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Date

Expt. No. 1A

Page No.

Aim To find the diameter of a solid cylinder using Vernier Callipers.

Apparatus Vernier Calliper, a solid cylinder

Theory Least Count is 0.01 cm. The main scale before the zero of VC scale. The VSR is reading which coincides with the the main scale reading.
The total diameter is equal to sum of main scale & the product of least count & VSR.

Object Small pipe
Least Count 0.01 cm

Result The diameter of the pipe came out to be (7.44 ± 0.03) cm

Precautions
- Backslash Error should be taken of.
- Parallax error should be take of.
- Pipe shouldn't be made tight by vernier scales

Teacher's Signature :

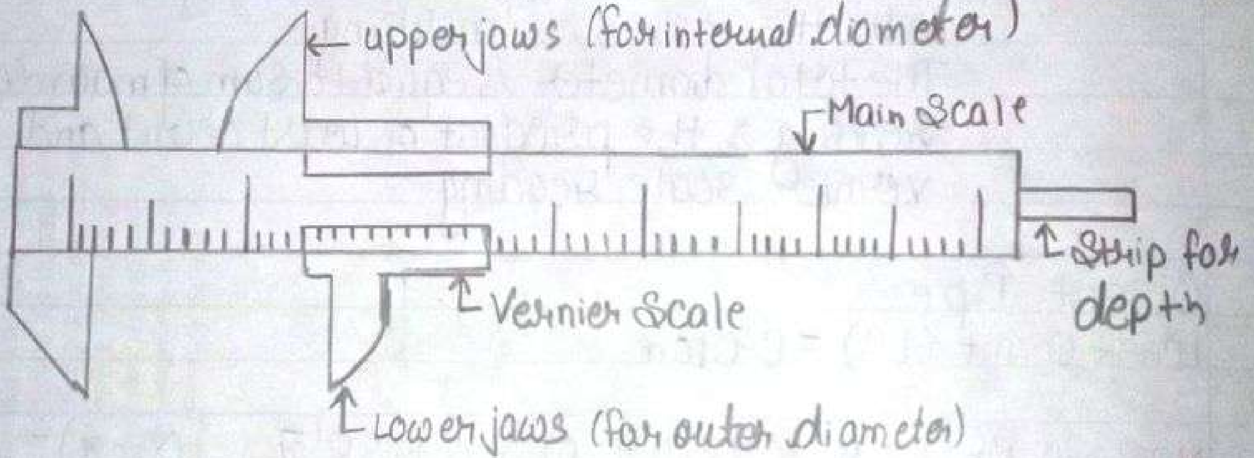

Fig:- Vernier Callipers

Table-1 Observation to obtain the diameter of given solid cylinder Using Vernier Callipe

S.No	MSR (a) cm	VSR	(VSR)×(LC) (b) cm	Total (x) cm $x=a+b$	$\lvert x-\bar{x}\rvert$	$(x-\bar{x})^2$
1	7.4	2	0.02	7.42	0.02	0.0004
2	7.4	6	0.06	7.46	0.02	0.0004
3	7.4	2	0.02	7.42	0.02	0.0004
4	7.4	0	0	7.4	+0.04	0.0016
5	7.4	4	0.04	7.44	0	0
6	7.4	1	0.01	7.41	+0.03	0.0009
7	7.4	2	0.02	7.42	0.02	0.0004
8	7.4	8	0.08	7.48	0.04	0.0016
9	7.4	2	0.02	7.42	0.02	0.0004
10	7.4	0	0.00	7.40	0.04	0.0016
11	7.4	1	0.01	7.41	0.03	0.0009
12	7.4	3	0.03	7.43	0.01	0.0001
13	7.4	0	0.00	7.40	0.04	0.0016
14	7.4	9	0.09	7.49	0.05	0.0025
15	7.4	2	0.02	7.42	0.04	0.0016
16	7.4	7	0.07	7.47	0.03	0.0009
17	7.4	5	0.05	7.45	0.01	0.0001
18	7.4	7	0.07	7.47	0.03	0.0009
19	7.4	4	0.04	7.44	0.00	0.0000
20	7.4	3	0.03	7.43	0.01	0.0001
$n=20$				$\bar{x}=7.44$		$\sum_{1}^{20}(x-\bar{x})^2=0.016$

$$\sigma=\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}\simeq 0.03\text{ cm}$$

Date

Expt. No. 1B Page No.

Aim To find the diameter of a wire using Screw gauge.

Apparatus Screw Gauge & thin wire

Theory Least Count of a screw gauge is 0.0001cm.
The MSR is the maximum reading on the main scale before the zero of the circular scale.
The circular scale reading is the reading of CS which coincides with the zero of main scale.
The total diameter of the thin wire is the sum of MSR & the product of VSR & LC.

Object Thin Wire.
LC 0.0001cm

Table-1 Reading to obtain the zero error of the provided Screw gauge

S.No.	MSR(a) cm	V.SR	(VSR)·(LC) (b) cm	Total (y = a+b)
1	0	15	0.015	0.015
2	0	12	0.012	0.012
3	0	9	0.009	0.009
4	0	11	0.011	0.011
5	0	14	0.014	0.014

n=5 $\bar{y} = 0.012$

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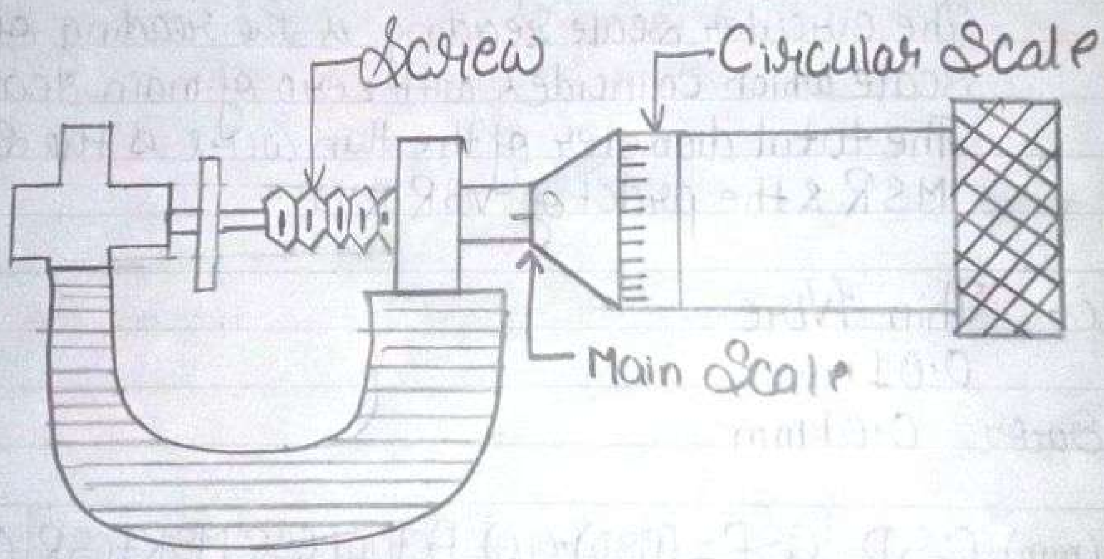

Fig:- Screw Gauge

Table-2 Observation to obtain the diameter of a wire using a screw gauge

S.No	MSR(l)cm	VSR	VSR x LC (m) cm	Total (l+m)	$\lvert(x-\bar{x})\rvert$	$(x-\bar{x})^2$
1	2	81	0.081	2.081	0.6085	0.37
2	3	36	0.036	3.036	0.3465	0.12
3	2	71	0.071	2.071	0.6185	0.38
4	2	85	0.085	2.085	0.6045	0.36
5	3	06	0.006	3.006	0.3165	0.10
6	2	62	0.062	2.062	0.6275	0.39
7	3	34	0.034	3.034	0.3445	0.12
8	3	06	0.006	3.006	0.3165	0.1
9	3	22	0.022	3.022	0.3325	0.11
10	3	0	0	3	0.3105	0.09
11	2	59	0.059	2.059	0.6305	0.39
12	2	61	0.061	2.061	0.6285	0.39
13	3	31	0.031	3.031	0.3415	0.11
14	3	21	0.021	3.021	0.3315	0.10
15	3	43	0.043	3.043	0.3535	0.12
16	3	15	0.015	3.015	0.3255	0.10
17	3	45	0.045	3.045	0.3555	0.12
18	3	22	0.022	3.022	0.3325	0.11
19	3	15	0.015	3.015	0.3255	0.10
20	2	75	0.075	2.075	0.6145	0.37
n=20				$\bar{x}=2.69$		$\Sigma = 4.128$

$$\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{N-1}} = 0.466 \simeq 0.47$$

Results The diameter of the wire came out to be
(2.69 ± 0.47) Cm

Precautions

- Backlash Error should be taken of.
- Parallax Error should be taken of
- Wire shouldn't be made tight by Screw Gauge

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Expt. No. 1C

Date

Page No.

Aim To determinge the angular position of a spectral Line on a prism spectrometer & estimate the uncertainity in its determination.

Theory Least Count / Vernier Constant $= 1\,MSR - 1\,VSR$

$$= \frac{1}{2}deg - \left(\frac{59}{60}\right)\frac{1}{2}deg$$

$$= \frac{1}{120}\ deg$$

Result The angular position of spectral Line is (33.4 ± 0.14) deg

Precautions

- The collimator must be so adjusted as to give out parallel rays
- The prism table must be optically Leveled.
- While taking observation of spectral Lines, the prism table must remain clamped.

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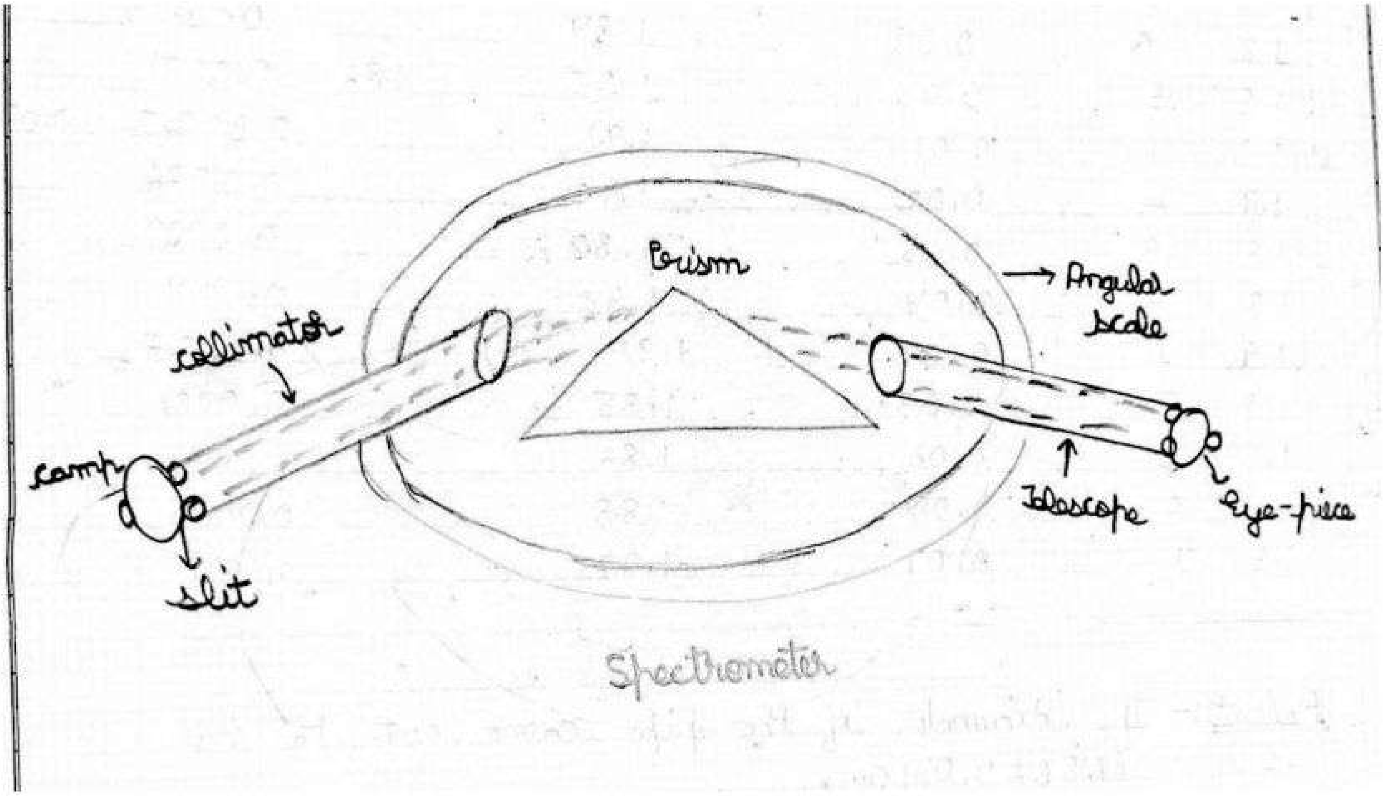
Table-1 Observations to obtain the angular position of a spectral Line on a prism spectrometer

S.No	MSR (a) deg	VSR	VSR×LC (b) deg	Total ($x = a+b$)	$\lvert x-\bar{x} \rvert$	$(x-\bar{x})^2$
1	33.5	38	0.304	33.804	0.176	0.030976
2	33.5	46	0.368	33.868	0.112	0.012544
3	33.5	55	0.44	33.94	0.04	0.0016
4	34	20	0.16	34.16	0.18	0.0324
5	33.5	39	0.312	33.812	0.168	0.028224
6	33.5	47	0.376	33.876	0.104	0.010816
7	34	12	0.096	34.096	0.116	0.013456
8	34	18	0.144	34.144	0.164	0.026896
9	34	15	0.12	34.12	0.14	0.0196
10	34	9	0.072	34.072	0.092	0.008464
11	33.5	51	0.408	33.908	0.072	0.005184
12	34	3	0.024	34.024	0.044	0.001936
13	33.5	43	0.344	33.844	0.136	0.018496
14	33.5	49	0.392	33.892	0.088	0.007744
15	34	9	0.072	34.072	0.092	0.008464
16	34	22	0.176	34.176	0.196	0.038416
17	34	15	0.12	34.12	0.14	0.0196
18	34	19	0.152	34.152	0.172	0.029584
19	33.5	37	0.296	33.796	0.184	0.033856
20	33.5	45	0.36	33.86	0.12	0.0144
N=20				$\bar{x} = 33.9868$		$\Sigma = 0.362656$

$$\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{N-1}} = 0.14$$


Prism
Angular
scale
collimator
camp
slit
Telescope
Eye-piece
Spectrometer

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Aim:- To determine the frequency of AC Mains with the help of Sonometer.

Apparatus:- Sonometer with non magnetic wire (Nichrome), Ammeter, Step down transformer (2-10 Volt), Key Horse Shoe Magnet, wooden Stand for mounting the magnet, set of 50gm masses, screwgauge & metre scale.

Theory:- Sonometer wire stretched under a constant load be placed in a uniform magnetic field applied at right angles to the sonometer wire in the horizontal plane & an alternating current of low voltage be passed the wire. The wire will be deflected on account of interaction between magnetic field & the ~~ac~~ wire current ($\vec{F} = i\,\vec{l} \times \vec{B}$) The direction of deflecⁿ is given by Fleming's Left hand rule. As the current is alternating, for half the wire will ~~be~~ move upward & for next half the wire will move downwards.

The frequency of AC mains, which is equal to the freq of vibration of the sonometer wire in its fundamental node i.e. having two nodes & one antinode is given by (under condition of resonance)

$$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

T = tension applied on the wire.

l = Length of sonometer between bridges.

m = Mass per unit Length of sonometer wire.

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Table-1: Observations for resonating length of wire for all various values of tension.

S.No	m (g)	T (dyne)	$\sqrt{T}$ $(dyne)^{1/2}$	While moving the Knife edges	Position of Knife edge 1st (cm)	Position of Knife edge 2nd (cm)	Length ℓ (cm)	freq f (Hz)	$(\bar{f}-f)$	$(\bar{f}-f)^2$
1	50	49000	221.36	apart	40.6	58.6	18	49.71	-0.1	0.01
2				close	40.0	57.3	17.3	51.72	1.91	3.64
3	100	98000	313.05	apart	37.2	62.8	25.6	49.43	-0.38	0.14
4				close	36.5	61.5	25	50.62	0.8	0.64
5	150	147000	383.41	apart	34.5	65.8	31.3	49.52	-0.3	0.09
6				close	34.8	66.8	32	48.43	-1.38	1.90
7	200	196000	442.72	apart	30.1	66.3	36.2	49.44	-0.38	0.14
8				close	31.4	67.2	35.8	49.99	0.18	0.0324
9	250	245000	494.97	apart	28.5	68.9	40.4	49.53	-0.29	0.0841
10				close	27.4	67.0	39.6	50.53	0.71	0.5041
11	300	294000	542.22	apart	25.2	69.8	44.6	49.14	-0.67	0.4489
12				close	24.0	68.1	44.1	49.7	-0.10	0.0121

$\bar{f} = 49.81$

$\sum_{1}^{n}(\bar{f}-f)^2 \Rightarrow 7.66$

$\mu = 0.0153\ g/cm$

$\boxed{\text{Frequency} = (49.81 \pm 7.66)\ Hz}$

Date

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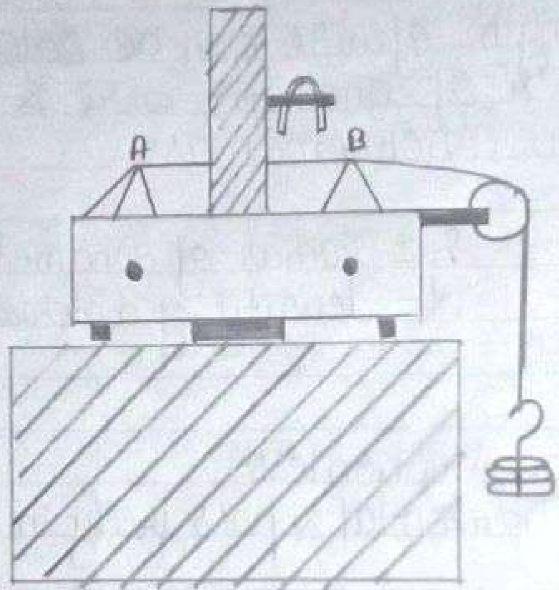
The mass per unit length of wire can be calculated in terms of the radius 'r' of sonometer wire & the density d of the material wire (Nichrome) as:-

$m = \pi r^2 d$

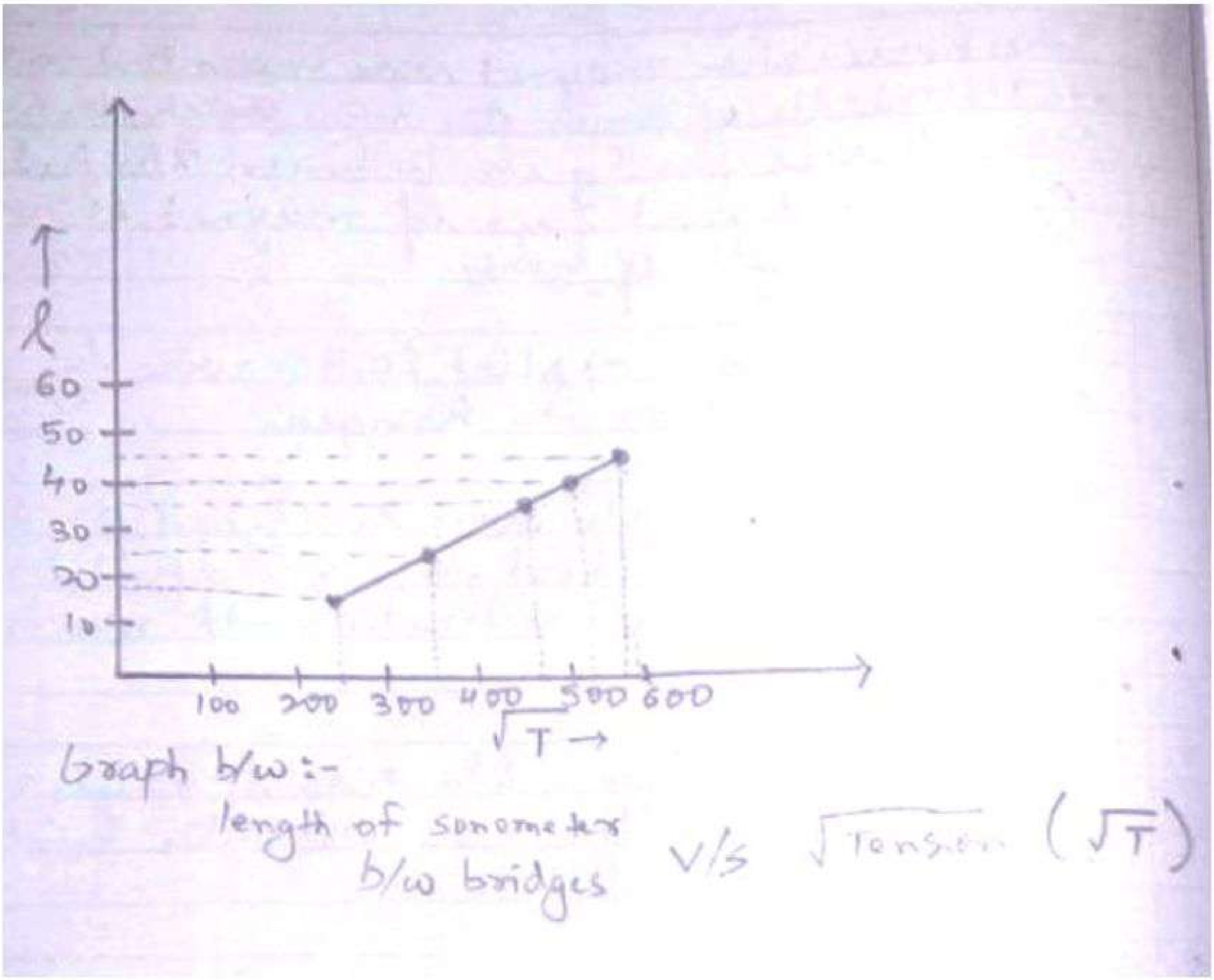
r = radius of sonometre wire.
d = density of material wire.

Precautions -

1. The pulley should be frictionless.
2. The wire should be horizontal & pass freely in between the poles of magnet.
3. The sonometer wire & the clamp used to hold the magnet should be non-magnetic.



Experimental setup for determination of frequency of AC Mains using sonometre


l
60
50
40
30
20
10
100 200 300 400 500 600
√T →
Graph b/w :-
length of sonometer b/w bridges V/s √Tension (√T)

Expt. No. 3 Date

Page No.

Aim To determine the resistance per unit length of a Carey Foster's Bridge wire and then to find the ~~resistance~~ resistivity of a material of a given wire

Apparatus Carey's Foster Bridge, Leclanche cell, Weston Galvanometer, 1-Ohm coil, sliding rheostat of small resistance, Plug key, Thick copper strips, Shunt wire & Connecting wire

Theory
$$\frac{P}{Q} = \frac{X + \sigma(l_1 + \alpha)}{Y + \sigma(100 - L_1 + \beta)} \quad (1)$$

$$\frac{P}{Q} + 1 = \frac{X + Y + \sigma(100 + \alpha + \beta)}{Y + \sigma(100 - L_1 + \beta)} \quad (2)$$

$$\frac{P}{Q} = \frac{Y + \sigma(L_2 + \alpha)}{X + \sigma(100 - L_2 + \beta)} \quad (3)$$

$$\frac{P}{Q} + 1 = \frac{X + Y + \sigma(100 + \alpha + \beta)}{X + \sigma(100 - L_1 + \beta)} \quad (4)$$

$$Y + \sigma(100 - L_1 + \beta) = X + \sigma(100 - L_2 + \beta) \quad (5)$$

$$X - Y = \sigma(L_2 - L_1) \quad (6)$$

Working
$$R = \sigma(L_2 - L_1)$$

$$\sigma = \frac{R}{L_2 - L_1} \quad (7)$$

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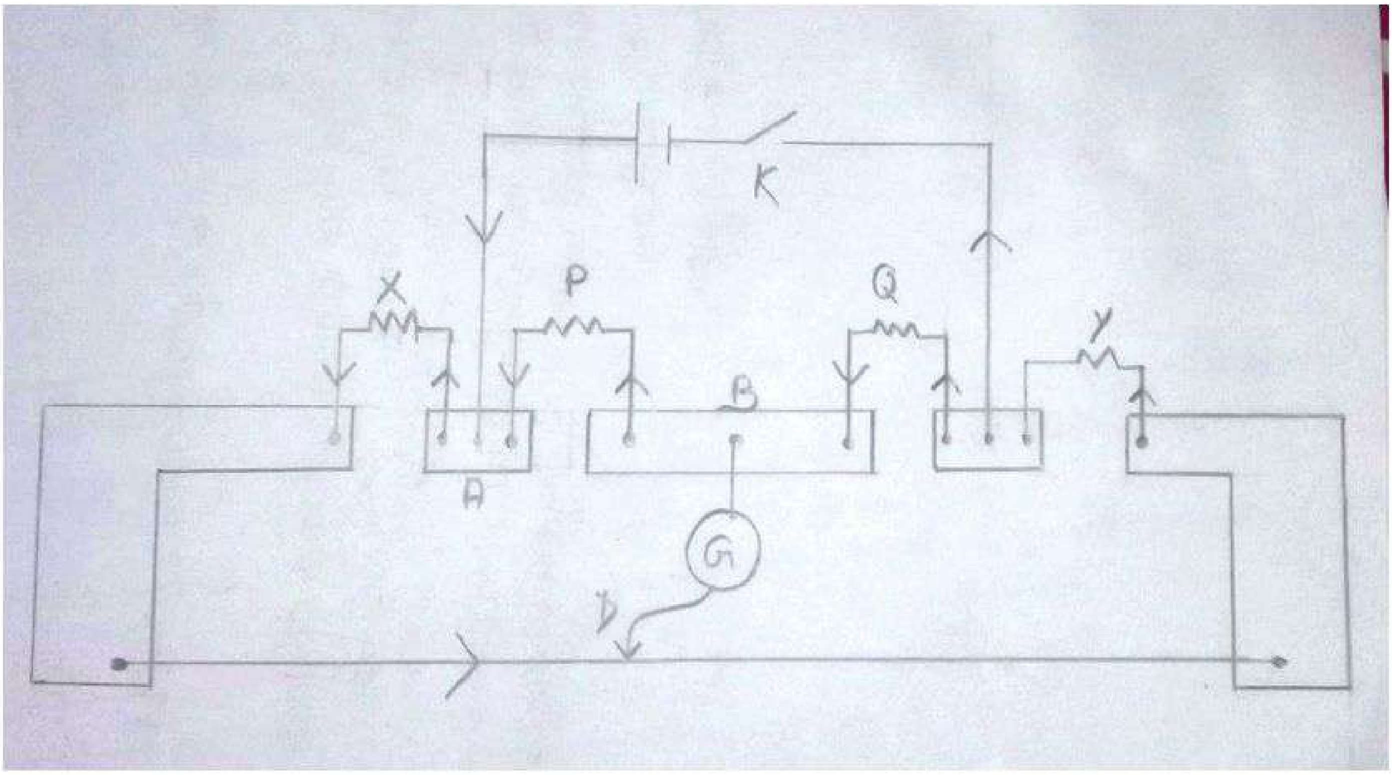
K
X
P
Q
Y
B
A
G
D

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$$X - Y = \sigma(l'_2 - l'_1) \quad (8)$$

$$X = \sigma(l'_2 - l'_1) + Y \quad (9)$$

This eqn can be used to calculate X, if σ is determined from eqn 7

$$X = \frac{\rho l}{a} \quad (10)$$

$$\rho = \frac{Xa}{l} \; \Omega\text{-cm} \quad (11)$$

Observations

- length of wire $L = 15$ cm
- Resistance per unit Length: $\sigma = \frac{1}{(l'_2 - l'_1)} \; \Omega/\text{cm}$

$$\boxed{\sigma = 0.047 \; \frac{\Omega}{\text{cm}}}$$

- ~~Standard~~ $X = 0.7755 \; \Omega$

Resistivity $\rho = \frac{Xa}{l} \; \Omega\text{-cm}$ $\quad \boxed{a = 1 \Omega}$

$$\rho = 0.0517 \; \Omega\text{-cm}$$

Table-1 Readings for balancing Length of CF bridge wire for determination of its resistance per unit Length.

S.No	P=Q	Position of Balance Point l'_1	l'_2	$(l'_2 - l'_1)$ (in cm)	$\sigma_i = \frac{1}{l'_2 - l'_1}$	$\bar{\sigma} - \sigma_i$	$(\bar{\sigma} - \sigma_i)^2$
1	5	32.5	56.8	24.3	0.041	0.006	0.000036
2	5	36.1	54.3	18.2	0.055	-0.008	0.000064
3	5	33.9	53.6	19.7	0.051	-0.004	0.000016
4	5	30.4	51.2	20.8	0.048	-0.001	0.000001
5	5	39.3	64.7	25.4	0.039	0.008	0.000064

$\bar{\sigma} = 0.047$

Table-2 Reading for balancing lengths of a CF bridge wire for determination of resistance of a given wire.

S.No	P = Q	Pos of Balance L		$L_2 - L_1$	$X = \sigma(L_2 - L_1)$	Mean ($\bar{X}$) − X	$(\bar{X} - X)^2$
		L_1	L_2				
1	5	22.4	42.2	19.8	0.9306	-0.1551	0.024
2	5	27.7	44.6	16.9	0.7943	-0.0188	0.0003
3	5	20.2	34.8	14.6	0.6862	+0.0893	0.007
4	5	23.8	36.5	12.7	0.5969	+0.1786	0.031
5	5	28.3	46.8	18.5	0.8695	-0.094	0.008

$\bar{X} = 0.7755$

Date

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Experiment

Aim Use a CRO to make experiments & to make measuremen on a sinusoidal signals generated by function generator and obtain their frequencies and voltage amplitude.

Apparatus

1) Cathode Ray Oscillascope
2) Multimeter
3) Oscillator

Theory An oscilloscope is an electronic measuring device which provides a 2-D visual representation of a signal. Because the oscilloscope allows the user to see the signals, their characteristic can be easily measured and observed.

The oscilloscope displays a graph voltage vs time most electrical circuits can be easily connected to the oscilloscope typically with problems.

Procedure Phase Measurement using Dual trace

One can ~~easily~~ approximately measure the phase difference between ~~the~~ two signals by entering signal to two inputs V_1 & V_2 of a dual trace CRO & noting the shift to peak positions. The shift is measured on the time scale & then converted into phase difference.

Calculate Frequency using $f = \frac{1}{T}$

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Table-1 Measurement of voltage amplitudes of sinusoidal signals using cathode ray oscilloscope.

S.No	Voltage from Source V_0 (V)	Voltage Measured on CRO: Y-amplifier (V/div)	Vertical span of waveform	V_{pk-pk} (V)	Ratio $\frac{V_{pk-pk}}{V_0}$
1	1·8	0·5	3·4 div	1·7	0·94
2	10·5	2	5·2 div	10·4	0·99
3	9·5	2	4·8 div	9·6	1·01
4	13·0	5	2·6 div	13	1
5	6·1	1	6·2 div	6·2	1·01

Table-2 Measurement of frequencies of sinusoidal signals using Cathode Ray Oscilloscope

S.No	Frequency from Source f_0 (Hz)	Frequency measured on CRO: Time-base knob setting (Time/div)	No of peaks along time axis	No. of div spanned	Freq f	Ratio $\frac{f_0}{f}$
1	2035 Hz	1 ms	17	8·4 div	2023·8	1·005
2	190 KHz	5 µS	9	9·6 div	187500	1·013
3	440 Hz	2 mS	8	8·8 div	454·5	0·96
4	2 Hz	1 S	13	6·4 div	2·0	1
5	75 Hz	10 mS	5	7·2 div	69·4	1.08

Calculation

←

Formula Used

1) Calculating (V_{pk-pk}) Voltage = $\left(\frac{V}{dv}\right)$ (vertical span)

2) Calculating frequency => {as $f = 1/T$}

(No. of peaks along time axis × Time Period = No. of disc spanned × Time / div)

Result and Discussion

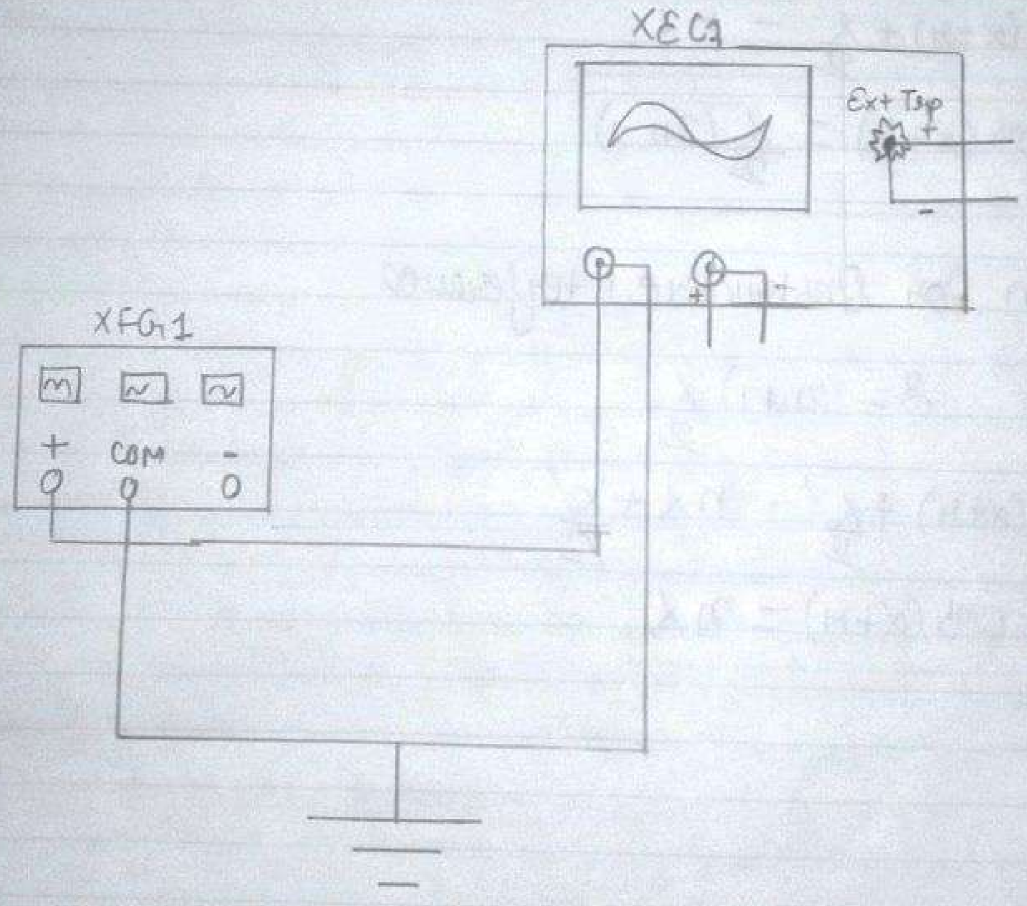
∴ Hence voltage amplitudes of sinusoidal signals using Cathode Ray is approx (≃) 1 $\left[\frac{V_{pk-pk}}{V_0}\right]$

∴ Hence frequency of sinusoidal signals are $\frac{f_0}{f} - 1$

Precaution

1) To clear the measurements from the screen, press the blue shift button and then press the clear button.

2) Be sure to turn off oscilloscope.



Circuit Diagram for the measurements voltage, time period & frequency

Expt. No. 4 Page No.

Aim To obtain the frequency response of a series LCR circuit & determine its quality factor for different values of R.

Apparatus Cathode Ray Oscilloscope (CRO) with probe, Funcⁿ Generator, Inductor, Capacitor, decade resistance box, 1 KΩ resistor, connecting wires with BNC & crocodile clip terminations.

Theory If we apply a sinusoidal voltage to a series LCR circuit the net impedance offered by the circuit to flow of current will be the vector sum of that offered by the resistive part as well as reactive part i.e

$$Z = \sqrt{R^2 + X^2} \quad \text{or} \quad \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

The current in the circuit is given by $I = \frac{\mathcal{E}}{Z}$

$$\text{or } I = \frac{\mathcal{E}}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

The phase angle between the applied voltage & current is given by

$$\phi = \tan^{-1}\left(\frac{\omega L - 1/\omega C}{R}\right)$$

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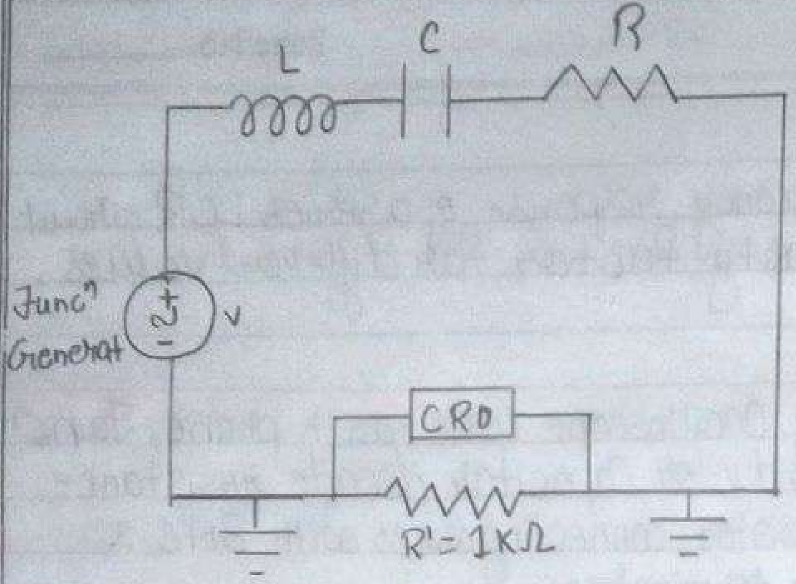
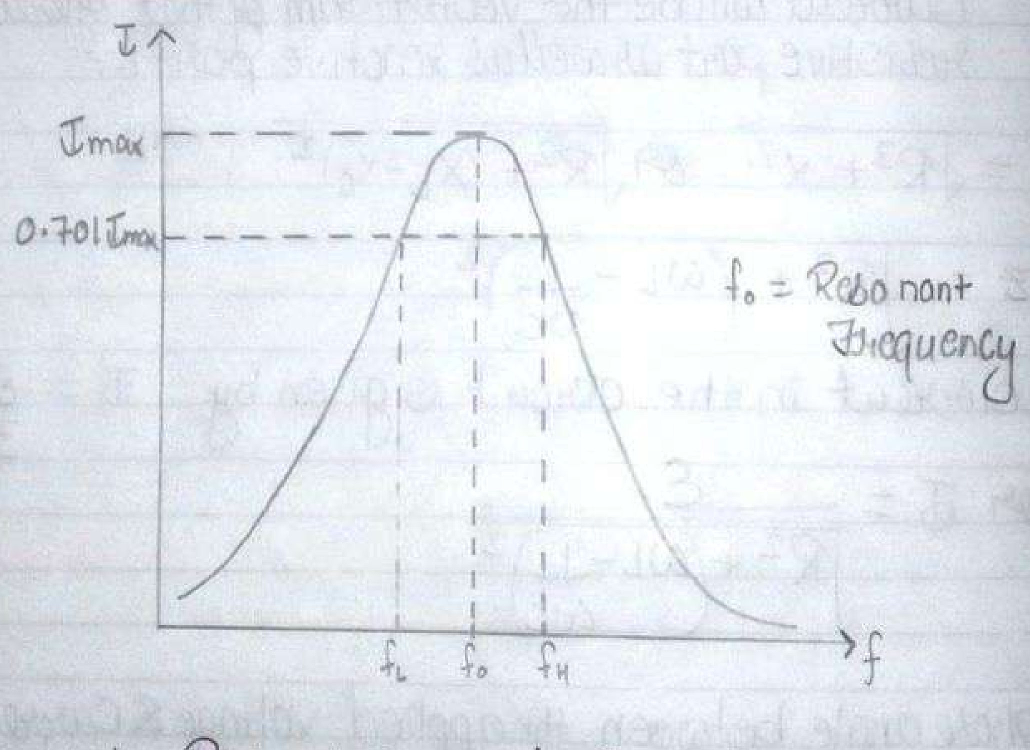


Fig1:- Schematic Representation of Series LCR circuit



Approximate Plot of Current I v/s frequency

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If the frequency (ω) of applied voltage matches the natural frequency (ω_0) of the circuit, then maximum current will be flowing the circuit as the inductive reactance & capacitive reactance equals each other i.e

$$\omega_0 L = \frac{1}{\omega_0 C}$$

Thus the resonant frequency of an LCR circuit:-

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

The maximum current flowing through the circuit

$$I_{max} = \frac{V}{R} = \frac{\varepsilon}{R}$$

$$\text{Quality Factor }(Q) = \frac{X_L}{R} = \frac{\text{Resonant Freq}}{\text{Bandwidth}} = \frac{f_R}{f_2 - f_1}$$

Procedure

1) Inductor (L), Capacitor (C), Resistor (R & 1KΩ) are connected in series with 2 extreme ends connected to the Funcn Generator

2) Oscilloscope is connected across the 1KΩ resistor
3) The circuit is connected as shown in figure.
4) Now, the frequency of the signal is varied slowly from lower to higher end & corresponding voltage amplitude is noted for a particular value of Resistance $R = 20\Omega$.

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S.No.	Freq v (Hz)	Current, I (mA)		
		R=20 Ω	R=100 Ω	R=400 Ω
1	100	0.001257	0.001257	0.001256
2	200	0.002514	0.002513	0.002511
3	300	0.003771	0.003771	0.003761
4	400	0.00503	0.005028	0.005004
5	500	0.006289	0.006286	0.00624
6	600	0.00755	0.007545	0.007466
7	700	0.008813	0.008805	0.00868
8	800	0.010078	0.010066	0.00988
9	900	0.011345	0.011328	0.011065
10	1000	0.012615	0.012591	0.012233
11	2000	0.025528	0.02533	0.022742
12	3000	0.039058	0.038362	0.030795
13	4000	0.053578	0.051822	0.036579
14	5000	0.069544	0.065828	0.04063
15	6000	0.087552	0.080463	0.043459
16	7000	0.108419	0.095751	0.045451
17	8000	0.133318	0.11162	0.046867
18	9000	0.164014	0.127855	0.047882
19	10000	0.2033	0.144045	0.04861
20	20000	0.398095	0.181638	0.049671
21	30000	0.146078	0.118793	0.047359
22	40000	0.094125	0.085476	0.0442
23	50000	0.070662	0.066774	0.04085
24	60000	0.056974	0.054877	0.037607
25	70000	0.047897	0.04663	0.034608
26	80000	0.041393	0.040567	0.031901
27	90000	0.036485	0.035916	0.029486
28	100000	0.032641	0.032231	0.027342
29	200000	0.016015	0.015966	0.015253
30	300000	0.01064	0.010625	0.010407
31	400000	0.00797	0.007964	0.007871
32	500000	0.006373	0.006369	0.006322
33	600000	0.005309	0.005307	0.005279
34	700000	0.00455	0.004548	0.004531
35	800000	0.00398	0.00398	0.003968
36	900000	0.003538	0.003537	0.003529
37	10000000	0.003184	0.003183	0.003177

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5) The value of R is changed to 100 Ω & 400 Ω & the readings are noted respectively

6) The graph of current (I) vs frequency f is plotted for different value of R = 20 Ω, 100 Ω, 400 Ω.

Observations & Results

$C = 1\,nF = \cancel{10^{-9}f}\ 10^{-9}\,f$

$L = \dfrac{1}{4\pi^2 f_0^2 C} = \cancel{1.5\times10^{8}\,H}\ \cancel{2\times10^{14}\,H}\ 3\times10^{-1}\,H$

$f_0 = 10^4$
$f_2 = 20\times10^3$
$f_1 = 8\times10^3$

$\boxed{\begin{array}{l} Q_1 = 9\times10^2 \\ Q_2 = 2\times10^2 \\ Q_3 = 5\times10^1 \end{array}}$

Precautions

1) Reading should be noted carefully.
2) The connections must be tight.
3) The circuit should not be left connected for a long period of time.

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Aim To determine the refractive Index of the material of a prism using spectrometer.

Apparatus Source of Light (Sodium Vapour Lamp), Prism, Spectrometer, Spirit Level

Theory Consider a ray of light EF incident on one of the refracting faces that gets refracted along the path FG in the prism & emerges along the path GH as shown in the Fig 1. The angle between produced incident ray (original direction of the ray) & emergent ray is called angle of deviation D. For refracⁿ through a prism

$$i + e = A + D$$

where i & e are the angle of incidence & angle of emergence respectively. A is the angle of prism & D is the angle of deviation.

Angle of deviation D depends upon the angle of incidence i. For certain angle of incidence, the angle of deviation is minimum, denoted by D_m. Refractive index of material of the prism (μ) is related to the angle of prism A and the angle of minimum deviation D_m through the relation

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

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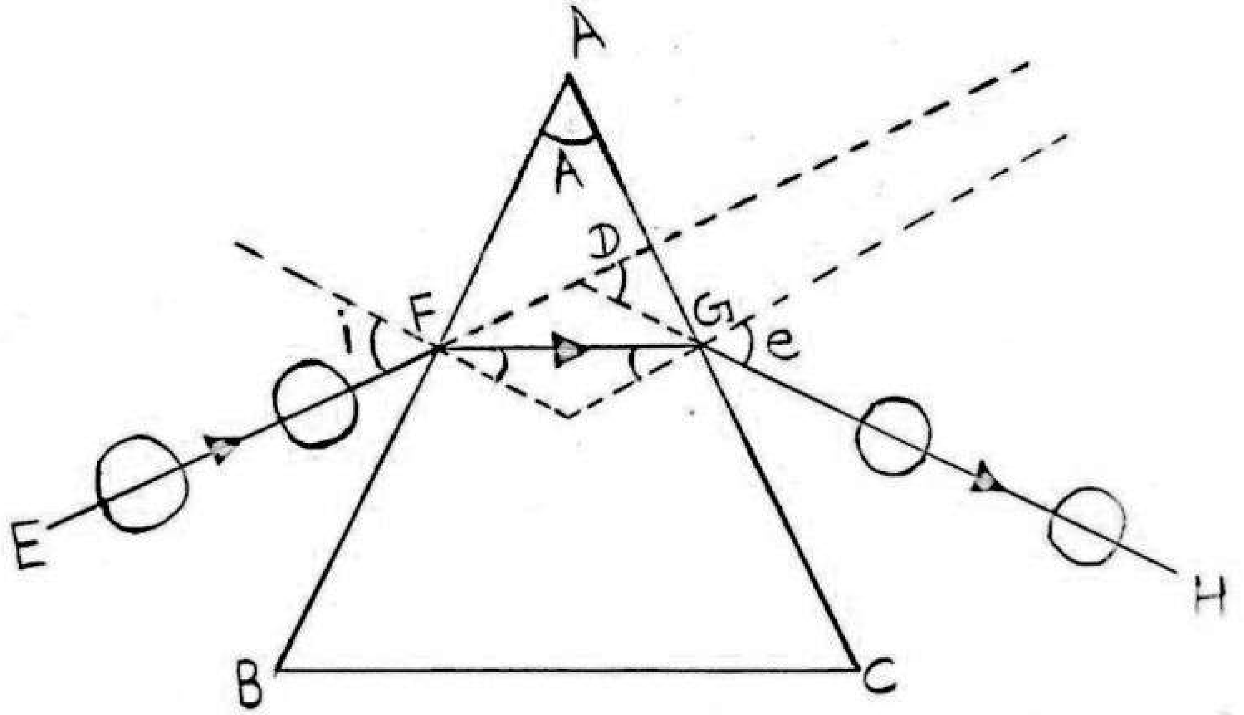
A
A
D
i
F
G
e
E
H
B
C

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Note that when prism is at minimum deviation position, the angle of incidence & angle of emergence are equal that is $i = e$.

Procedure Measurement of refractive Index of the prism consists of two parts:-

① Determination of the angle of prism A.

② Determination of angle of minimum deviation D_m.

A Measurement of the angle of the prism

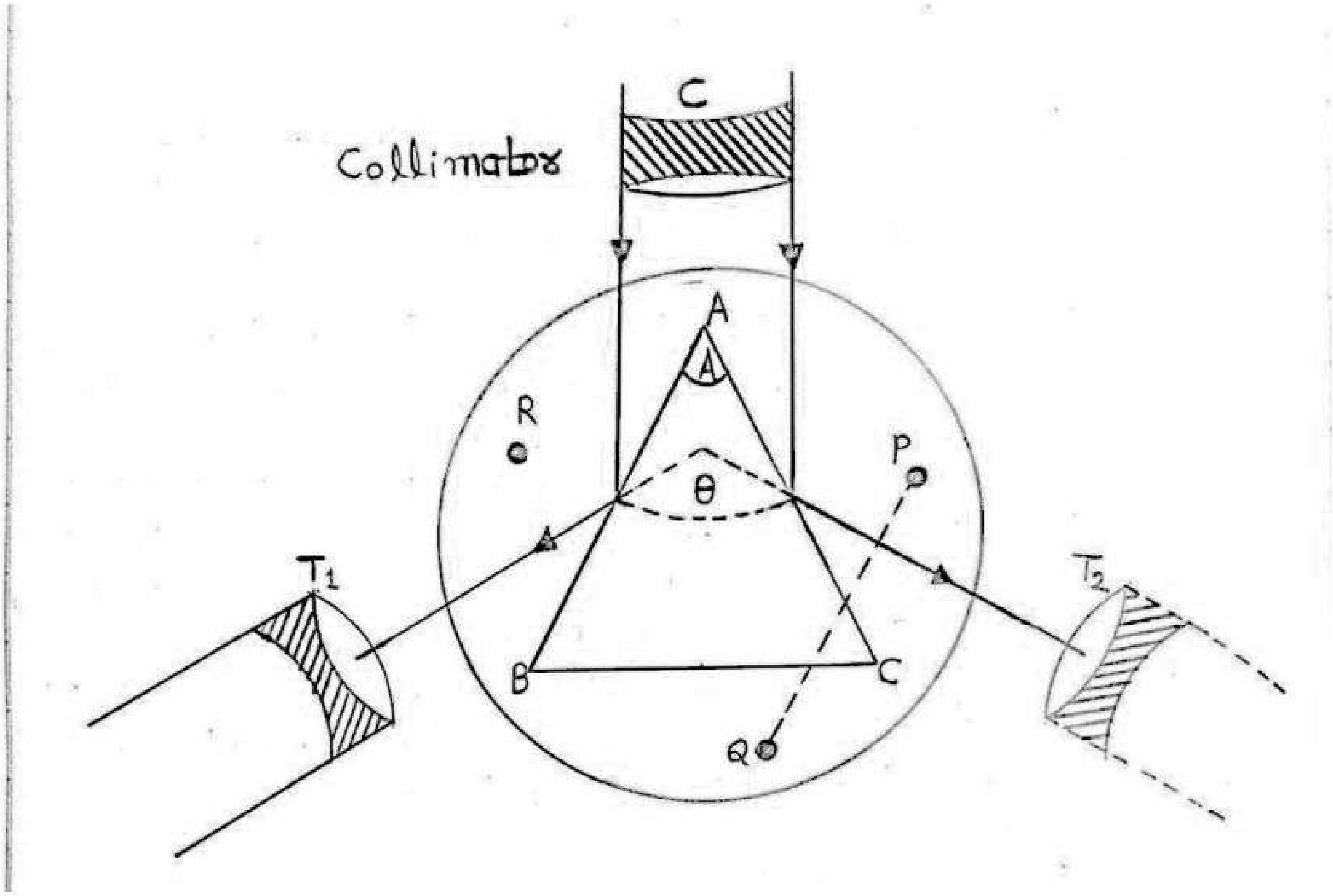
1) Determine the least count of the spectrometer
2) Level the spectrometer & the prism table.
3) Place the prism on the table with edge A towards the collimator. In this configuration light from collimeter falls on each face & reflected light can be received using the telescope & image of the slit can be seen.
4) The telescope is moved to one side to receive the light reflected from the face AB, the crosswire is coincided with image of slit & readings of both spectrometer scales are taken.
5) The telescope is moved in other side to receive the light reflected from the face AC again the crosswire is coincided with image of the slit & readings of both spectrometer scales are taken.

(b)Table for the angle (A) of the prism

S.No.	Scales	Telescope Reading for Reflection						Difference $\theta = a - b = 2A$	Mean Value of 2A	A	Mean A Degree
		From 1st face of prism			From 2nd face of prism						
		MSR	VSR	TR (a)	MSR	VSR	TR (b)				
1	S1	283	3	283.05	164	23	164.3833333	118.6666667	-61.1065	-30.55325	
	S2	102.5	56	103.4333333	343.5	44	344.2333333	-240.8			
2	S1	282.5	32	283.0333333	164	12	164.2	118.8333333	-61.217	-30.6085	**-30.65725**
	S2	102.5	36	103.1	343.5	52	344.3666667	-241.2666667			
3	S1	282.5	46	283.2666667	164.5	15	164.75	118.5166667	-61.62	-30.81	
	S2	103	4	103.0666667	344	50	344.8333333	-241.7666667			

(c) Table for the angle of minimum deviation (D_m):

S.No.	Scales	Telescope Reading for minimum deviation			Telescope Reading for direct image			Difference	Mean Value of D_m
		MSR	VSR	TR (a)	MSR	VSR	TR (b)	$D_m = a - b$	
1.	S_1	265.5	06	265.6	224.5	54	225.4	40.2	40.38
	S_2	85.5	15	85.75	45.0	12	45.2	40.55	
2.	S_1	265.0	52	265.87	225.0	15	225.25	40.62	40.43
	S_2	85.5	08	85.63	45.0	24	45.4	40.23	
3.	S_1	265.5	14	265.73	225.0	11	225.18	40.55	40.5
	S2	85.5	25	85.92	44.5	56	45.43	40.49	
									40.44


C
Collimator
A
A
R
P
θ
T_1
T_2
B
C
Q

B Measurement of the angle of minimum deviation

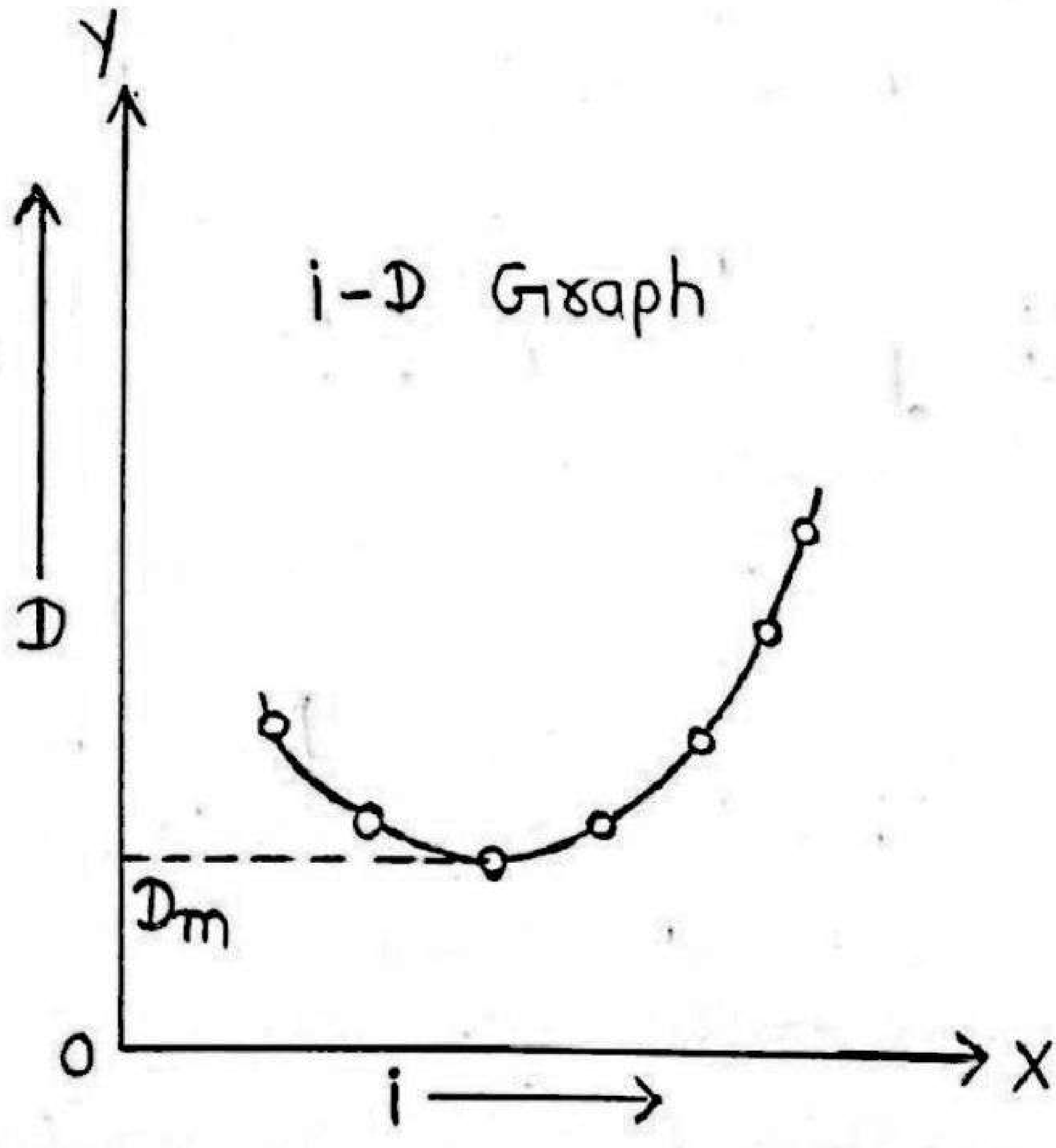
① Remove prism, see the slit directly through telescope, coincide the slit with crosswire and note the readings of both spectrometer scales (this is the direction in which light goes if there is no deviation).

② Place the prism so that its center coincides with the center of the prism table. Light falls on one of the polished faces and emerges through the other polished face, after refraction.

③ The emergent light is received through the telescope. Gradually adjust the telescope position & prism orientation to obtain the minimum deviation position. This is achieved in following way:

Move the telescope till image of the slit is in field of view. Rotate the prism table slightly and observe how the image moves. If it moves towards smaller deviation continue rotating prism table in same direction & if it moves towards larger deviation rotate prism table in opposite direction. Keep adjusting the telescope to keep the image in view. By doing so a position will be reached where image will begin to move in opposite direction (towards higher deviation) although the rotation of the prism table is continued in the same direction.

④ The difference between respective spectrometer scale readings at minimum deviation position & direct position gives the angle of minimum deviation Dm.


Y
i-D Graph
D
Dm
O
X
i

5) If polychromatic Light is used then repeat the above procedure for various wavelengths (colors) to obtain the angle of minimum deviation for each wavelength.

6) Another way to determine the angle of minimum deviation is measure angle of deviation for various angle of incidence and plot angle of deviation Vs angle of incidence, taking angle of incident i along the X-axis & Dm on Y-axis

Observations

(a) Value of the one division of main scale = 0.5°

(b) Total number of Vernier Scale Division = 60

60 division on Vernier Scale = 59 on Main Scale

Least Count of the spectrometre = $\frac{1}{60}$ degrees = 60 seconds

Calculations & Results

Angle of prism (A) = -30.65°

Angle of minimum deviation (Dm) = 40.44°

$$\text{Refractive index } (\mu) = \frac{\sin\left(\frac{A+Dm}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\mu = \frac{-0.984}{-0.37} = 2.65$$

Precautions

1. The telescope & collimeter are set individually for parallel race.
2. Narrow slit is taken
3. Reading from both the verniers were taken.

Exp - 6

Experiment To determine the wavelength of prominent spectral Lines of mercury (Hg).

Appartus Used Spectrometer, diffraction grating element mercury Lamp, grating table, reading Lens.

Theory Diffracⁿ grating is a thin film of clear glass or plastic that has a Large number of Lines drawn on it (15000 linch) When a Light from a source passes through diffraction it generates Large number of sources at the grating. The thin space between every two adjacent Lines of the grating become an independently such that each source sends act waves in all direction.

Let a beam of Light of wavelength λ which is incident making an angle 'i' with the normal to the plane of diffraction grating be diffracted through an angle 'θ'. The path difference between the diffracted rays from consecutive points (i.e from A & C) of transparent spaces -

$$\Rightarrow LC + CM = (e+d)(\sin\theta + \sin i)$$

where

AC = e+d is the grating element.

For the n^{th} order spectrum the condition is given by

$$(e+d)(\sin\theta + \sin i) = n\lambda$$

$$\Rightarrow 2(e+d)\left[\sin\left(\frac{i+\theta}{2}\right)\cos\left(\frac{i-\theta}{2}\right)\right] = n\lambda$$

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$$\sin\left(\frac{i+\theta}{2}\right) = \frac{n\lambda}{2(e+d)\cos\left(\frac{i-\theta}{2}\right)}$$

$$\boxed{i+\theta = D}$$

$$\sin\left(\frac{D}{2}\right) = \frac{n\lambda}{2(e+d)\cos\left(\frac{i-\theta}{2}\right)}$$

The value of $\sin[(i+\theta)/2]$ is minimum when $\cos[(i-\theta)/2]$ is maximum i.e. $i=\theta$.

If D_m is the angle of minimum deviation of diffracted beam from its original path, then

$D_m = i+\theta = 2i$ or $i=\theta$ at minimum deviation.

When the grating is used in the minimum deviation position then

$$2(e+d)\sin\left(\frac{D_m}{2}\right) = n\lambda$$

$$2\left(\frac{2.54}{N}\right)\sin\left(\frac{D_m}{2}\right) = n\lambda$$

N = Total number of Lines per inch of the grating.

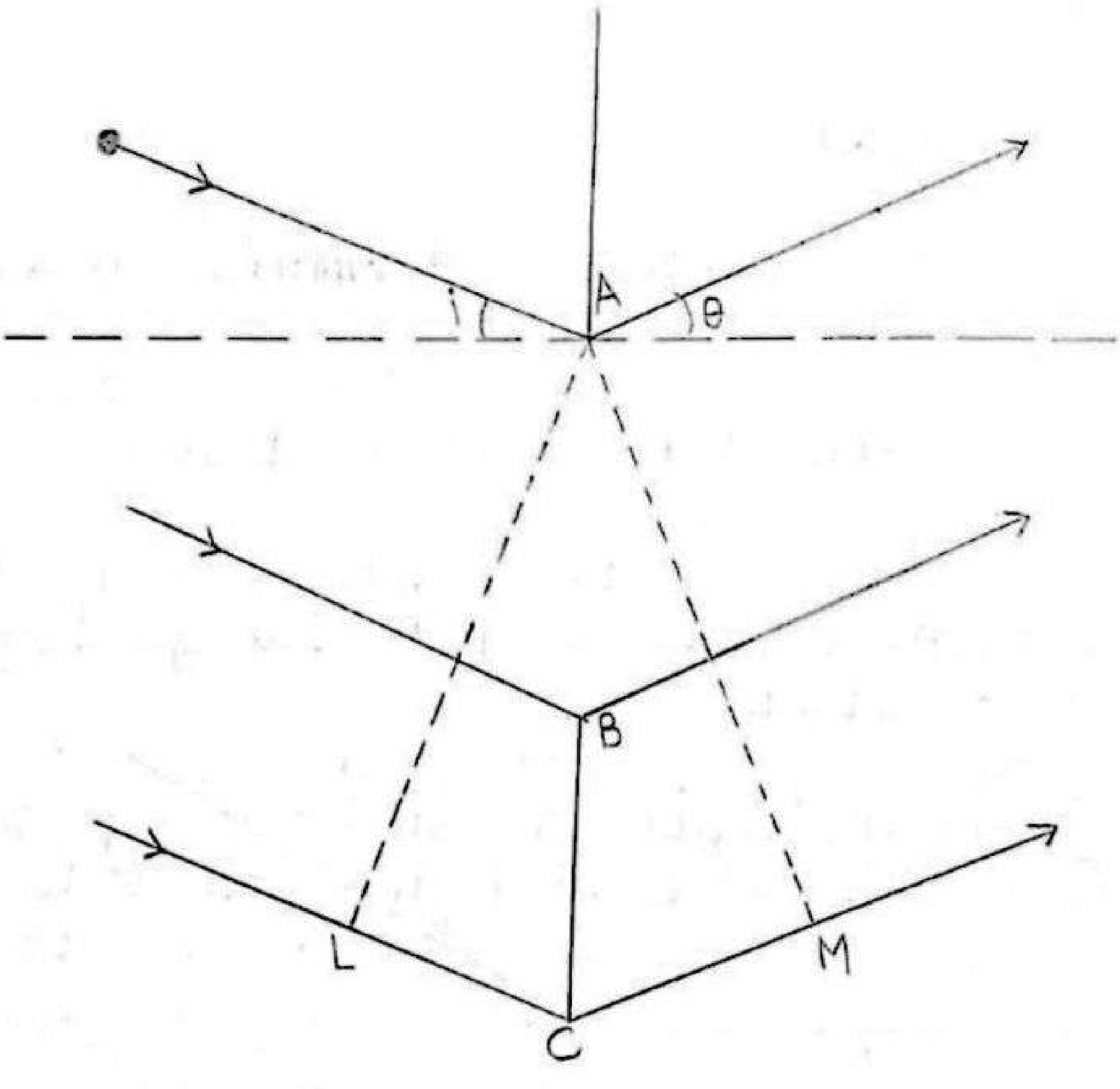

Fig.-1 : Diffracted rays from consecutive points

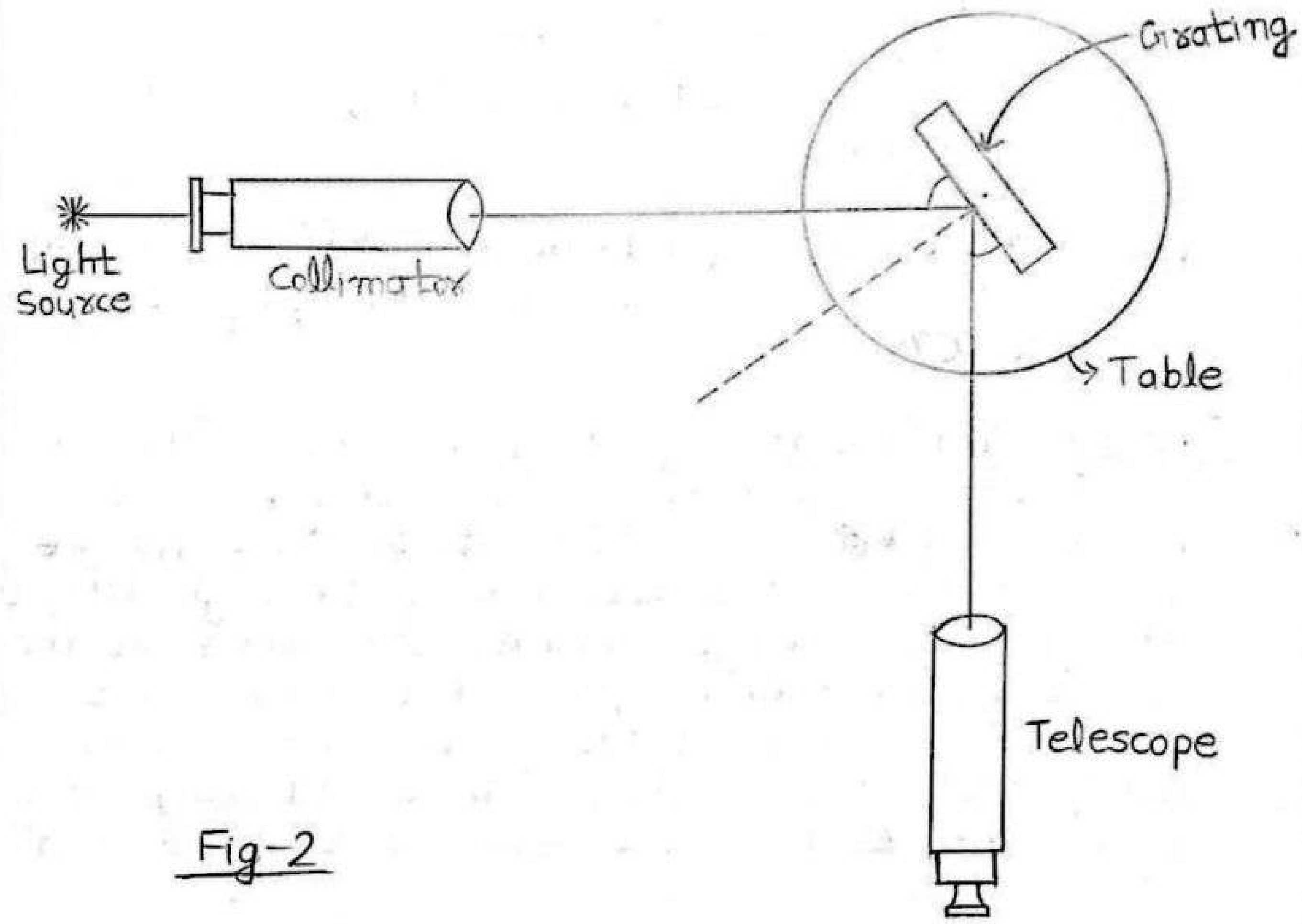

Fig-2

Procedure

① The Optical axes of the telescope & collimator should be perpendicular to the axis of rotation of the turn table.

② The telescope should be focused for parallel rays.

③ The telescope should be adjusted for rendering the ray from the illuminated slit parallel.

④ The turn table is rotated in a direction such that the spectrum of first order moves towards the direct image of the slit. A point is reached when the spectrum when ~~the spectr~~ becomes stationary for a moment & then reverse the direction of motion through the turntable is rotated in same direction. The turntable & telescope are clamped. Since θ is different for different spectral lines, the grating is to be set in the minimum deviation position separately.

Results The wavelength can be calculated using the formula

$$\lambda = \left(\frac{2 \times 25.4}{N}\right) \sin\left(\frac{D_m}{2}\right) \qquad n = 1, \quad N = 15000$$

For Blue color of Line $\lambda = 4596 \,\mathring{A}$.

For Green color of Line, $\lambda = 5770 \,\mathring{A}$

For Yellow color of Line, $\lambda = 6099 \,\mathring{A}$

Table-1: Observation table for angular positions of prominent lines on the spectrum of mercury.

Color	Diffracted ray positions (deg)												Difference 2θ (deg)			θ (deg)	λ (Å)
	Left						Right										
	Window - A			Window - B			Window - A			Window - B							
	MSR	VSR	Total	MSR	VSR	Total	MSR	VSR	Total	MSR	VSR	Total	Win-A	Win-B	Mean		
Blue 4358	68.0	9	68.3	248	29	248.12	99	26	99.26	279.5	7	279.52	31.13	31.4	31.2	15.6	4596
Green 5461	64.0	10	64.15	244	22	244.09	103	23	103.22	283.5	2	283.51	39.07	39.42	39.24	19.62	5710
Yellow 5780	63.0	3	63.05	243	8	243.03	104.5	5	104.56	284.5	16	284.56	41.49	41.53	41.51	20.75	6099

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Precautions

(1) The telescope must be so adjusted to receive parallel rays from slit.

(2) The grating table must be optically Levelled.

(3) The slit should be as narrow as possible & parrallel to the ruled surface of the grating.

(4) While handling the grating one must hold it between the thumb and fingers by edges only.

(5) The grating must be clamped while taking observation of the spectral Lines.

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Aim To determine Electromotive force of an unknown cell using a stretched wire potentiometer

Apparatus Required Stretched wire potentiometer, jockey galvanometer, power source cell, standard cell, rheostat, resistance box, connecting wire, plug & key.

Theory If a current 'i' flows through the potentiometer wire of L cm & resistance R_p ohm. If R is the series resistance with potentiometer then

$$i = \frac{E}{R+R_p} \quad (\varepsilon = \text{emf of cell})$$

The potential drop across the end A & B of the potentiometer wire is

$$V = i \times R_p = \frac{\varepsilon}{R+R_p} \times R_p \text{ Volts}$$

Hence, the potential drop per cm of wire is

$$v = \frac{V}{L} = \frac{\varepsilon}{R+R_p} \times \frac{R_p}{L}$$

If C_1 & C_2 cells of emfs ε_1 & ε_2 respectively are connected to circuit & the required lengths of the

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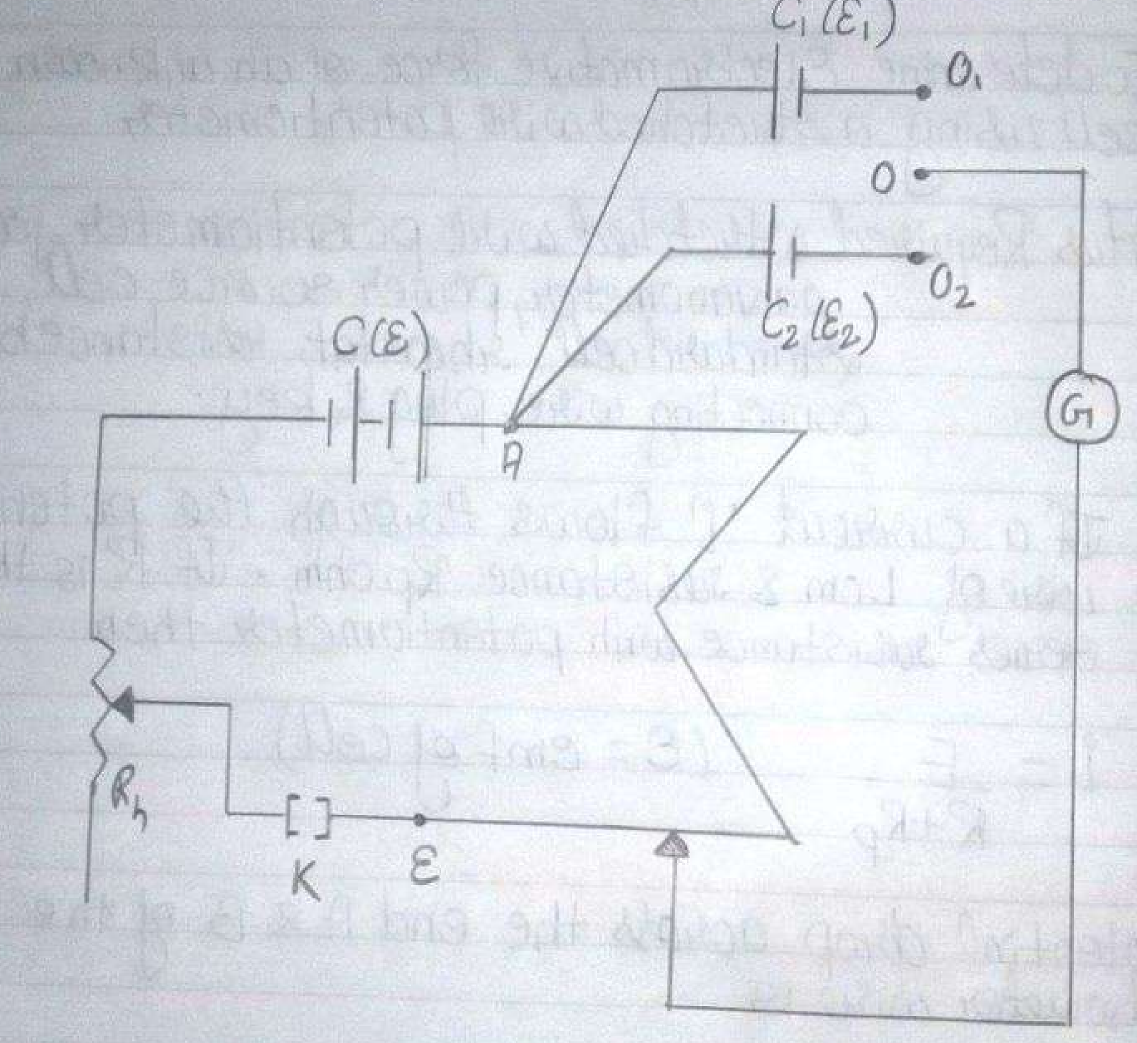

Circuit diagram to determine the emf of Onknown cell.

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potentiometer wire for balance are l_1 & l_2 then emf $\mathcal{E}_1$ & $\mathcal{E}_2$ are given by

$$\mathcal{E}_1 = \phi l_1 = \frac{\mathcal{E}}{R+R_p} \times \frac{R_p}{L} \times l_1 \text{ volts}$$

$$\mathcal{E}_2 = \phi l_2 = \frac{\mathcal{E}}{R+R_p} \times \frac{R_p}{L} \times l_2 \text{ volts}$$

The ratio of emf of two cells is.

$$\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{l_1}{l_2}$$

Procedure

1) The apparatus was connected as shown in figure. The positive terminal of the power supply was connected to the end A of the potentiometer wire & negative through the rheostat.

2) The positive terminal of the two cells C_1 & C_2 were connected to A & the negative terminal to the binding sources O_1 & O_2 of the 2 way K1.

3) The third binding screw was joined to one terminal of the galvanometer to the Jockey.

4) The resistance R_h was made zero & resistance R_p maximum. Put the jockey in contact with the first & last wire

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5) The same process was repeated for C

6) After verifying the deflection, null point was found for both C_1 & C_2.

7) If the Length of C_1 is greater than that of C_2 then emf $\mathcal{E}_1$ is greater them EMF for $\mathcal{E}_2$ of C_2.

8) Rheostat can be adjusted for different values and readings were taken

Observations Reading of the balancing Length of potentiometer wire for the determination of emf of a given cell using the stretched wire arrangement.

Result The emf of unknown cell is $\frac{e_1+e_2+e_3}{3} = 1.5161\,V$

Precautions

1) All the connections terminals should be clean and tight
2) Jockey should be held vertical.
3) Area of crossectional of wire should be uniform otherwise potential gradient will not be constant.

4)

S No	Gradient-1		Gradient-2		Gradient-3	
	L1	L2	L1	L2	L1	L2
1	556.4	864.1	360.4	521	198.5	326.2
2	562.5	851	343.5	510.3	215.4	307
3	589	863.5	359.1	543.9	189.2	318.7
4	530.1	878.2	346.5	563.7	220.6	302.3
5	590.9	830.7	365.8	526.2	247.4	298.6
Average	565.78	857.5	355.06	533.02	214.22	310.56
x= L2 / L1	1.515606773		1.501211063		1.449724582	
e = x * E	1.543342377		1.528683225		1.476254542	

The emf of Western Cadmium standard cell is E = 1.0183 volts

Aim: To verify the lorentz force relation for a current carrying conductor placed in a unifor magnetc Field.

Apparatus Required A digital balance, large power & supply current limiting resistor, ammeter, current balance apparatus, rod, clamp, magnets.

Theory When a conducting wire is kept in a uniform magnetic field then the free $e^{\ominus}s$ (in the conducting particle) flow with velocity V_d & experience Lorentz force $\vec{F} = q(\vec{V_d} \times \vec{B})$. Hence a resultant force works on the conductor.

According to the figure 1 suppose the length of the current carrying conductor is L & the cross sectional area is A. The number of $e^{-}s$ in the unit volume of the $\vec{F} = I(\vec{l} \times \vec{B})$ ①

Suppose, I magnitude current is flowing in the conductor & conductor rod makes an angle θ with magnetic field $\vec{B}$.

If the free electrons are moving with speed V_d then magnitude force on them

$$|\vec{F}| = qV_d \sin\theta$$

$$F = neAl V_d B \sin\theta \quad (\because q = neAl)$$

$$= (neAV_d)(Bl\sin\theta)$$

Or

$$\vec{F} = I(\vec{l} \times \vec{B}) \quad (\text{ii})$$

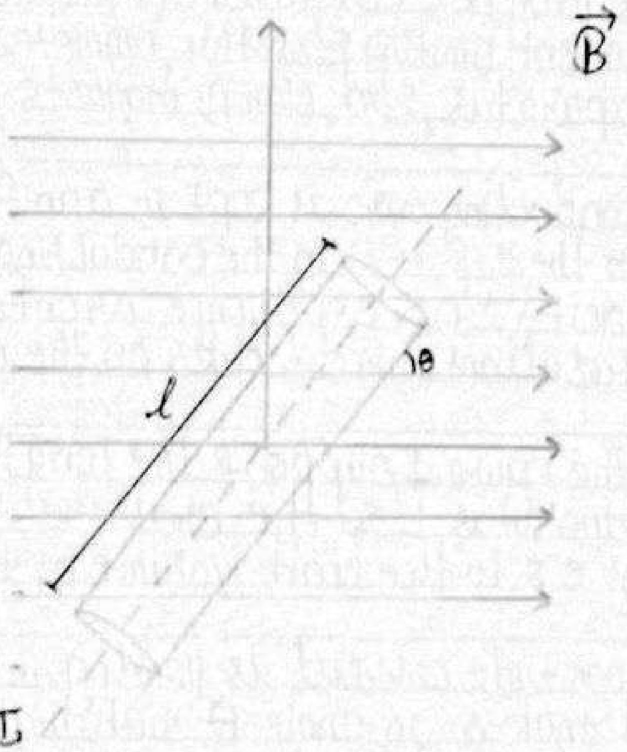

Fig:
Showing conductor carrying current with perpendicular magnetic field to its length

Procedure

Part-1: Force vs Current

1. Build the circuit as shown in figure 2 using current Loop
2. Locate the magnet for the wire loops & center the magnet on the balance pan. On the digital balance, there is a "zero" button.
3. Lower the balance arm to the wire Loop passes through the pole region of the magnet.
4. Plug in the power supply. Adjust the power until the current is approximately the value to be taken.
5. If the current is on magnet should repel. If its get attracted reverse the wire connected to the person power supply, turn off the balance & repeat steps.
6. Measure m & I.
7. Repeat until current increments from 0A to 2A.
8. Collect the data & unplug the power supply.
9. Calculate force for each current value

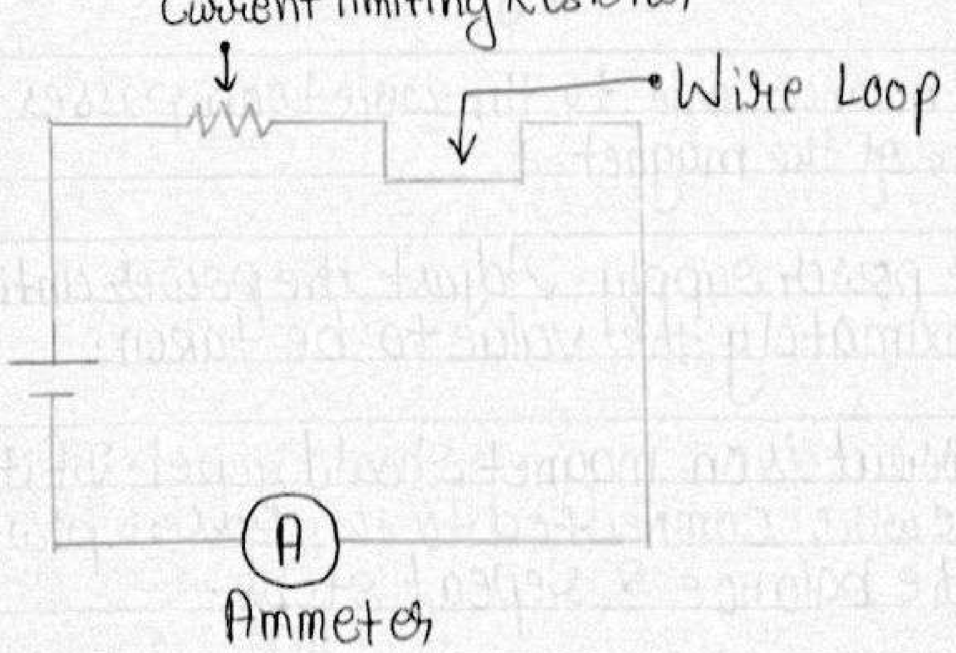

Fig2: Circuit for F vs I

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Part 2: Force vs Length of wire

1. Insert the wire segment into balance arm.
2. Let the current to 2A & measure balancing mass.
3. Repeat for each of the wire Loops & calculate force.
4. unplug the power supply after data colletion.
5. Return the wire Loops & magnet to their box

Part-3: Force vs Magnetic field

1. Centre the variable-angle magnet on the balance pan & tare the balance.
2. Plug the CBA into the balance arm. Adjust the height of the CBA as needed & lower it into magnet
3. Turn the CBA to 0°.
4. Turn the CBA from 0° to 180° to see if it will not hit the magnet at that point
5. Return the CBA to 0° & set current to 2A
6. Measure m as you increase magnetic field by changing angle in 10° increment through 180°
7. Turn off the power supply & unplug.
8. Calculate force for each magnetic field.

Table-1: Readings for Lorentz force experienced by a current carrying conductor of length 30 mm placed in a 900 gauss, magnetic field.

I (A)	Balancing Mass (g)	Force (dyne)
0.00	0.0000	0.000
0.20	0.0647	63.406
0.40	0.1272	124.656
0.60	0.1885	184.730
0.80	0.2772	271.656
1.00	0.2968	290.864
1.20	0.3858	378.084
1.40	0.4291	420.518
1.60	0.4662	456.876
1.80	0.5083	498.134
2.00	0.5511	540.078

Table-2: Readings for Lorentz force experienced by conductors of various lengths that vary in the range of 5mm to 30mm, each carrying a uniform current of 2A and placed in a magnetic field of 900 gauss.

Length (mm)	Balancing Mass (g)	Force (dyne)
5	0.1054	103.292
10	0.2146	210.308
15	0.3946	386.708
20	0.4053	397.194
25	0.5511	540.078
30	0.6746	661.108

Table-3: Readings for Lorentz force experienced by a 30mm conductor carrying 2A current, placed in a magnetic field that is varied in the range of 0 to 900 gauss

B (gauss)	Balancing Mass (g)	Force (dyne)
0	0.0000	0
150	0.1341	131.418
300	0.2339	229.222
450	0.3216	315.168
600	0.4128	404.544
750	0.4919	482.062
900	0.5511	540.078

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Precaution

1. Only use supplied connecting Leads.
2. Switch off all power supplies before altering the setup
3. Don't power up the experiment until the apparatus is fully assembled & cabled up.
4. Don't apply any mechanical stress on the setup.

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Aim To determine the wavelength of sodium lines by Newton's Rings Method

Appartus Required An optical arrangement for Newton's Ring with a plano-convex lens of large radius of curvature (nearly 100cm), an optically plane glass plate, a short focus convex lens, sodium light source, travelling microscope, magnifying, lens, reading lamp, a spherometer

Theory When a plano-convex lens of large radius of curvature is placed with its convex surface in contact with a plane glass plate, a thin wedge shaped film of air is enclosed between the two. The thickness of the film at the point of contact is zero & gradually increases as we move away from the point of contact towards the periphery of lens. When parallel beam of rays passing through the lens strikes the lens air interface a part of the ray gets reflected & other one is trasmitted through the air. The transmitted ray on reaching the glass plate gets reflected again & a phase change of π is obtained.

The effective path difference (Δx) between the two interfering ~~ras~~ rays is given by:-

$$\Delta x = 2\mu t \cos(\theta + r) + \frac{\lambda}{2}$$

$t \rightarrow$ thickness of air film $\theta \rightarrow$ Angle of film at that point

$r \rightarrow$ angle of refraction $\mu \rightarrow$ refraction index of medium

Thus, for normal incidence, $r=0$, the angle θ is extremely small & $\mu = 1$ (for air film)

$$\Delta x = 2t + \frac{\lambda}{2}$$

At the point of contact, the thickness of the film is zero i.e. $t=0$. So $\Delta x = \frac{\lambda}{2}$ which is condition of minimum intensity.

Thus for Maxima

$$\Delta x = n\lambda$$

$$2t + \frac{\lambda}{2} = n\lambda$$

$$2t = (2n-1)\frac{\lambda}{2} \quad (\mathrm{I})$$

Thus for Minima

$$\Delta x = (2n+1)\frac{\lambda}{2}$$

$$2t = n\lambda \quad (\mathrm{II})$$

Thus we have

$$R^2 = (R-t)^2 + r_n^2 \Rightarrow r_n^2 = 2Rt - t^2$$

Since $R >>> t$ $\quad r_n^2 = 2Rt$

$$\boxed{2t = \frac{r_n^2}{R}}$$

Diameter of n^{th} dark ring

$$\frac{r_n^2}{R} = n\lambda \Rightarrow \boxed{D_n = \sqrt{4nR\lambda}}$$

Similarly, diameter of n^{th} bright ring →

$$D_n^2 = 2(2n-1)\lambda R$$

$$D_n = \sqrt{2(2n-1)\lambda R}$$

The wavelength of λ of the Sodium Light employed for Newton's Rings experiment is given by

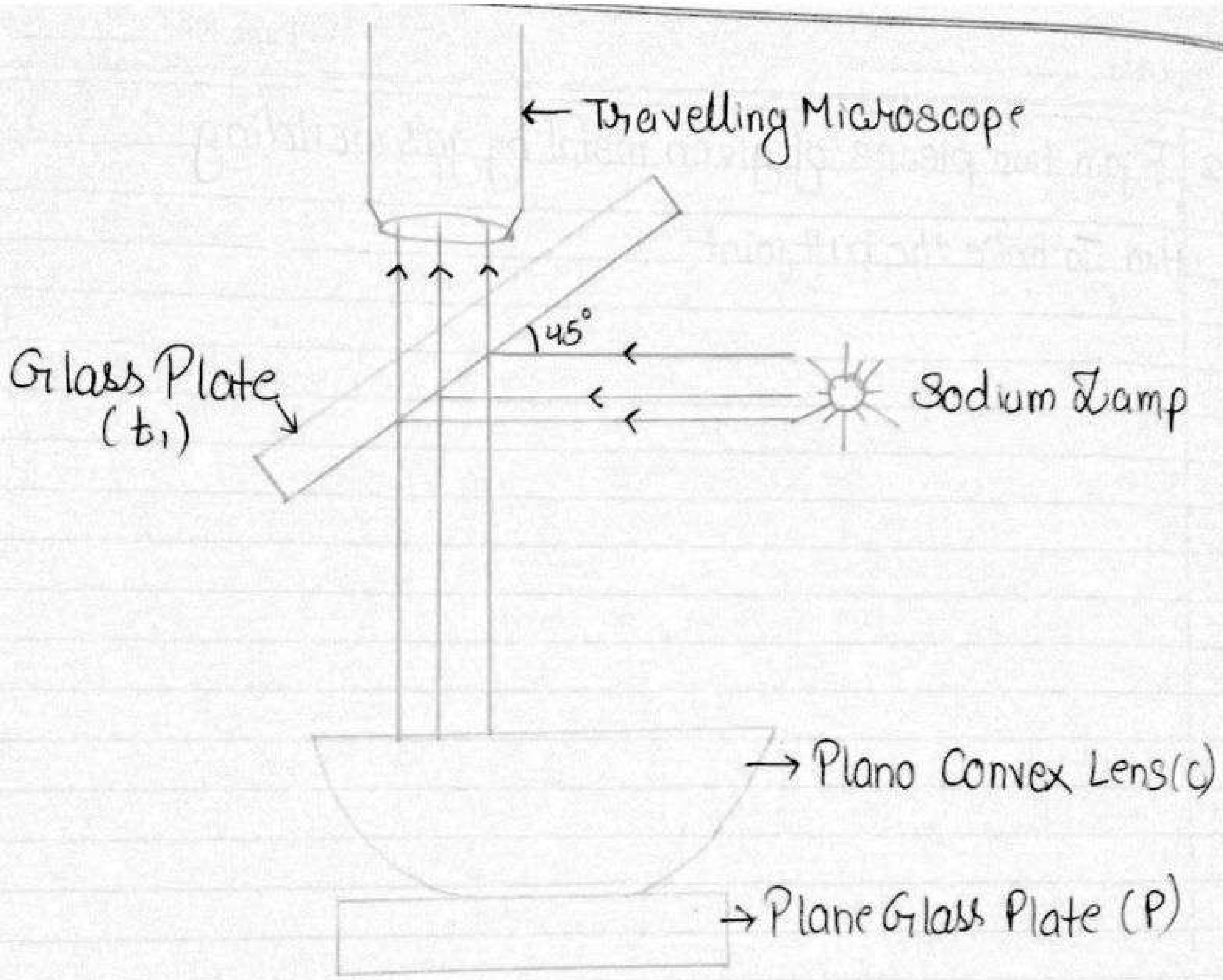
$$\lambda = \frac{D_{n+m}^2 - D_n^2}{4mR}$$

D_{m+n} = diameter of $(n+m)^{th}$ ring
D_n = diameter of n^{th} ring
m = No. of the rings (an integer)
R = radius of curvature of the plano-convex lens

Procedure

1. Level the travelling microscope, table & the microscope tube is set in vertical position
2. The surface of glass plate, the lens are cleaned. They are placed as shown in figure.
3. The arrangement is placed in front of sodium Lamp kept in the wooden box having a hole in it to transmit the light
4. The convex lens (short focal length) is adjusted such that a parallel beam of monochromatic Light is made to fall on the glass

Bloom | Teacher's Signature :



Experimental Setup

plate at an angle of cetain degree (approx 45°)

(6) The position of microscope is adjusted till the point of ~~inte~~ intersection of cross wires coincides with the centre of the ring system.

(7) The microscope is kept on sliding to the right & the reading are noted for 4^{th}, 6^{th}, 8^{th}, 10^{th}, 12^{th}, 14^{th}, 16^{th} & 20^{th} dark ~~for~~ rings respectively

(8) Measure radius of curvature of the Lens using spherometer

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

l = mean distance b/w two Legs of the spherometer

h = max height of convex surface of the Lens from the plane surface

(9) ~~Are~~ The diameter of each ring is calculated from difference of observation taken on the Left & Right side of the center

S. No.	Ring No.	Travelling Microscope Reading (mm)						Dm	Dm^2	D(m+p)^2 - Dm^2	λ (mm)
		Left (L)			Right (R)						
		MCR	VSR x LC	Total	MCR	VSR x LC	Total				
1	1	88	0.16	88.16	87.5	0.15	87.65	0.51	0.2601	1.728	0.00012
2	2	88.5	0.11	88.61	87	0.2	87.2	1.41	1.9881	1.8928	0.0001314444444
3	3	88.5	0.39	88.89	86.5	0.42	86.92	1.97	3.8809	2.4192	0.000168
4	4	89	0.16	89.16	86.5	0.15	86.65	2.51	6.3001	2.8808	0.0002000555556
5	5	89	0.42	89.42	86	0.39	86.39	3.03	9.1809	3.1392	0.000218
6	6	89.5	0.16	89.66	86	0.15	86.15	3.51	12.3201	3.2824	0.0002279444444
7	7	89.5	0.38	89.88	85.5	0.43	85.93	3.95	15.6025	3.32	0.0002305555556
8	8	90	0.08	90.08	85.5	0.23	85.73	4.35	18.9225	3.2616	0.0002265
9	9	90	0.26	90.26	85.5	0.05	85.55	4.71	22.1841	3.3184	0.0002304444444
10	10	90	0.43	90.43	85	0.38	85.38	5.05	25.5025	3.3344	0.0002315555556
11	11	90.5	0.09	90.59	85	0.22	85.22	5.37	28.8369	3.312	0.00023
12	12	90.5	0.24	90.74	85	0.07	85.07	5.67	32.1489	3.2536	0.0002259444444
13	13	90.5	0.38	90.88	84.5	0.43	84.93	5.95	35.4025	3.1616	0.0002195555556
14	14	91	0.01	91.01	84.5	0.3	84.8	6.21	38.5641	3.0384	0.000211
15	15	91	0.13	91.13	84.5	0.18	84.68	6.45	41.6025	2.8864	0.0002004444444
16	16	91	0.24	91.24	84.5	0.07	84.57	6.67	44.4889	2.708	0.0001880555556
17	17	91	0.34	91.34	84	0.47	84.47	6.87	47.1969	2.5056	0.000174
18	18	91	0.43	91.43	84	0.38	84.38	7.05	49.7025	2.2816	0.0001584444444
19	19	91.5	0.01	91.51	84	0.3	84.3	7.21	51.9841	2.0384	0.0001415555556
20	20	91.5	0.08	91.58	84	0.23	84.23	7.35	54.0225	2.02	0.000151

Taken p=1

Sum = 0.00359

Average = 0.000189

Precaution

① The plano-convex lens should have a large value of radius of curvature.

② The micrometer screw of travelling microscope should be moved very slowly in one direction to avoid any back lash error.

③ The reading must be taken carefully

④ Optical instruments should be clean