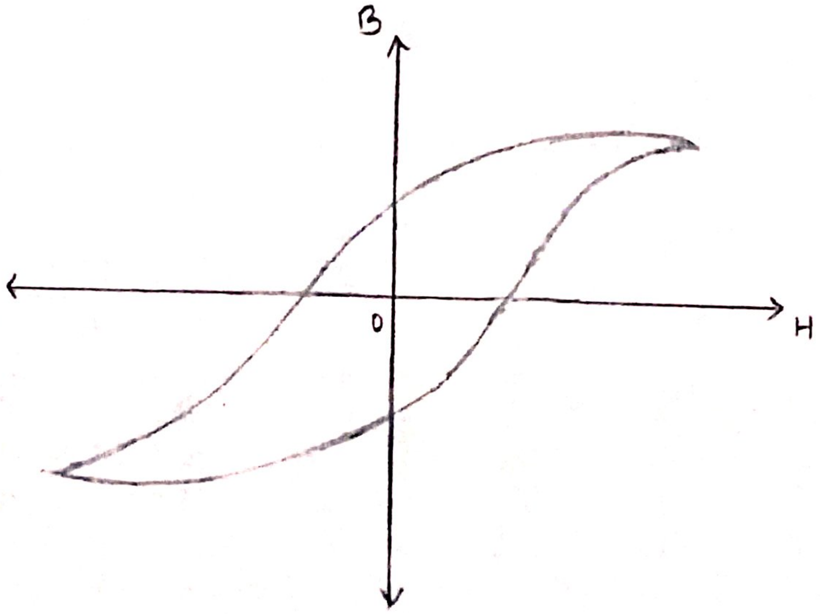
BH- CURVE -

Diagram.





B-H CURVE

Aim: Determination of coercivity, retentivity & energy loss of magnetic materials.

Apparatus: CRO, universal, B-H curve tracer, core of the transformer, hacksaw blade & ferrite rod.

Formula:

The energy loss is given by

$$E = \frac{0.5 \times N}{R \times L} \times S_V \times S_H \times \text{area of the loop.}$$

where N is number of turns in the transformer (300 turns)

R → resistance in circuit (55Ω)

L → length of the specimen (0.033m)

A → area of cross section of the specimen.

S_V and S_H are sensitive of Vertical & horizontal of CRO

Coercivity $H_c = \frac{N \times V_x}{R \times L}$ amperes turns/meter.

Retentivity $B_r = 0.5 \times V_y$ Weber/m².

Procedure:

1. Connect one terminal of the magnetizing coil to point C of main unit & the other to the terminal marked V_1 (say 6 Volts ac). Connect H to the horizontal input of the CRO & V to the vertical input of the CRO. Operate CRO in X-Y mode.

(2) Connect the IC probe to the "IC" marked on the unit.

(3) Switch ON the kit. To get proper loop vary the

Observation table

Parameter	Hacksaw blade	Transformer stamping.
N	300 turns	300 turns
R	55 Ω	55 Ω
L	0.033 m	0.033 m
S_v	0.5 v/div	0.5 v/div
S_H	2 v/div	2 v/div
Area of loop	$439 mm^2 = 439 \times 10^{-6} m^2$	$164 mm^2 = 164 \times 10^{-6} m^2$
V_y	$0.5 \times 2 = 1V$	$0.25 \times 2 = 0.5V$
V_x	$0.5 \times 0.5 = 0.25V$	$0.25 \times 0.25 = 0.125V$

Calculations :-

1) Hack saw blade

$$E = \frac{0.5 \times N}{R \times L} \times S_V \times S_H \times \text{area of loop.}$$

$$= \frac{0.5 \times 300}{55 \times 0.033} \times 0.5 \times 2 \times 439 \times 10^{-6} \times 10^{4}$$

$$= \frac{65850}{1.815} \times 10^{-6} \times 10^{4}$$

$$= 362.80 \text{ J/cycle/v.}$$

$$H = \frac{N \times V_x}{R \times L} = \frac{300 \times 1}{55 \times 0.33 \times 10^{-1}} = 165.2 \text{ ampere/turns/meter}$$

$$B = 0.5 \times 0.25$$

$$= 0.125 \text{ wb/m}^2$$

2) transformer stamping

$$E = \frac{0.5 \times 300}{55 \times 0.033} \times 0.5 \times 2 \times 164 \times 10^{-2}$$

resistance to the maximum value with the help of knob P on the panel.

(4) With no specimen through the coil adjust horizontal gain of CRO untill a convenient x deflection is obtained. Note down this readings as S_H. Insert a magnetic specimen, eg a 5" nail stampings through the magnetizing coil such that it touches the probe at the center. Make sure that sample is touching IC only & conducting tracks are not shorted in any case. Adjust the Oscilloscope vertical gain (Y gain) & horizontal gain (X gain) untill a trace showing the Bell shape loop conveniently fills the screen. Note down these readings as S_V. If the curve is back to front, reverse the connection of the magnetizing coil

(5) Trace the area of the loop of the butter paper from the screen of the CRO and retrace it on graph paper.

(6) Note down the x intercept V_x & y intercept V_y from the graph paper. Calculate the coercivity H and retentivity B using relation.

$$H_c = \frac{N \times V_x}{R \times L} \text{ ampere turns/metre.}$$

$$B_r = 0.5 \times V_y \text{ Weber/m}^2.$$

(7) Measure the area of the loop with the help of graph paper. The energy loss is calculated.

$$E = \frac{0.5 \times N}{R \times L} \times S_V \times S_H \times \text{area of the loop Joules/cycle/unit volume}$$

where S_V and S_H are vertical & horizontal sensitivities of the CRO for that particular setting of the gains.

$$= 13553.71901 \times 10^{-2}$$

$$= 135.53 \text{ J/cycle/v.}$$

$$H = \frac{N \times V_x}{R \times L} = \frac{300 \times 0.5}{55 \times 0.033} = \frac{165.2}{2} \text{ ampere/turns/meter.} = 82.64 \text{ amp/turns/m}$$

$$B = \frac{0.5 \times 0.125}{1} = 0.0625 \text{ wb/m}^2.$$

(8) Repeat the experiments with different specimen & note down your comments on properties of different materials.

Precautions :-

(1) The specimen should be at the centre of the magnetizing coil very close to the probe.

(2) If the area of the loop is expressed in cm^2, the sensitivity should be expressed in volt/cm in either case the length of the coil should be in meters.

Results :-

The energy loss of hacksaw blade = 362.80 J/cycle/v

Coercivity (H_c) = 165.2 ampere/turns/meter.

Retentivity (B_R) = 0.125 wb/m^2

The energy loss of transformer stamping = 135.53 J/cycle/v

Coercivity (H_c) = 82.64 ampere/turns/m

Retentivity (B_R) = 0.0625 wb/m^2.

Experiment-4

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STRAIN GAUGE SENSOR.

Aim: To find strain using strain gauge sensor.

Apparatus: Strain gauge sensor, cantilever beam, weights

Formula: Micro strain = $S = \frac{6MgL}{bd^2E}$

where M = mass applied in grams. $g = 1000\ cm/sec^2$.
L = effective length of the beam in cm = 22 cm
b = width of the beam = 2.8 cm.
d = thickness of the beam = 0.25 cm.
E = Young's modulus = $2 \times 10^{12}\ dynes/cm^2$.

Procedure:

(1) Switch on the circuit and allow it for 5 minutes for initial warm up.

(2) Adjust the zero ADT Potentiometer knob on the panel till the display reads '000'.

(3) Apply 1 Kg load on the cantilever beam and adjust the CAL potentiometer knob till the display reads 377 micro strain.

(4) Remove the weights. The display should come to zero. In case of any variation, adjust the zero ADJ potentiometer knob again and ~~report~~ repeat the procedure again.

(5) Now the instrument is calibrated to read the microstrain.

(6) Apply load on the sensor using the loading arrangement provided in steps of 100 gm upto 1kg.

Tabular form :-

S.No	Weight (gms)	Theoritical value of S (micro strain)	Indicator value	% error
1.	100	37.71	38	0.76%
2.	200	75.42	75	0.56%
3.	300	113.13	113	0.1%
4.	400	150.84	150	0.56%
5.	500	188.55	189	0.23%
6.	600	226.26	227	0.32%
7.	700	263.93	264	0.02%
8.	800	301.68	302	0.1%
9.	900	339.39	338	0.41%
10.	1000	377.1	377	0.02%

Calculations :

Microstrain $S = \frac{6Mgl}{bd^2E}$

for weight M = 100g

$S = \frac{6 \times 100 \times 1000 \times 22}{2.8 \times (0.25)^2 \times 2 \times 10^{12}}$

= 37.71 microstrain

M = 600g

$S = \frac{6 \times 600 \times 1000 \times 22}{2.8 \times (0.25)^2 \times 2 \times 10^{12}}$

= 226.26 Micro S

M = 200g

$S = \frac{6 \times 200 \times 1000 \times 22}{2.8 \times (0.25)^2 \times 2 \times 10^{12}}$

= 75.42 M-Strain.

Similarly for M = 700, 300, 800, 400, 900, 500, 1000 grams.

$\% \text{ error} = \frac{\text{theoritical value} - \text{indicator value}}{\text{indicator value}} \times 100$

1) $\% \text{ error} = \frac{38 - 37.71}{38} \times 100 = 0.763\%$

2) $\% = \frac{75.42 - 75}{75} \times 100 = 0.56\%$

Similarly for remaining values also.

(7) The instrument displays exact micro strain received by the cantilever beam.

(8) Note down the readings in the tabular form and calculate theoritical value of the micro strain for each weight using above formula.

(9) Also calculate percentage error in each case using the formula.

$$\%\ \text{error} = \frac{(\text{theoritical value} - \text{indicator reading})}{\text{theoritical value}} \times 100$$

Graph: A graph is drawn between load values & taken along x axis and corresponding microstrain values taken along y axis. It is a straight line passing through origin.

Precautions:

(1) Do the zero adjustments should be done before measuring the actual reading.

(2) Take the readings carefully.

(3) Handle the equipment with care.

Result: The microstrain values shown by the sensor are noted and are compared with theoritical values.

Experiment-5

NEWTON RINGS

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Aim: Determination of radius of curvature of a convex lens by forming newton Rings.

Apparatus: Sodium vapour lamp, travelling microscope, reading lens, convex lens and plane glass plates.

Formula

$$R = \frac{D_n^2 - D_m^2}{4\lambda(n-m)} \text{ cm}$$

where, R = Radius of curvation.

D_n = Diameter of nth ring.

D_m = Diameter of mth ring.

λ = wave length of monochromatic light source used = 5893 Å.

Procedure:

1) The travelling microscope is adjusted to view the center of the ring system.

2) By working the tangential screw, microscope is moved to extreme left by counting 12 dark rings. Then by coinciding the vertical cross wire tangentially with the 12th dark ring the corresponding reading is noted. The experiment is repeated by noting readings for every alternative ring (say for all even rings) on left side.

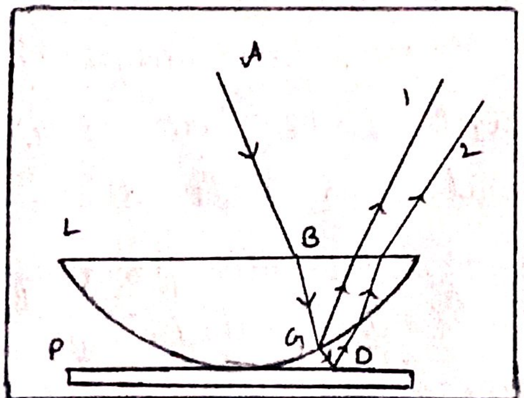
(3) 3 observations are noted by moving the microscope to the right of the center of the rings system as explained above. From these observations the diameters of various rings are found.

(4) A graph is drawn b/w order of rings (on x axis)

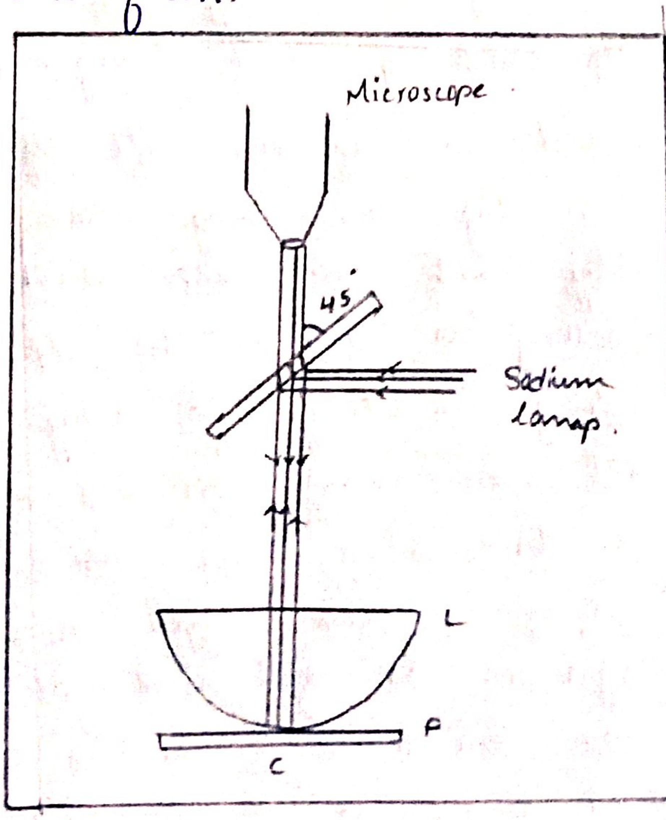
and diameter square values (on y axis). A straight line passing through the origin is obtained. From the graph the values of D_n^2 & D_m^2 corresponding to nth and mth rings are found. The radius of curvature is

$$R = \frac{D_n^2 - D_m^2}{4\lambda(n-m)} \text{ cm.}$$

Its important to note that while taking observations care must be taken while moving the microscope in only 1 direction (i.e from 12th ring on the left side to 12th ring on right side) to avoid backslash error. Any screw type instrument will have backslash error. Any screw type instrument will have BSE. Least count of travelling microscope is calculated. The observations are tabulated in tabular form.



Ray diagram



Calculations :

$$R = \frac{D_n^2 - D_m^2}{4\lambda(n-m)}$$

where $n = 8$, $m = 2$

$D_n^2 = 0.261$ $D_m^2 = 0.081$

$$R = \frac{0.261 - 0.081}{4 \times 5893 (6 \times 10^{-8})}$$

$$R = \frac{0.177 \times 10^8}{23572 \times 6} = 1.25148 \times 10^8$$

$$\boxed{R = 125.148 \text{ cm}}$$

From graph :- $n = 9$ $m = 3$

$$R = \frac{D_n^2 - D_m^2}{4\lambda(n-m)} = \frac{2.7 - 0.1}{4 \times 5893 \times 6 \times 10^{-8}}$$

$$= 127.2 \times 10^2$$

$$= 127.2 \text{ cm}.$$

given $R = 130$ cm

$$\% \text{ error} = \frac{130 - 125.148}{130} \times 100 = \frac{4.852}{130} \times 100 = 3.732\%.$$

Percentage error in radius of curvature $= \frac{\Delta R}{R} \times 100$

$= 3.732\%.$

Precautions :

1) Wipe the lens and glass plates with clean cloth before starting the experiment.
2) The centre of the rings must be dark.
3) The microscope should be displaced in one direction only throughout the experiment to avoid

Table for observations of diameter of the Newton rings:

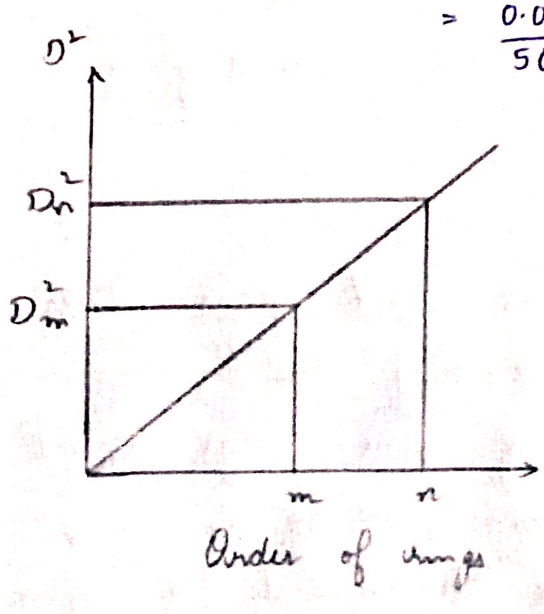
S.No	Order of the Rings. (12th to 2nd ring)	Travelling microscope readings (cm) Left edge (L) MSR	V.C × L.C	T.R	Right edge (R) MSR	V.C × L.C	T.R	Diameter (L~R) (cm)	D^2 (cm^2)
1.	12th	7.0	2	7.002	6.4	2	6.402	0.600	0.360
2.	10th	6.9	35	6.935	6.4	10	6.410	0.525	0.275
3.	8th	6.9	21	6.921	6.4	20	6.420	0.601	0.251
4.	6th	6.9	16	6.916	6.4	34	6.434	0.482	0.232
5.	4th	6.8	43	6.843	6.5	14	6.514	0.329	0.108
6.	2nd	6.8	10	6.810	6.5	25	6.525	0.285	0.088.

Observations:

Least count of microscope (L.C) $= \dfrac{\text{Value of 1 MSD}}{\text{No. of divisions on V.S}}$

$= \dfrac{0.05}{50} = 0.001$ cm.

Model graph:-



black slash error.

4) Use readings lens while observing the readings.

Result

The radius of curvature (R) of the given lens (from table) = 125.148 cm

The radius of curvature (R) of the given lens (from graph) = 127.2 cm.

Experiment 6

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PARTICLE SIZE DETERMINATION BY LASER.

Aim:- Determination of particle size of the given lycopodium powder using laser diffraction method.

Apparatus : Semiconductor laser, lycopodium powder, glass plate, screen and metre scale.

Formula : Grain size (diameter) '2d' of the grain

$$2d = \frac{n \lambda D}{x_n} \ \mu m$$

where
n = order of diffraction
λ = wavelength of laser light used in Å (6350 Å)
D = distance b/w glass plate & screen in cm.
x_n = distance b/w central bright spot & the nth fringe in cm.

Procedure:

1) Keep the laser stand and screen stand on a horizontal wooden plank such the source and the screen faced to each other.

2) Switch on the laser source a beam of laser light will fall on the screen.

3) Insert the sample containing lycopodium powder in between the source and screen.

4) Adjust the distance b/w the source & screen

to get circular diffraction rings pattern on the screen.

5) Measure the distance b/w the screen and the sample (D) with the help of a meter scale and note it.

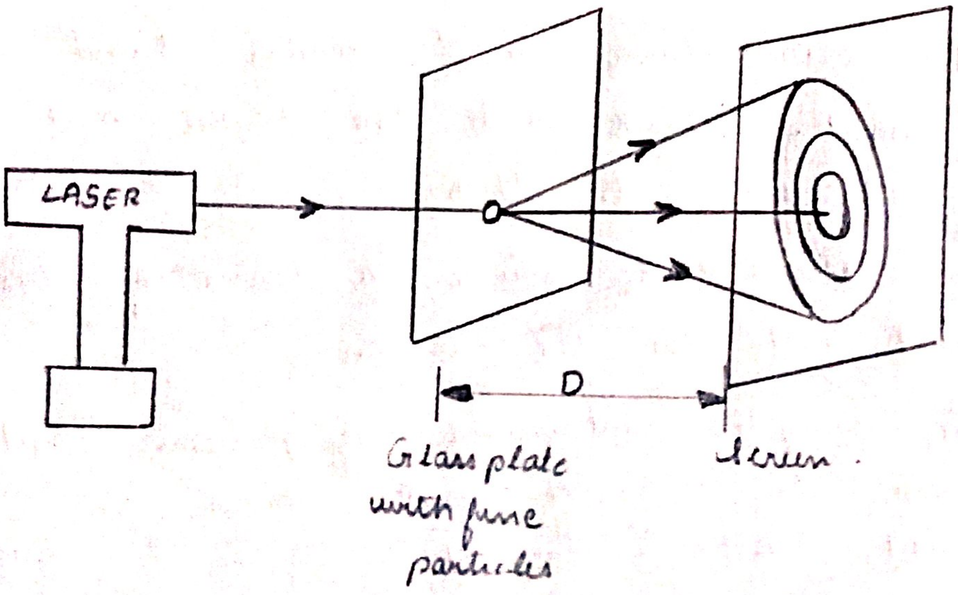
6) Measure the radius of the circular dark rings (X_n) for n=1 and n=2 with the help of the graduated lines on the screen or mark the diffraction rings pattern on a trace paper sheet and measure the radius of the dark circular rings (X_n) for n=1 & n=2.

7) Repeat the following steps 3,4,5 & 6 for another values of D and note the values (X_n) for n=1 & n=2.

8) Calculate the particle size of the given lycopodium powder by using the formula.

9) Calculate the average value of the 2d.

particle size determination by laser.



Observation table:

S NO	Distance b/w the screen & glassplate (D)	Order of diffraction (n)	distance b/w the central bright spot & nth fringe (x_n)	$2d = \frac{n\lambda D}{x_n}$
units	cm	–	cm	cm
1	10	1	1	63.5×10^{-5}
		2	2	63.5×10^{-5}
2	16.5	1	1.5	69.85×10^{-5}
		2	3.1	67.5×10^{-5}

Calculations:

$\lambda = 6350 \mathring{A}$

$= 6350 \times 10^{-8}$ cm.

1) $2d = \frac{1 \times 10 \times 6350 \times 10^{-8}}{1} = 63.5 \times 10^{-5}$ cm

2) $2d = \frac{2 \times 6350 \times 10^{-8} \times 10}{2} = 63.50 \times 10^{-5}$ cm.

3) $2d = \frac{1 \times 6350 \times 10^{-8} \times 16.5}{1.5} = 69.85 \times 10^{-5}$ cm.

4) $2d = \frac{2 \times 6350 \times 10^{-8} \times 16.5}{3.1} = 67.5 \times 10^{-5}$ cm.

$\text{Avg} = \frac{63.5 + 63.5 + 69.85 + 67.5}{4} \times 10^{-5}$ cm

$\boxed{\text{Avg} = 66.0875 \times 10^{-5} \text{ cm}}$

Mean = 660.8 μm.

Result: The average size of lycopodium particle is 660.8 μm.