ONLINE SUBMISSION OF LAB RECORDS

Lab Subject	PHYSICS	**Submit Date**	03-07-2020
SIC No	190610193	**Regd. No**	1901209198
Name	ANIRUDH PANDA	**Branch**	EEE
Semester	2ND	**Section/Group**	D-D2

INDEX

Expt. No.	Details of the Experiment	Page No.
1	RC CIRCUIT	
2	DIFFRACTION GRATING USING LASER	
3	KATER PENDULUM	
4	RIGIDITY MODULUS	
5	SURFACE TENSION	

UNDERTAKING

I hereby declare that, I had submitted the laboratory records for the experiments which were physically completed in the Institute and the lab record folder is properly preserved by me. In this online submission, I am submitting the lab records for the experiments (as mentioned in the index above) which were explained and demonstrated in online mode. I have written the lab record myself, scanned into PDF format for soft copy submission. I undertake that I will preserve these hard copies with me. After the institute reopens, I will add these pages to the existing lab record folder and submit the complete folder within 7 days of reopening. I understand that, unless I submit the complete lab record folder in hard copy form, the marks awarded in the lab subject may be revoked by the institute.

Anirudh Panda.

Date: 03-07-2020 Full Signature of Student

RC Circuit

Experiment No.: 06 **Date:** 03-07-2020

Aim:

To study the charging and discharging of a capacitor with different pulses of width much less than the time constant.

Apparatus:

a) RC Circuit KIT
b) Function generator

Theory:

a) Let V_C =Potential difference across capacitor

C = Capacitance of the capacitor

I = The charging current

q = The charge on the capacitor plates

V = The applied voltage

V_R = The voltage across the resistor

$$V = V_R + V_C = IR + V_C \quad \text{------} \quad (1)$$

Now $I = \frac{dq}{dt} = \frac{d}{dt}(CV_C) = C\frac{dV_C}{dt}$

$$\therefore \; V = CR\frac{dV_C}{dt} + V_C \quad \text{------} \quad (2)$$

$$-\frac{dV_C}{V-V_C} = -\frac{dt}{CR}$$

Integrating the above we get,

$$\int -\frac{dV_C}{V-V_C} = -\frac{1}{CR}\int dt$$

$$\therefore \log_e(V - V_C) = -\frac{1}{CR} + K \quad \text{------} \quad (3)$$

K is constant of integration, whose value can be found from initial known conditions. We know that when charging begins, i.e. $t = 0, V_C = 0$

Substituting these values in equation (3)

We get $\log_e V_C = K$

Hence, equation (3) becomes $\log_e(V - V_C) = \frac{-t}{CR} + \log_e V$

$$\Rightarrow \log_e \frac{V-V_C}{V} = \frac{-t}{CR} = \frac{-t}{\lambda}$$

(Where $\lambda = CR =$ Time constant)

$$\Rightarrow \frac{V-V_C}{V} = e^{\frac{-t}{CR}} = e^{\frac{-t}{\lambda}}$$

$$\Rightarrow V_C = V\left(1 - e^{\frac{-t}{\lambda}}\right)$$

When $t = \lambda$; $V_C = V\left(1 - e^{-\frac{\lambda}{\lambda}}\right) = V(1 - e^{-1}) = V\left(1 - \frac{1}{e}\right) = V\left(1 - \frac{1}{2.718}\right) = 0.632V$

This is equation of charging.

b) While discharging, $V = 0$ (Applied potential difference is zero.)

$$\Rightarrow 0 = V_R + V_C$$

$$\Rightarrow 0 = IR + V_C$$

$$\Rightarrow 0 = IR + \frac{Q}{C} \Rightarrow IR = -\frac{Q}{C}$$

$$\Rightarrow I = -\frac{Q}{RC} \Rightarrow I = -\frac{Q}{\lambda}$$

$$\Rightarrow \frac{dQ}{dt} = -\frac{Q}{\lambda}$$

Integrating both the sides

$$Q(t) = Q_{max}\, e^{-\frac{t}{\lambda}}$$

$$\Rightarrow I(t) = \frac{dQ(t)}{dt} = \frac{d\left(Q_{max}e^{-\frac{t}{\lambda}}\right)}{dt}$$

$$I(t) = -I_{max}e^{-\frac{t}{\lambda}}$$

Taking absolute value of above

$$V_R(t) = I(t)R$$

$$= RI_{max}e^{-\frac{t}{\lambda}} = V_{max}e^{-\frac{\lambda}{\lambda}} = V_{max}e^{-1}$$

$$\Rightarrow V_R = \frac{V_{max}}{e} = \frac{V_{max}}{2.718} = 0.37V_{max}$$

Procedure:

Charging:

a) Connect the circuit of the supplied RC KIT as per the circuit diagram.

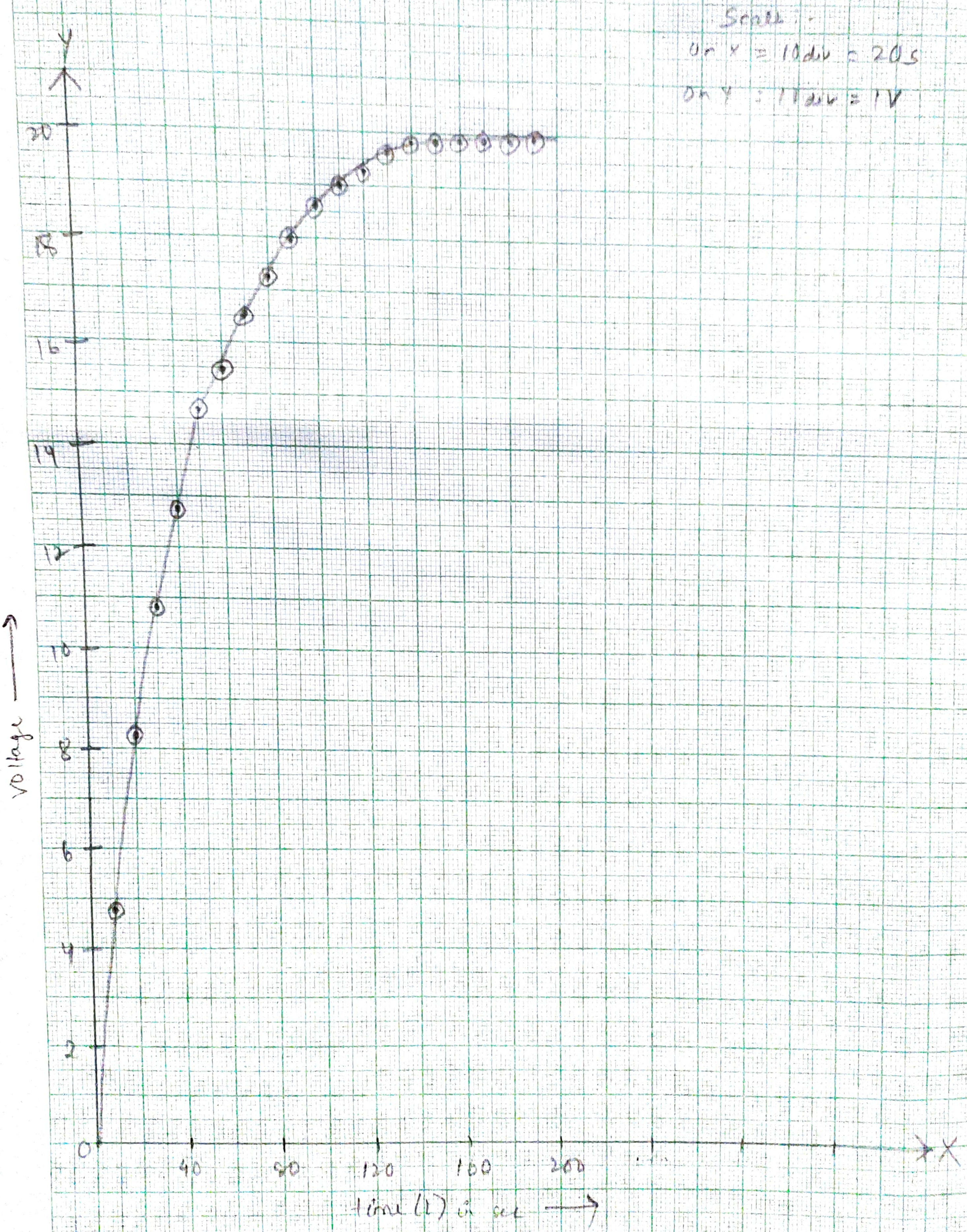
b) Supply the desired pulse on the function generator, keeping the voltage range at 20 volt.

c) Note the charging voltages of the capacitor in the pulse time interval.

Assignment

CHARGING GRAPH

Page No. Date / /



d) Plot the graph between V_C (Capacitor Voltage) versus time.

e) From capacitor charging graph, calculate the time corresponding to the capacitor voltage 0.632 V_{max} which is time constant (λ) of the RC circuit.

Discharging:

a) Disconnect the supplied voltage from the function generator and not the discharging capacitor voltage from the voltmeter in pulse time interval.

b) Plot the graph between VC (discharge) versus time and calculate the time corresponding to 0.37 of the V_{max}. This is the time constant (λ) of the circuit.

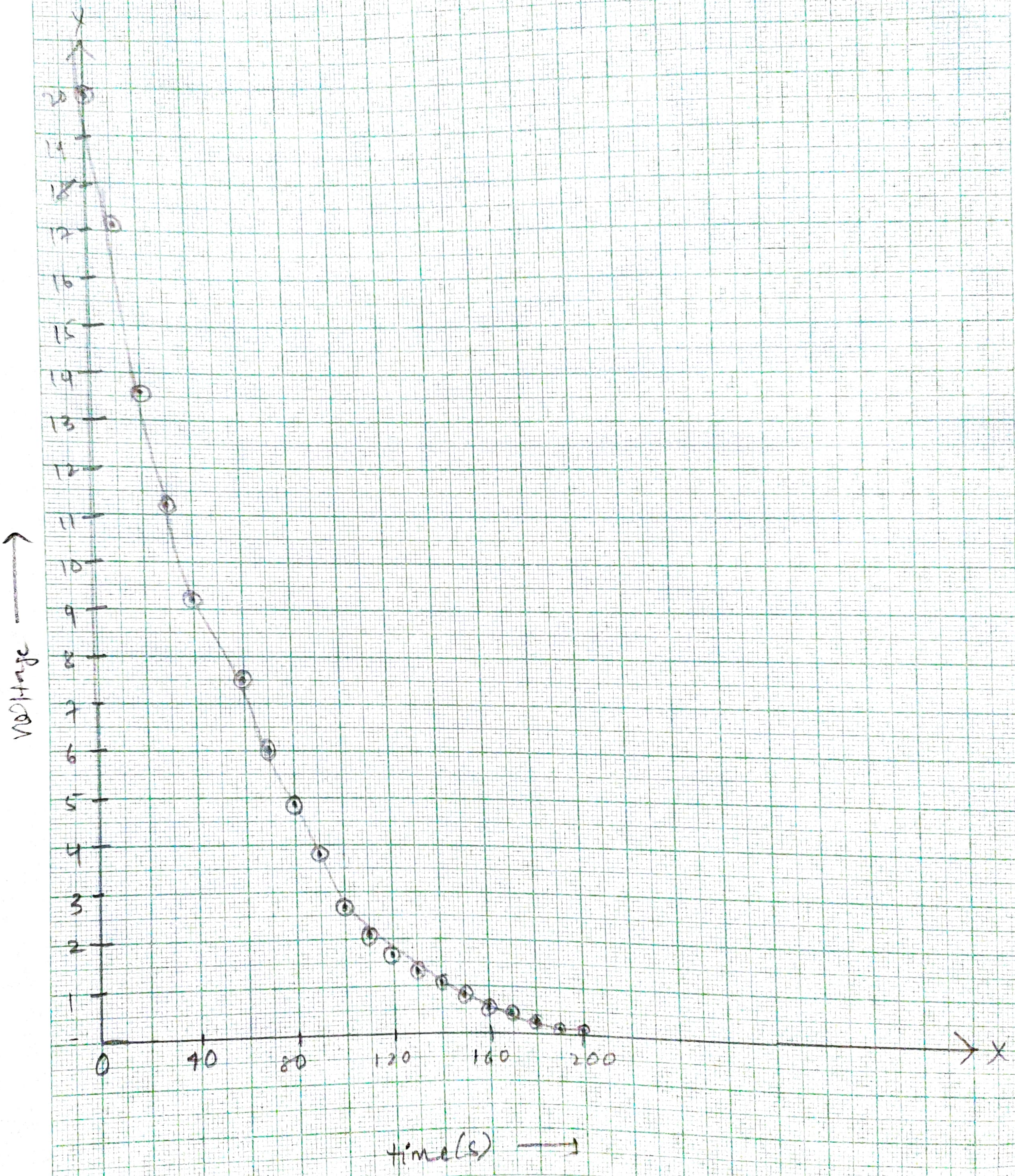
c) Compare the calculated time constant (λ) value from the graph with the RC product value of the used circuit.

Observation:

R = 470 KΩ C = 100 μF RC = 47

Table – 1: (Charging of Capacitor)

Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)		Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)
1	0	0		21	200	
2	10	4.82		22	210	
3	20	8.32		23	220	
4	30	10.91		24	230	
5	40	12.85		25	240	
6	50	14.74		26	250	
7	60	15.55		27	260	
8	70	16.56		28	270	
9	80	17.39		29	280	
10	90	18.03		30	290	
11	100	18.55		31	300	
12	110	18.99		32	310	
13	120	19.36		33	320	
14	130	19.72		34	330	
15	140	19.94		35	340	


Y
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18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
40
80
120
160
200
X
voltage
time(s)

16	150	19.99		36	350	
17	160	19.99		37	360	
18	170	19.99		38	370	
19	180	19.99		39	380	
20	190	19.99		40	390	

Circuit Diagram:

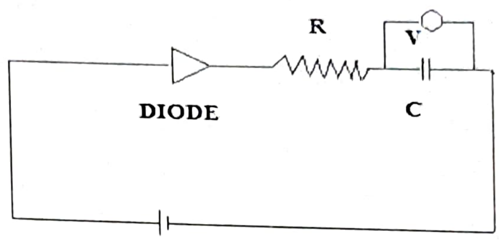


Table – 2: (Discharging of Capacitor)

Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)		Sl No.	Rectangular pulse time (t) in sec.	Charged Voltage V_C (Volts)
1	0	19.99		21	200	
2	10	17.03		22	210	
3	20	13.59		23	220	
4	30	11. 24		24	230	
5	40	9.27		25	240	
6	50	7.52		26	250	
7	60	6.09		27	260	
8	70	4.92		28	270	
9	80	3.87		29	280	
10	90	3.84		30	290	
11	100	2.62		31	300	
12	110	2.15		32	310	
13	120	1.74		33	320	
14	130	1.43		34	330	
15	140	1.15		35	340	
16	150	0.94		36	350	
17	160	0.54		37	360	

18	170	0.44		38	370	
19	180	0.31		39	380	
20	190	0.25		40	390	

Calculation:

$R =$ 470KΩ, $C =$ 100μF,

$RC =$ 47, $\lambda =$ 52 (From graph)

Percentage of Error:

$$\frac{52-47}{47} \times 100 = 10.6\%$$

Conclusion:

From the above experiment I have studied the charging and discharging of capacitor.

Marks Awarded

Planning and Execution (2)	Result and Report (6)	Viva (2)	Total (10)

Signature of the student: Anirudh Panda

Regd. No: 1906101193

Group: D2(16)

Branch: EEE

Signature of the Faculty

Diffraction grating using LASER

Experiment No.: 07 **Date:** ____________

Aim:

To determine the wavelength of LASER by plane diffraction grating.

Apparatus:

a) Optical bench
b) Four uprights
c) Diffraction grating
d) LASER source
e) Screen
f) Convex lens
g) Graph paper

Theory:

a) When a parallel beam of monochromatic light is incident normally on a grating, the transmitted light gives rise to primary maxima in certain direction given by the relation

$$(a+b)\sin\theta_n = n\lambda \text{ --- } (1)$$

Where,
a = Width of transparency

b = Width of opacity

$(a+b)$ = Grating element

θ_n = The angle of diffraction for the n^{th} order maxima

λ = Wavelength of light

n = Order of spectrum

So,

$$\boxed{\lambda = \frac{(a+b)\sin\theta_n}{n}} \text{ -------------------------------- } (2)$$

b) If θ_1 & θ_2 are the angles of diffraction in the first and second order spectra respectively, then

$$\lambda = (a+b)\sin\theta_1 \qquad and \qquad \lambda = \frac{(a+b)\sin\theta_2}{2}$$

Procedure:

a) To one end of the optical bench, He – Ne LASER is placed in between the two rods of optical bench.

b) In front of LASER source on one rider optical slit, on another rider optical screen with graph paper are fitted. The heights of all these are adjusted to be the same.

c) The optical slit is placed close to the LASER source and its width is kept very small. The rider on which convex lens is fitted, is placed at a distance equal to the focal length of lens from the slit.

d) At a few centimetre distances, the rider of the grating and at a comparatively larger distance the rider of optical screen is placed. The slit should be adjusted parallel to the lines and the grating should be normal to the parallel rays coming from lens and optical bench should be levelled.

e) While switching on the LASER source, a spectrum is formed on the optical screen. Distances in between slit, grating and the optical screen are adjusted so that well defined spectrum of LASER is obtained on the screen.

f) On the optical screen, spectrum of diffraction pattern is formed with maximum at the middle (central maximum) and maxima of increasing order on its either side are formed. The distances of maxima of different order from central maxima are noted from the graph paper of optical screen and noted in the observation table. The positions of riders of grating and the optical screen are also noted.

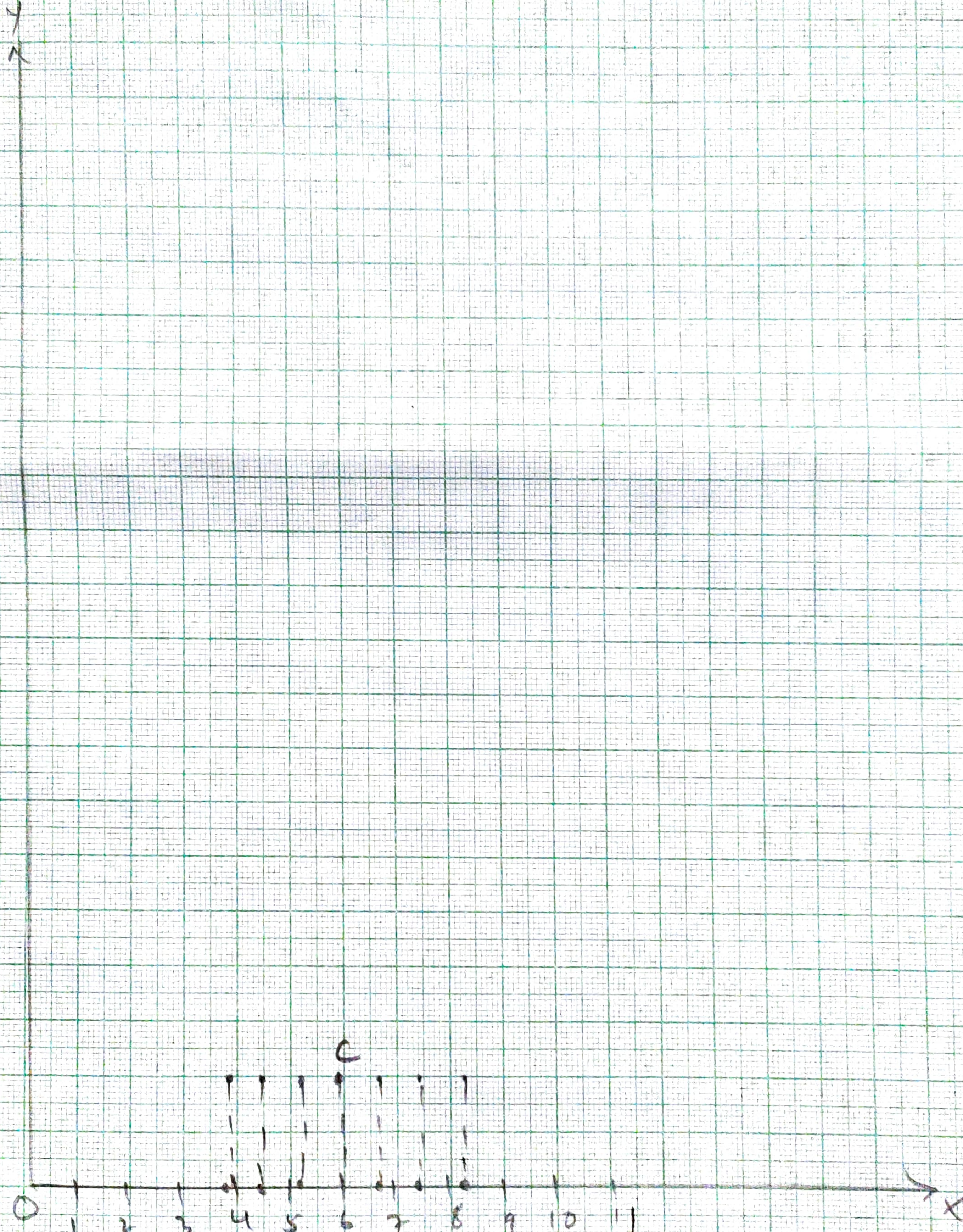
Observations:

1. Position of the rider of diffraction grating (L_1) = 40 cm
2. Position of the rider of optical screen (L_2) = 100 cm

Distance between diffraction grating and the optical screen, X = ($L_2 - L_1$) = 60 cm

No. of lines on grating, 'N' (Per inch) = 500

Grating element = $(a+b) = \frac{1}{N} =$ 0.005 cm per line



y
C
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8
9
10
11
X

Table: (Determination of diffraction angle and wavelength)

Order of spectrum	Observation on right side of the central maxima (A)	Observation on left side of the central maxima (B)	Difference $2Y = (A - B)$	$Y = \frac{(A-B)}{2}$	Diffraction angle, $\theta \cong \sin\theta \cong \tan\theta = \frac{Y}{X}$
$n = 1$	6.7	5.2	1.5	0.75	0.0125
$n = 2$	7.4	4.4	3.0	1.5	0.025
$n = 3$	8.2	3.8	4.4	2.2	0.036

Calculation of λ:

For first order, $\lambda_1 = \frac{(a+b)\sin\theta_1}{1}$ $= 0.005 \times 0.0125$ $= 6250$ Å

For second order, $\lambda_2 = \frac{(a+b)\sin\theta_2}{2}$ $= \frac{0.005 \times 0.0250}{2}$ $= 6250$ Å

For third order, $\lambda_3 = \frac{(a+b)\sin\theta_3}{3}$ $= \frac{0.005 \times 0.036}{3}$ $= 8000$ Å

Mean wavelength, $\lambda = \frac{\lambda_1+\lambda_2+\lambda_3}{3} =$ 6166 cm

Percentage of Error:

Standard value of wavelength $\lambda = 6328\ A^0$

& the measured value of $\lambda =$ 6166 A^0

Therefore, % error = $\left|\frac{Standard\ value - Measure\ \ value}{Standard\ value}\right| \times 100$

= 2.5 %

Precautions:

a) Height of LASER source, slit, lens, grating and optical screen on all riders should be same.

b) All riders must be aligned along one common axis.

c) Slit, grating and optical screen should be vertical and parallel to each other.

d) Grating should be fixed for normal incidence.

e) Don't see LASER directly. It is very injurious. Be extremely careful.

Conclusion:

The wavelength of the LASER light was found to be 6166 with 2.5 % of error.

Marks Awarded

Planning and Execution (2)	Result and Report (6)	Viva (2)	Total (10)

Signature of the faculty

Signature of the student: Anirudh Panda

Regd. No: 190610193

Group: D2 (16)

Branch: EEE

KATER'S PENDULUM

Experiment No.- 08

Date-

Aim: To determine the value of acceleration due to gravity by Kater's pendulum.

Apparatus: 1) Kater's pendulum 2) Stop watch, 3) Telescope & 4) Meter scale.

Theory:

Kater's pendulum is a **compound pendulum** constructed on the principle that *the centre of oscillation and centre of suspension are interchangeable*. It consists of a brass or steel bar capable of vibrating about two adjustable knife edges K_1 & K_2 facing each other. Two metal weights **W** and **w** can be made to slide, along the length of bar & can be clamped at any position. A wooden weight '**W**' exactly similar to metal weight **W** can also slide along the bar. The smaller weight **w** is exactly placed between the two knife edges and the larger weight **W** is fixed at one end, while the wooden weight '**W**' was kept symmetrically at the other end of the bar. In this position, the centre of gravity lies between small weight and near one the knife edges.

The position of the two knife edges & the weight **w** are so adjusted that the time period of the pendulum about the two knife edges are equal. In such a case, one knife edge is at the centre of oscillation w.r.t the other and the distance between the two knife edges is equal to the length of an equivalent simple pendulum **L**. If't' the time period, then the acceleration due to gravity **g** can be found out from the relation.

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

If t_1 and t_2 are time periods about the two knife edges K_1 & K_2 respectively. Also, 'l_1' the distance the knife edge K_1 & 'l_2' that of the knife edge K_2 from the C.G, then

$$t_1 = 2\pi\sqrt{\frac{l_1^2 + k^2}{l_1 g}} \qquad (1)$$

$$t_2 = 2\pi\sqrt{\frac{l_2^2 + k^2}{l_2 g}} \qquad (2)$$

From eq. (1) and (2),

$$g = \frac{8\pi^2}{\frac{t_1^2 + t_2^2}{l_1 + l_2} + \frac{t_1^2 - t_2^2}{l_1 - l_2}}$$

Procedure:

1) Shift the weight **W** to one end of the Kater's pendulum (say A) of and fix it. The knife edge (K_1) is fixed just below it. '**W**' is kept at one end of the rod to shift the centre of gravity (CG) of the pendulum.. The two points about which the time period is same will now lie unequal distances from the **CG** on either side of it.

2) K_2 is kept at the other end of the pendulum (say B) and the smaller weight **w** is placed nearly in the centre. 'W' is fixed near the end **B** in such way that it is , symmetrical to **W**.

3) Suspend the pendulum about K_1 & set into vibration with a very small amplitude. Start the stop watch when the pendulum is just passing through the equilibrium position. Note the time taken for 20 oscillations.

4) Pendulum is then suspended about K_2 and again the note the time for 20 oscillations.

5) Adjust K_2 to obtain nearly the same time period as that of K_1.

6) Again suspend the pendulum about K_1 & note the time for 20 oscillations (this time period may differs from the time period taken in step **3**, as the **CG** has been shifted).

7) Again suspend the pendulum about K_2 & adjust the position very slightly such that the time period about K_2 is nearly equal to the time period about K_1..

8) Adjust the telescope such that the cross wires are clearly visible and focus the telescope on the Kater's pendulum. Find the time period for 50 vibrations about K_1 and K_2 for three times.

9) Balance the pendulum on a sharp wedge and mark the position of CG. Measure the distance (l_1 & l_2) of the knife edges K_1 & K_2 from the CG.

Table 1

Knife edge	Time for 20 oscillations	
K_1	35	35.41
K_2	34.5	35

Table 2

Knife edge	Time for 50 oscillation				Time Period
	T_1	T_2	T_3	Mean	
K_1	87.5	87.28	87.72	87.5	t_1 1.75 s
K_2	86.38	86.88	86.48	86.56	t_2 1.73 s

Observation: l_1 = Distance between K_1 & CG = 26.5 cm

l_2= Distance between K_2 & CG = 45.5 cm

So, $l_1 + l_2$= 72 cm, and $l_1 - l_2$= -19 cm.

Calculation:

$$g = \frac{8\pi^2}{\frac{t_1^2 + t_2^2}{l_1 + l_2} + \frac{t_1^2 - t_2^2}{l_1 - l_2}} = 9.76 \text{ m/s}^2$$

% error: 0.35 %.

Conclusion: The acceleration due to gravity "g" was found to be 9.76 with % error 0.35

Precaution:

1) *W should be placed at one end, so that the CG lies near one of the knife edges and wooden weight W' is symmetrically at the other end to avoid error due to air drag.*
2) *The two knife edges should be parallel to each other.*
3) *The amplitude of vibration should be small, so that the motion of the pendulum satisfies the condition sin $\theta = \theta$.*
4) *The readings should be taken only after the vibrations are regular.*

Mark s awarded

Planning and execution (2)	Result & Report (6)	Viva (2)	Total (10)

Signature of the Student Anirudh Panda

Regd. No. 1906101093

Branch & Group EEE D2

Signature of the faculty

Rigidity Modulus

Experiment No: 09 **Date:** ______________

Aim:

To determine the rigidly modulus of the given wire by Barton's apparatus (Static Method).

Apparatus Required:

a) Barton's apparatus
b) Vernier callipers
c) Micrometer
d) Slotted weights (500gm)
e) Meter scale
f) Spirit Level

Theory:

Let 'D' be the diameter of the cylinder, to which tortional couple is applied by a suspending equal loads on the two pans attached, each of value 'm' grams.

Then, twisting couple = mgD

If $\propto$ is the twist indicated by the pointer in degrees on the scale S, then **Twist** in radians:

$$\theta = \frac{\pi}{180} \times \propto$$

Restoring couple for a twist θ radians; $$c\theta = \frac{\pi\eta r^4}{2l} \times \theta$$

Where 'l' is the length of the wire from torsion head to the pointer and 'r' the radius of the wire. Let C = Restoring couple per unit angular twist.

At equilibrium, twisting couple = restoring couple i.e.,

$$MgD = \frac{\pi\eta\ ^4\theta}{2l}$$

Or $$\eta = \frac{MgD \times 2l}{\pi r^4 \theta} = \frac{MgD\ \times\ 2l}{\pi r^4 \times \left(\frac{\pi}{180}\right) \times \propto}$$

Or $$\boxed{\eta = \frac{360\ l\ g\ D}{\pi^2\ r^4} \left(\frac{M}{\propto}\right)}$$

Procedure:

a) Measure the diameter of the rod in two mutually perpendicular directions at several places with the help of screw gauge, hence find mean radius (r) of the rod.

b) Find the diameter and hence radius(R) of the cylinder by vernier calliper or measure the circumference $2\pi R$ of the cylinder by thread. From the circumference find out the radius (R) of the pulley.

c) For zero weight on the hanger, adjust the pointer so that read zero on the respective circular scales.

d) Measure the distance '*l*' of the pointer from the fixed end A of the rod.

e) Gently place 0.5 kg slotted weight on the hanger. Wait for few minutes and note down the reading of the pointer.

f) Increase the load in steps of 0.5 kg slotted weight on the hanger. Wait for few minutes and note down the reading of the pointer on the scale at each step. Let it be X_1 (say).

g) Now decrease the load in steps of 0.5 kg till the zero loads is reached. Note down the reading of the pointer on the scale at each step. Let bit be X_2 (say). Find the mean of loading and unloading i.e. $\theta = \frac{X_1+X_2}{2}$. Angle of twist for zero loads is $\theta_0 = 0$. The twist for 0.5 kg, 1.0 kg, 1.5 kg etc is $\theta_1,\ \theta_2,\ \theta_3$ respectively.

h) Plot a graph load (M) versus angle of twist (θ). The nature of the graph nis a straight line as shown in figure. The slope of the straight line gives $\frac{\Delta M}{\Delta \theta}$.

i) Repeat the steps (d) to (g) by changing the position of the pointer for three to four different lengths (*l*).

j) Calculate the angle of twist for a give load 2 kg (say) by making proper subtraction and note the mean angle of twist for 2 Kg (Table – 1).

Precautions:

a) Pulley should be frictionless.

b) Load should be increased or decreased gradually and gently and should never exceed the maximum permissible limit.

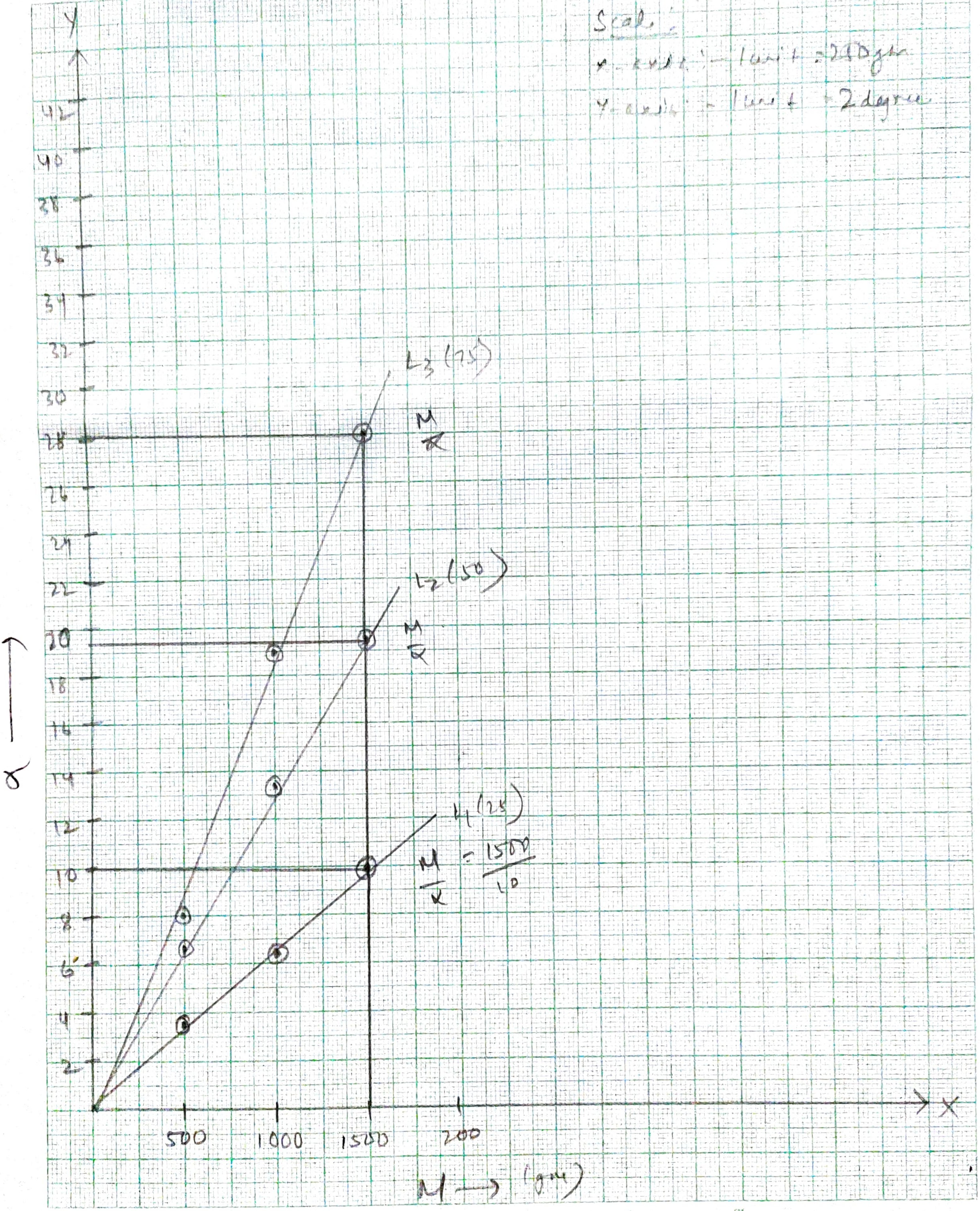
c) As the radius of the rod of course in fourth power, it should be measured accurately in two mutually perpendicular directions.

Observation:

Pitch of micrometer: ____________ cm

Least count of micrometer: 0.001 cm

Least count of Vernier callipers: 0.01 cm


Scale:
x-axis :- 1 unit = 250 gm
y-axis :- 1 unit = 2 degree
Y
42
40
38
36
34
32
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28
26
24
22
20
18
16
14
12
10
8
6
4
2
L_3 (75)
$\frac{M}{K}$
L_2 (50)
$\frac{M}{K}$
L_1 (25)
$\frac{M}{K} = \frac{1500}{10}$
500
1000
1500
200
X
M ⟶ (gm)
θ ⟶

Table – 1: (Radius of the wire using micrometer)

No. of Obs.	ICSR (I)	NCR (N)	FCSR (F)	Diff. (I - F)	PSR (cm) [Pitch×N]	CSR (cm) [(I – F)×L.C.]	Total (cm)	Mean (cm)
1								
2								0·191
3								
4								

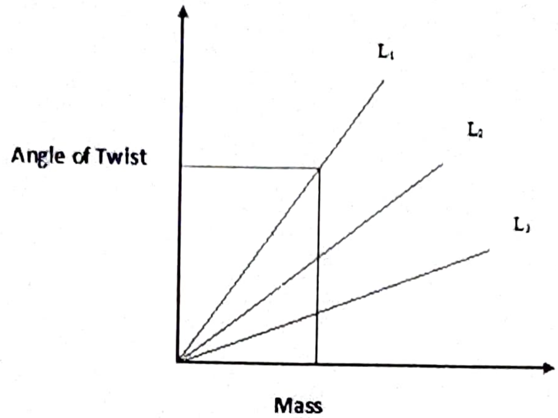
Table – 2: (Diameter of the cylinder using vernier-calliper)

No of Obs.	MSR (cm)	V.C.	VSR (cm)	Total (cm)	Mean (cm)
1					
2					3·62
3					
4					

Table – 3: (Angle of Twist)

No of Obs.	Length in cm	Load in kg	Load increasing		Load decreasing		Mean
			Position of the pointer on scale θ_1 in degree	Change in position of the pointer on scale $\Delta\theta_1$ in degree	Position of the pointer on scale θ_2 in degree	Change in position of the pointer on scale $\Delta\theta_2$ in degree	$\propto = \frac{d\theta_1 + d\theta_2}{2}$ in degree
1		0	0	0	1	0	0
2		0.5	4	4	4	3	3.5
3	L_1	1.0	6	6	8	7	6.5
4	25	1.5	10	10	11	10	10
5		2.0	15	15	15	14	14.5
6		0	0	0	1	0	0
7		0.5	6	6	8	7	6.5
8	L_2	1.0	12	12	16	15	13.5
9	50	1.5	19	19	21	20	19.5
10		2.0	28	28	28	27	27.5
11		0	0	0	1	0	0
12		0.5	8	8	9	8	8
13	L_3	1.0	17	17	22	21	19
14	75	1.5	27	27	30	29	28
15		2.0	39	39	39	38	38.5

Graph:



Calculation:

Put the value of D, l, r and $\frac{m}{\alpha}$ from the graph in equation, $\eta = \frac{360\, l\, g\, D}{\pi^2 r^4}\left(\frac{M}{\alpha}\right)$

$\eta_1 = \frac{360\, l\, g\, D}{\pi^2 r^4}\left(\frac{1}{Slope}\right)$ For L_1

$$= \frac{360 \times 25 \times 980 \times 3.62}{(3.14)^2 \times (0.292)^4} \times 150 = 3.68 \times 10^{11} \text{ dyne/cm}^2$$

$\eta_2 = \frac{360\, l\, g\, D}{\pi^2 r^4}\left(\frac{1}{Slope}\right)$ For L_2

$$= \frac{360 \times 50 \times 980 \times 3.62}{(3.14)^2 \times (0.191)^4} \times 76.92 = 3.77 \times 10^{11} \text{ dyne/cm}^2$$

$\eta_3 = \frac{360\, l\, g\, D}{\pi^2 r^4}\left(\frac{1}{Slope}\right)$ For L_3

$$= \frac{360 \times 75 \times 980 \times 3.62}{(3.14)^2 \times (0.191)^4} \times 53.57 = 3.94 \times 10^{11} \text{ dyne/cm}^2$$

Standard value:

Rigidity modulus of the copper wire = 4.55×10^{11}

Rigidity modulus of the steel wire = 7.9 *to* 8.9×10^{11}

% of Error:

$$= \frac{4.55 \times 10^{11} - 3.79 \times 10^{11}}{4.55 \times 10^{11}} \times 100$$

$$= 16.7\,\%$$

Conclusion:

The value of rigidity modulus of the given wire was found to be 3.79×10^{11} dyne/cm^2 with 16.7 % of error.

Marks Awarded

Planning and Execution (2)	Result and Report (6)	Viva (2)	Total (10)

Signature of the Faculty

Signature of the student: Anirudh Panda

Regd No: 190610193

Group: D2

Branch: EEE

Surface Tension

Experiment No. 10 **Date:**

Aim:

To determine the surface tension of a liquid by capillary rise method.

Apparatus:

a) Two capillary tubes having different bore
b) Needle
c) Travelling microscope
d) Beaker
e) Clamp
f) Sprit level

Theory:

When a capillary tube is immerged (vertically) in a liquid, the liquid rises in the tube is known as the capillary rise. If the height through which liquid rises is 'h', the surface tension of the liquid (here, water) is given by;

$$\boxed{S = \frac{\rho g r}{2}\left(h + \frac{r}{3}\right)}$$

Where, ρ = density of liquid

r = radius of the capillary tube

g = acceleration due to gravity

S = surface tension of the liquid

h = height of the liquid inside the capillary tube.

Procedure:

a) Clean the capillary tube with some dilute caustic soda and wash out repeatedly with water. Then dry the tubes with dry air.
b) Fill the glass dish with water and note its temperature. Place the dish on an adjustable stand.

c) Take at least three capillary tubes of different diameter. Mount them on the glass strip by a rubber band and set them vertical on the dish. Water will rise in the capillary tubes. Fix the needle on the glass strip parallel to the capillary tubes. Adjust its height such that the tip of the needle just touches the surface of water.

d) Focus the travelling microscope (TM) on one of the capillary tubes by removing parallax between the cross wire and the image of the water column in the tube. Set the horizontal cross wire tangential to the meniscus of water at **M** in the tube. The meniscus of the water in the capillary tube will be inverted *i.e, convex*. Read the meniscus **M** by vertical scale of TM (h_1 say).

e) Move the travelling microscope along the horizontal scale and bring it in front of the second and third tube and repeat the step (d) to read the microscope vertical scale.

f) Now, bring the travelling microscope in front of needle and lower it till the horizontal cross wire lies symmetrically between the tip of the needle and its image at N in the water. Note the reading on the vertical scale of TM at N (h_2 say). ($h_1 - h_2$) gives the height 'h' of the water column in the capillary tube.

g) Take out the capillary tubes from the rubber band and find the diameter at the bore of the tubes in two mutually perpendicular directions with the help of travelling microscope.

Observation:

Room temperature = 32°C

Density of water ρ at t° C = 1 gm.cc^{-1}

Value of acceleration due to gravity g = 980 cm.sec^{-2}

Table – 1: (For capillary rise height 'h')

Tube No.	Microscope reading at the meniscus M				Microscope reading at the Needle N				Capillary rise 'h' in cm
	MSR in cm	VC	VSR in cm	Total = MSR + VSR in cm	MSR (cm)	VC	VSR (cm)	Total = MSR + VSR in cm	
1	5.25	42	0.042	R_1 5.292	2.56	20	0.020	R 2.57	$h_1 = (R_1 - R)$ = 2.72
2	4.35	20	0.020	R_2 4.370					$h_2 = (R_2 - R)$ = 1.80

Table – 2: (For radius of the capillary tube 'r')

Tube No.		MSR (cm)	VC	VSR (cm)	Total = MSR + VSR in cm	Difference in cm	Mean (d) in cm	$r = \frac{d}{2}$ in cm
1	Horizontal Left	4.3	14	0.014	4.314	0.104	0.104	r_1 0.052
	Horizontal Right	4.4	18	0.018	4.418			
	Vertical Lower	7.8	16	0.016	7.816	0.104		
	Vertical Upper	7.7	12	0.012	7.712			
2	Horizontal Left	6.8	10	0.010	6.810	0.155	0.1515	0.076 r_2
	Horizontal Right	6.95	15	0.015	6.965			
	Vertical Lower	7.8	20	0.020	7.822	0.148		
	Vertical Upper	7.65	22	0.022	7.670			

Precautions:

a) *Tubes should be of uniform bore and water should rise freely into the tubes.*

b) *Tube should be parallel to each other and vertical.*

c) *The surface of water should not be touched in hand.*

d) *The tip of the needle should just touch the water surface and not dip into it.*

Calculation:

Put the value of 'h' and 'r' in equation, $S = \frac{\rho g r}{2}\left(h + \frac{r}{3}\right)$

$S_1 = \frac{\rho g r}{2}\left(h_1 + \frac{r_1}{3}\right) =$ 69.56 dyne/cm

$S_2 = \frac{\rho g r}{2}\left(h_2 + \frac{r_2}{3}\right) =$ 67.97 dyne/cm

$Mean\ S = \frac{S_1 + S_2}{2} = \frac{69.56 + 67.97}{2} =$ 68.76 dyne/cm

Standard value:

The surface tension of water at 20° C = 72.7 Dyne/cm

The surface tension of water at 30°C = 71.2 Dyne.cm^{-1}

The surface tension of water at 40°C = 69.6 Dyne.cm^{-1}

At $32^{\circ}C$; $S = 71{\cdot}2$ dyne cm^{-1}

% of Error:

$$\frac{71{\cdot}2 - 68{\cdot}76}{71{\cdot}2} \times 100 = 3{\cdot}15\ \%$$

Conclusion:

Surface tension of water at 32 °C was found to be 68·76 Dyne.cm^{-1} or N.m^{-1} with 3·15 % of error.

Marks Awarded

Planning and Execution (2)	Result and Report (6)	Viva (2)	Total (10)

Signature of the Faculty

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