Expt. No. 1 Date: 11th June

DIFFRACTION GRATING - MINIMUM DEVIATION

Name: V. manvitha
Rollno: 19131A05Q6
Branch: CSE-4

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

Apparatus: plane diffraction grating, spectrometer, 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 no. of lines per cm.

Procedure:

1) Switch on the mercury lamp.
2) Focus the telescope towards a distant object. Adjust rack and pinion screw to get clear and sharp image.
3) Adjust the rack and pinion screw of the collimator and micrometer screw for sharp and narrow slit.
4) Main scale & Vernier scale are adjusted for direct reading i.e., 0-0 and 0-180 on

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Vernier 1 and Vernier 2 respectively.

5) The leveling 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 falls approximately in the center of the field of view.

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

8) Rotate the grating table in the Same direction (towards left). You will notice that the spectral lines also rotate in Same direction first & then rotates in 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 called as position of minimum deviation.

10) Set the cross-wire of the telescope at one of the spectral line by fine adjustement

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

12) Repeat the procedure on right Side also.

13) take the difference of the left & right reading of the 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 the wave length(λ) of the desired Spectral line

Observations:

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

calculations:-

Green = $x_1 = 344^\circ 18'$

$x_3 = 164^\circ 14'$

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

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

$$= \frac{32^\circ 1' + 32^\circ 12'}{2} = 32^\circ 6' 30''$$

$2D = 32^\circ 6' 30''$

$$D = \frac{32^\circ 6' 30''}{2} = 16^\circ 3' 15''$$

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

$$\boxed{\lambda = 5456.75 A^\circ}$$

% Error , λ for green

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

$$= 0.091\%$$

$\therefore$ for green $\lambda = 5456.75 A^\circ$ & % Error $= 0.091\%$

Violet:-

$x_1 = 167^\circ 38'$ $\quad$ $x_3 = 347^\circ 2'$

$x_2 = 192^\circ 35'$ $\quad$ $x_4 = 372^\circ 41'$

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

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

$$= \frac{24^\circ 57' + 24^\circ 20'}{2}$$

$$2D = \frac{48^\circ 79'}{2} = 24^\circ 38' 30'' \Rightarrow D = 12^\circ 19' 15''$$

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

$$\lambda = \frac{0.20905}{5118.110} \text{ cm} \qquad \boxed{\lambda = 4084.65 A^\circ}$$

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

$$= 0.147\%$$

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∴ for violet $\lambda = 4084 A^\circ$ & % error = 0.147%.

observation table:

order of Spectrum	colour of Spectral line	Spectrometer readings												2D			D	λ A°
		Ver-I						Ver-II										
		left (x_1)			Right (x_2)			left (x_3)			Right (x_4)			verI ($x_1 \sim x_2$)	verII ($x_3 \sim x_4$)	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	T.R	M.S.R	V.C×L.C	T.R					
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 A°
1	violet	167.5	8'	167°38'	192.5	5'	192°35'	347	2'	347°2'	372.5	11	372°41'	24°57'	24°20'	24°38' 30"	12°19' 15"	4084 A°

Observations:

least count of spectrometer = $\frac{\text{value of 1M.S.D}}{\text{no. of divisions on V.S}}$

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

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

15000 → 2.54 cm

? → 1 cm

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

precautions:

1) The initial arrangement of the Spectrometer Should be done before starting the experiment

2) The reading should be taken in systematic order

Results:

The wavelength of Green = 5456.75 A°

the wavelength of Violet = 4084.65 A°

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PARTICLE SIZE DETERMINATION BY LASER:

Aim: determination of particle size of the given lycopodium powder using lacer 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 A^0 ($6350 A^0$)

D = distance between glass plate and screen in centimetre.

X_n = Distance between central bright spot and then 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 between the source and 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.

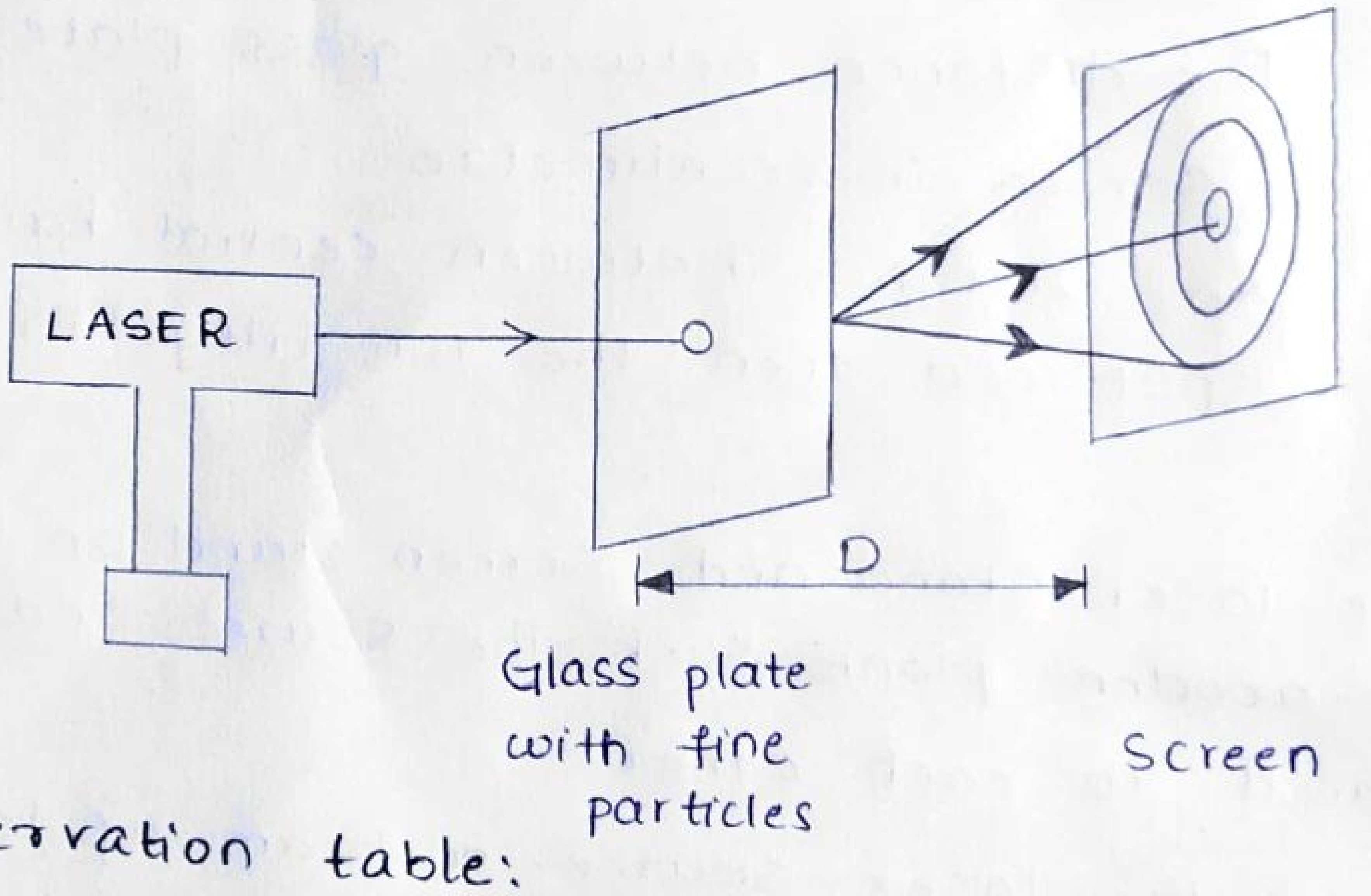
6) Measure the radius of the circular dark rings (x_n) for n=1 and n=2 with the help of the graduated lines on the screen. Or mark the diffraction rings pattern on a trace paper sheet & measure the radius of the dark circular rings (x_n) for n=1 & n=2

7) Repeat the steps 3,4,5 and 6 for another value of D and note the values (x_n) for n=1 and 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 between the screen & glass plate (D)	order of diffraction (n)	distance b/w the central bright spot & n^{th} 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}

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Calculations:

$\lambda = 6350 A^{\circ}$
$= 6350 \times 10^{-8} cm$

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

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

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

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

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

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

Mean = $660.8 \mu m$

Result:-

The average size of lycopodium particle is $660.8 \mu m$

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WAVELENGTH OF LASER LIGHT USING GRATING:

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

Apparatus:- Semi conductor diode laser, Grating, Screen, optical bench

formula:- wave length λ of a source light incident normally on a transmission grating is

$$\lambda = \frac{\sin\theta}{nN} A^0$$

where

λ = wave length of light

θ = angle of diffraction

N = number of lines per cm on the grating.

n = order of spectrum

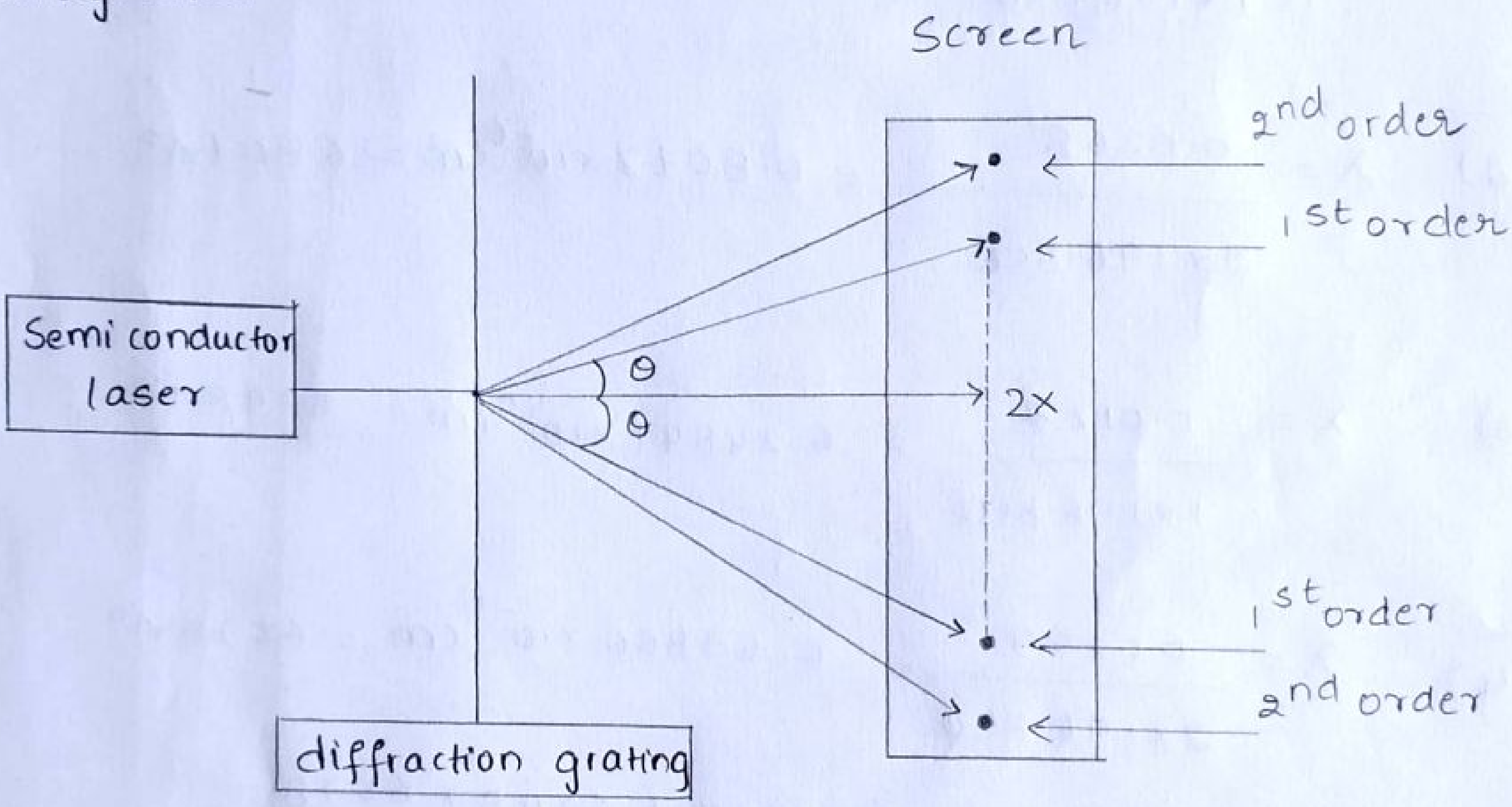
Procedure:

1. The grating is mounted on the optical bench and the light beam from the 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) b/w 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' is measured for first and second order diffraction pattern.

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

Diagram:-



observation table:-

S.No	order	r(cm)	x(cm)	Tanθ $= \left(\frac{x}{r}\right)$	sinθ	$\lambda = \frac{\sin\theta}{nN}$
1	1	59.5	0.8	0.0134	0.0566	6807A°
2	2	59.5	1.6	0.0268	0.867	6807A°
3	1	81.0	1.0	0.0123	0.0123	6248A°
4	2	81.0	2.1	0.0259	0.0259	6578A°

Calculations:

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

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

1) $\lambda = \dfrac{0.0134}{1 \times 196.850} = 6.8072 \times 10^{-6}\, cm = 6807\, A^{0}$

2) $\lambda = \dfrac{0.0268}{2 \times 196.850} = 6.8072 \times 10^{-6}\, cm = 6807\, A^{0}$

3) $\lambda = \dfrac{0.0123}{1 \times 196.850} = 6.24841 \times 10^{-5}\, cm = 6248\, A^{0}$

4) $\lambda = \dfrac{0.0259}{2 \times 196.850} = 6.57866 \times 10^{-5}\, cm = 6578\, A^{0}$

$$\text{mean } (\gamma) = \frac{6807 + 6807 + 6248 + 6578}{4}$$

$$= 6610\, A^{0}$$

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

1) $\theta = \tan^{-1}\left(\dfrac{0.8}{59.5}\right) = 0.767^{0}$

2) $\theta = \tan^{-1}\left(\dfrac{1.6}{59.5}\right) = 1.535^{0}$

3) $\theta = \tan^{-1}(1/81) = 0.704^{0}$

4) $\theta = \tan^{-1}(2.1/81) = 1.483^{0}$

$\sin(0.767) = 0.0134$

$\sin(1.535) = 0.0268$

$\sin(0.704) = 0.0123$

$\sin(1.483) = 0.0259$

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precautions:-

1) Donot look into the laser light directly
2) Take the reading without any parallax error.

Result:-

The wave length of the laser light used is found to be 6610A°

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NEWTONS RINGS

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 curvature

D_n = Diameter of n^{th} ring

D_m = Diameter of m^{th} ring

λ = wave length of monochromatic light

Source used = 5893 A°

procedure:-

1) The travelling microscope is adjusted to view the centre of the rings 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 tangenti-ally with the 12^{th} dark ring the corresponding reading is noted. The experiment is repeated by noting the readings for every alternative ring (Say for all even rings) on the left side.

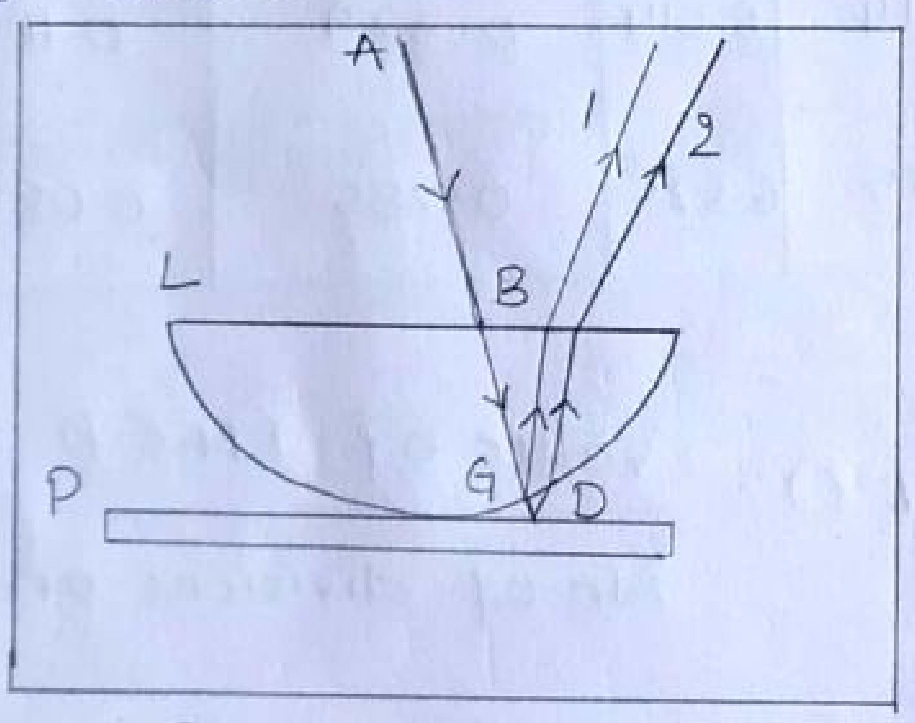
3) 3 observations are noted by moving the microsco-pe to the right of the centre of the rings system as explained above. from these observations the diameters of various rings can be found.

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

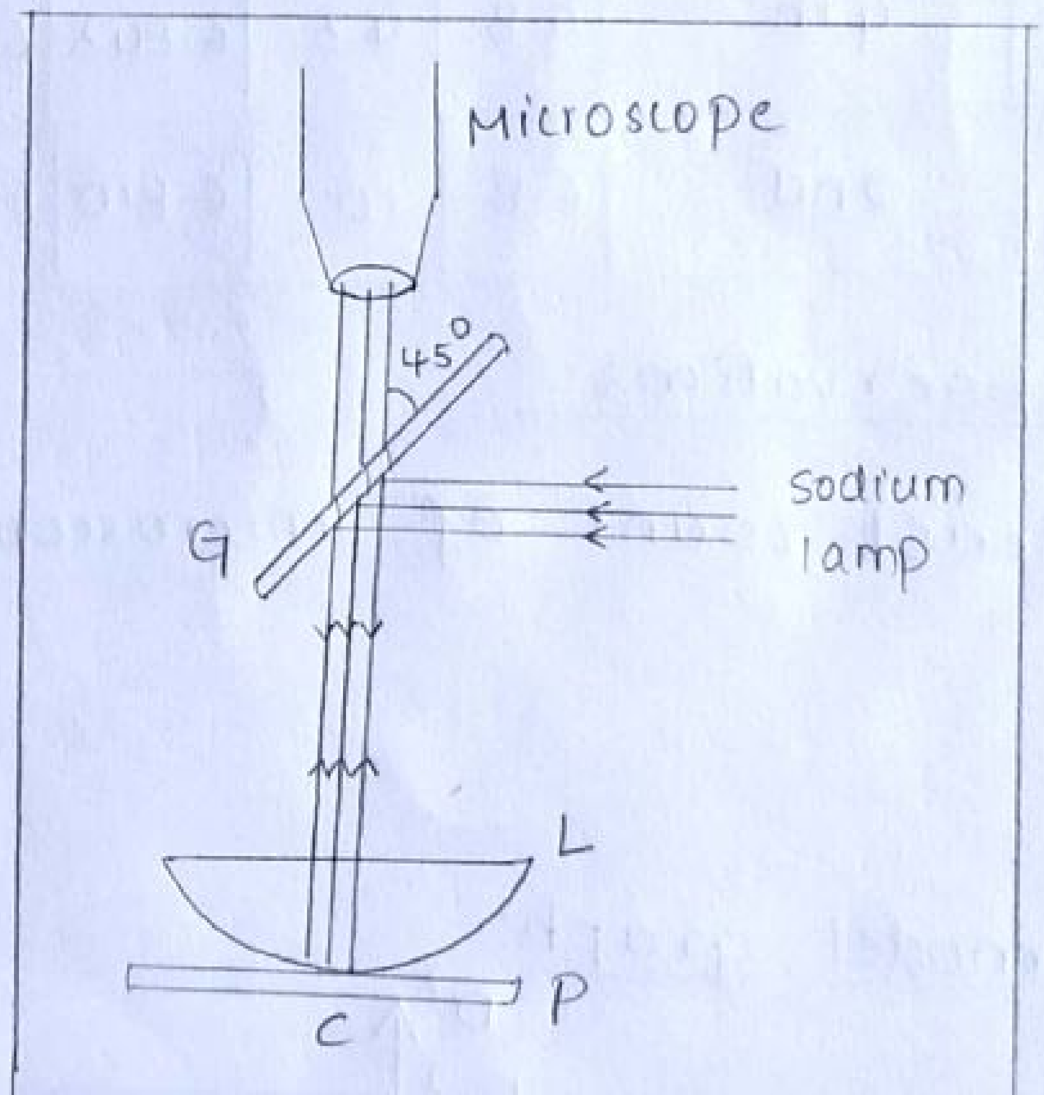
and diameter square values (on y-axis). A straight line passing through the origin is obtained. from the graph the value of D_n^2 and D_m^2 corresponding to n^{th} and m^{th} rings are found. The radius of the curvature is

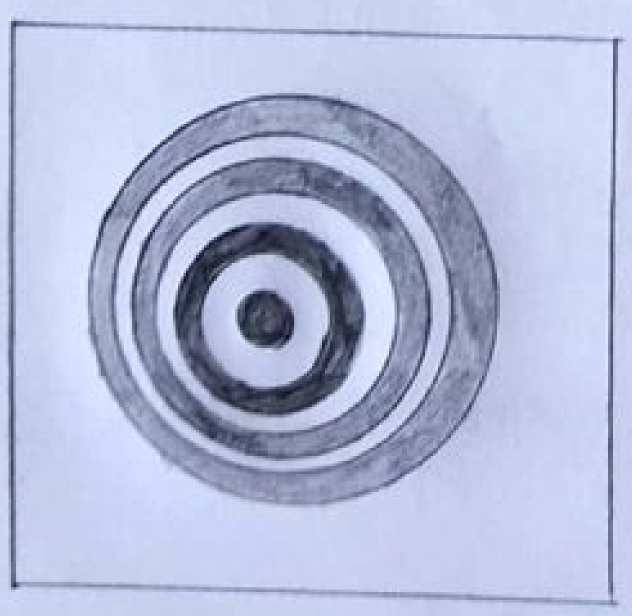
$$R = \frac{D_n^2 - D_m^2}{4\lambda(n-m)} \text{ cm}$$

it's important to note that while taking observations care must be taken while moving the microscope in only 1 direction (i.e from 12^{th} ring on the left side to 12^{th} on the right side) to avoid backlash error. Any screw type instrument will have backlash error. least count of the travelling microscope is calculated. The observations are tabulated as shown in the tabular form.



Ray diagram





Ring system

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Table for the observations of diameter of the Newton's rings:

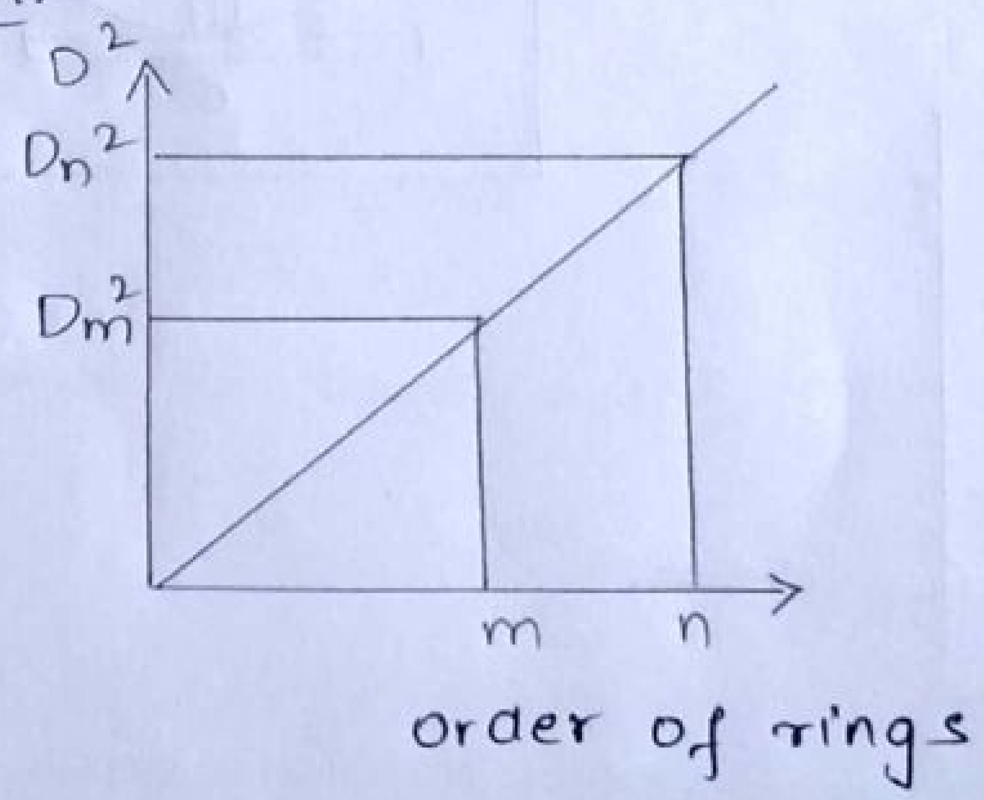
Sl·No	order of the rings	Travelling microscope readings (cms)						Diameter (L~R) (cm)	D^2 (cm^2)
		left edge (L)			Right edge (R)				
	(12^{th} to 2^{nd} ring)	M·S·R	V·C x L·C	T·R	M·S·R	V·C x L·C	T·R		
1	12th	7.0	2	7.002	6.4	2	6.402	0.600	0.360
2	10th	6.9	35	6.935	6.4	10	6.410	0.525	0.275
3	8th	6.9	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) = $\frac{\text{Value of 1 M·S·D}}{\text{No·of divisions on VS}}$

$= \frac{0.05}{50} = 0.001$ cm

model graph:-



Calculations:-

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

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

$Dn^2 = 0.261$ $Dm^2 = 0.081$

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

$$= \frac{0.177 \times 10^8}{23572 \times 6} = \frac{177000}{141432} \times 10^{-8}$$

$$R = 1.25148 \times 10^8$$

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

from graph:- $n = 9$, $m = 3$

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

$$= 127.2 \times 10^2$$

$$= 127.2\ cm$$

Given $R = 130\ cm$

$$\%\ error = \frac{130 - 125.148}{130} \times 100$$

$$= \frac{4.852}{130} \times 100 = 3.732\ \%$$

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 black slash error.

4) Use reading 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

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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 = 22cm

b = width of the beam = 2.8 cm

d = thickness of the beam = 0.25cm

E = Youngs modulus = 2×10^{12} dyne/cm^2

procedure:

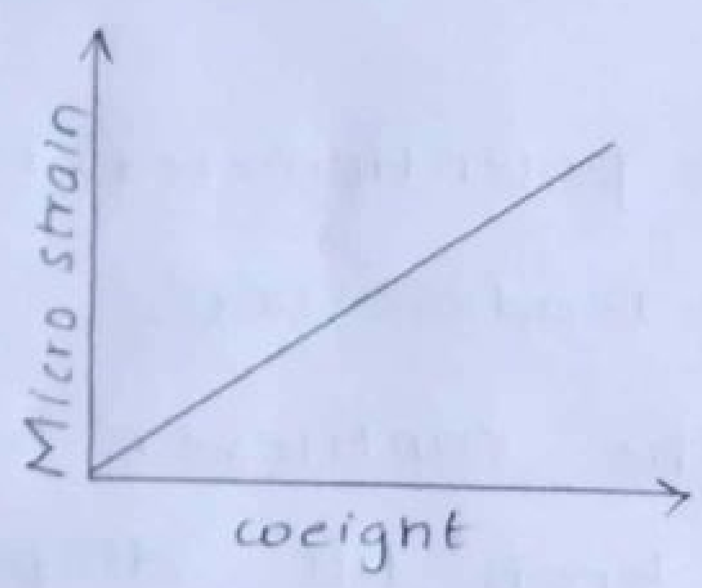
1) switch on the circuit and allow it for 5 minutes for initial warm up.
2) Adjust the ZERO ADJ potentiometer knob on the panel till the display reads '000'.
3) Apply 1kg load on the cantilever beam and adjust the CAL potentiometer knob till display reads 377 micro strain.
4) Remove the weights. The display should come to zero. In case of any variation, adjust ZERO ADJ potentiometer knob again and repeat the procedure.
5) Now the instrument is calibrated to read the micro strain.
6) Apply load on the sensor using the loading arrangement provided in steps of 100gm upto 1kg.

7) The instrument displays exact micro strain recieved by the cantilever beam.
8) Note down the readings in the tabular form and calculate theoretical value of the micro strain for each weight using above formula.
9) Also calculate % error in each case using the formula

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

Graph:-

A graph is drawn b/w load values taken along X-axis and corresponding micro strain values 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 care-fully
3) Handle the equipment with care.

Tabular form:-

S.NO	weight (gms)	Theoretical 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:-

Micro strain $S = \dfrac{6Mgl}{bd^2E}$

for weight $M = 100g$

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

$= 37.71$ micro strain

$M = 600g$

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

$= 226.26$ micro strain

$M = 200 \Rightarrow S = \dfrac{6 \times 200 \times 1000 \times 22}{2.8 \times (0.25)^2 \times 2 \times 10^{12}} = 75.42$ micro strain

Similarly for M= 700, 300, 800, 400, 900, 500 & 1000 gms

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

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

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

Similarly for the remaining values also.

Result: The micro strain values shown by the sensor are noted and are compared with the theoretical values.

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BH-curve

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

Apparatus: CRO, Universal B-H curve tracer, core of the transformer, hacksaw frame and 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)

R represents resistance in the circuit (55 Ω)

L is the length of the specimen

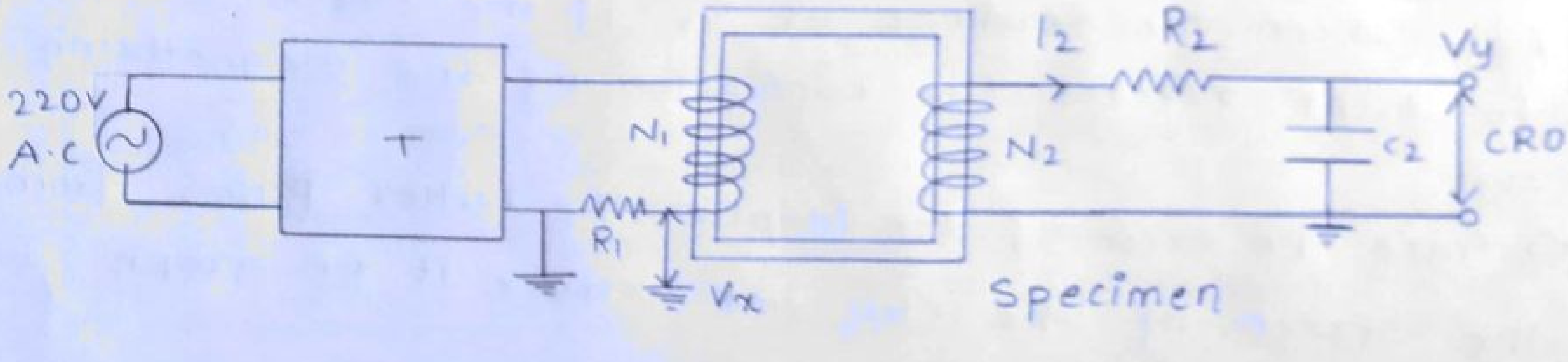
A is the area of cross section of the specimen

S_V and S_H are sensitivity of vertical and horizontal of CRO

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

$$\text{Retentivity} \quad B_r = 0.5 \times V_y \text{ weber/m}^2$$

Diagram:-



BH-curve

procedure:-

1) connect one terminal of the magnetizing coil to point C of main unit and the other to the terminal marked V1 (say 6 volts ac). connect H to the horizontal 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 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 the CRO until a convinient x-deflection is obtained. Note down this reading as SH. Insert a magnetic specimen. e.g a 5" nail, stampings or ferrite rod through the magnetizing coil such that it touches the probe at the center. Make sure that sample is touching IC only and conducting tracks should not be shorted in any case. Adjust the oscilloscope vertical gain / sensitivity (Y-again) and the horizontal gain/ sensitivity (X-gain) until a trace showing the B-H loop convieniently fills the screen. note docon the readings as Sv. if the curve is back to front, reverse the connection of the magnetizing coil.

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

6) Note down the X-intercept Vx and Y intercept Vy from the graph paper. calculate the coercivity H and retentivity B using relation.

$$Hc = \frac{N \times Vx}{R \times L} \text{ ampere turns/metre}$$

$$Br = 0.5 \times Vy \text{ weber/m}^2$$

7) measure the area of the loop with the help of the graph paper. Then 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 & S_H are vertical and horizontal sensitivities of the CRO for that particular setting of the gains.

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

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/dev
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	$0.5 \times 0.5 = 0.25V$	$0.25 \times 0.5 = 0.125V$

calculations:

1) Hack saw blade

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

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$$= \frac{0.5\times300}{55\times0.033}\times0.5\times2\times439\times10^{-6}\times10^{4}$$

$$= \frac{65850}{1.815}\times10^{-6}\times10^{4}$$

$$= 36280.99174\times10^{-6}\times10^{4}$$

$$= 362.80\ J/cycle/v$$

$$H = \frac{N\times V_x}{R\times L} = \frac{300\times1}{55\times0.033} = 165.2\ \text{ampere/turns/meter}$$

$$B = 0.5\times0.25$$

$$= 0.125\ wb/m^2$$

2) transformer stamping

$$E = \frac{0.5\times300}{55\times0.033}\times0.5\times2\times164\times10^{-6}\times10^{4}$$

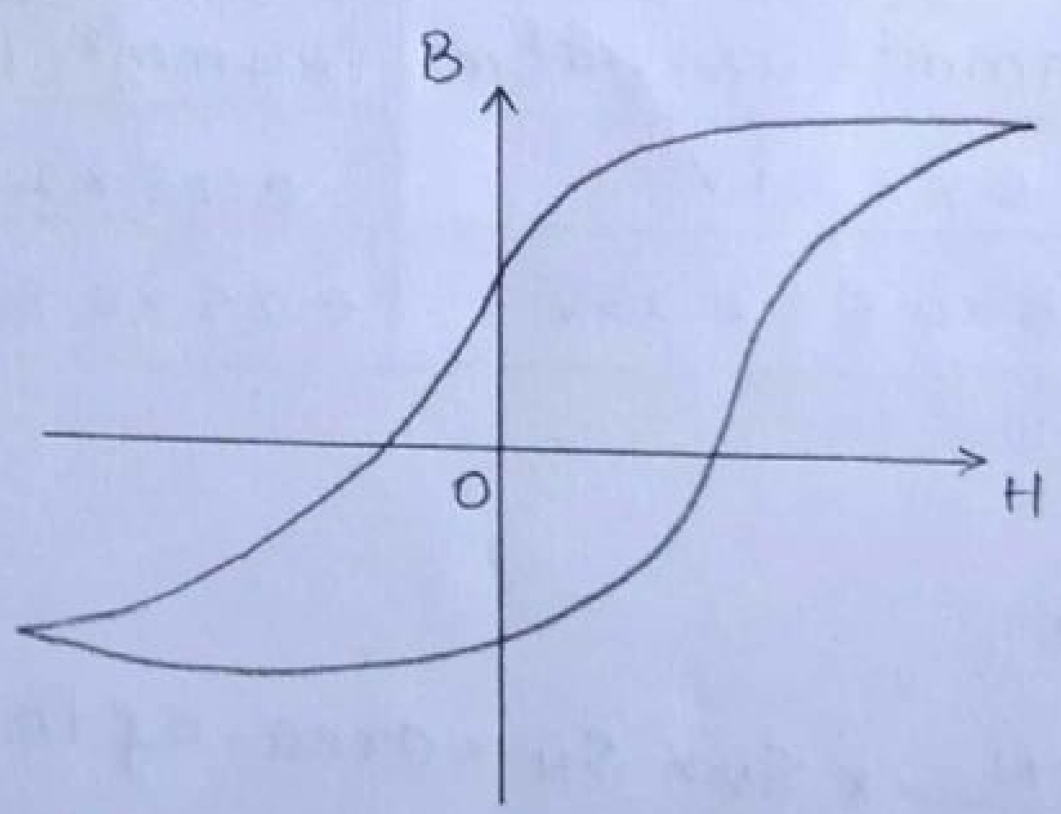
$$= 13553.71901\times10^{-6+4}$$

$$= 135.53\ J/cycle/v$$

$$H = \frac{300\times0.5}{55\times0.033} = 82.64\ \text{ampere/turns/m}$$

$$B = 0.5\times0.125 = 0.0625\ weber/m^2$$

Graph:



precautions:

1) The specimen should be at the center 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.