RC Circuit

Experiment No.: 06 **Date:** 12. 05 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

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

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

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

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

Integrating the above we get,

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

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

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.

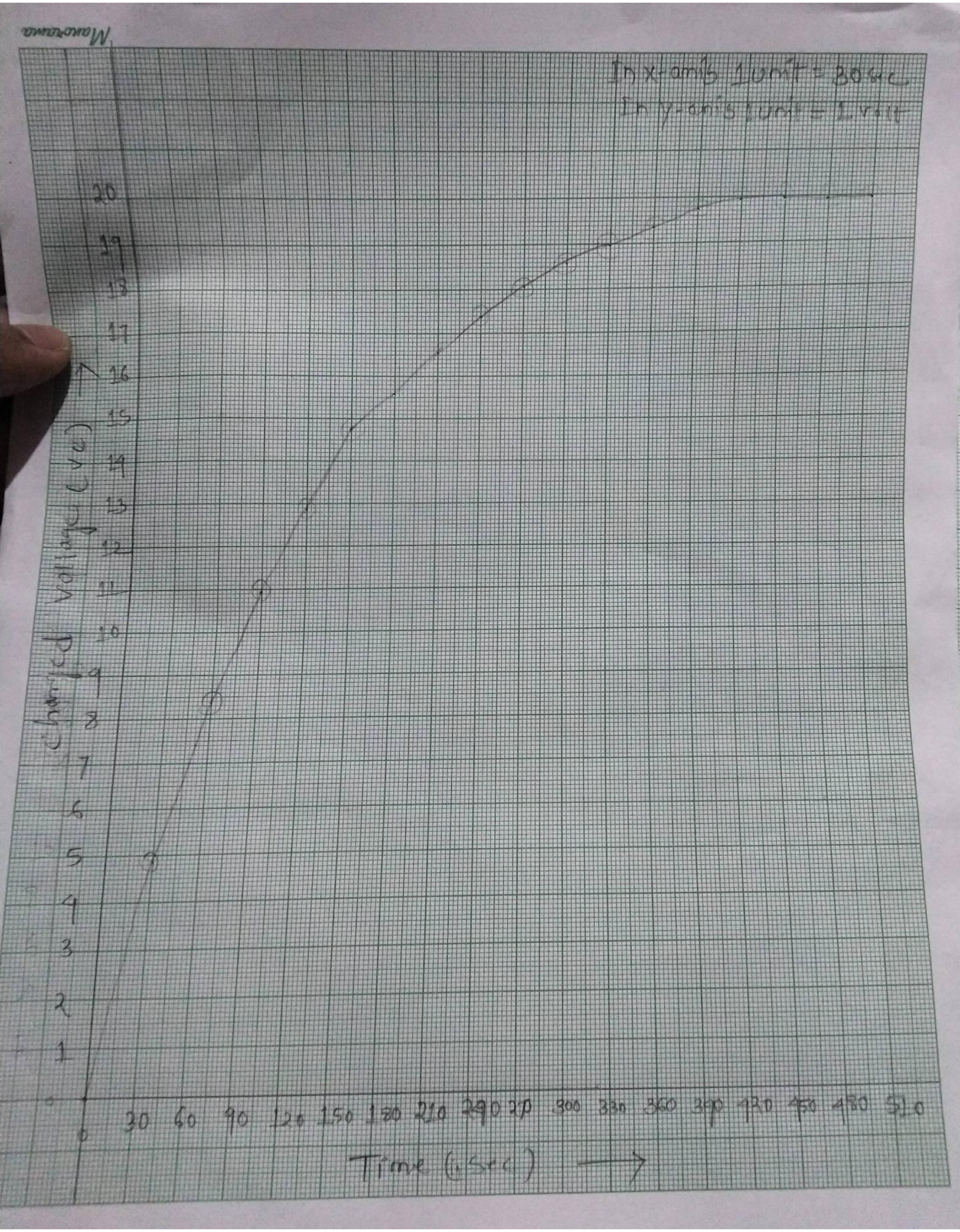
d) Plot the graph between V_C(Capacitor Voltage) versus time.

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.



In x-axis 1 unit = 30 sec
In y-axis 1 unit = 1 volt
Charged Voltage (vc)
Time (sec)
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
1
2
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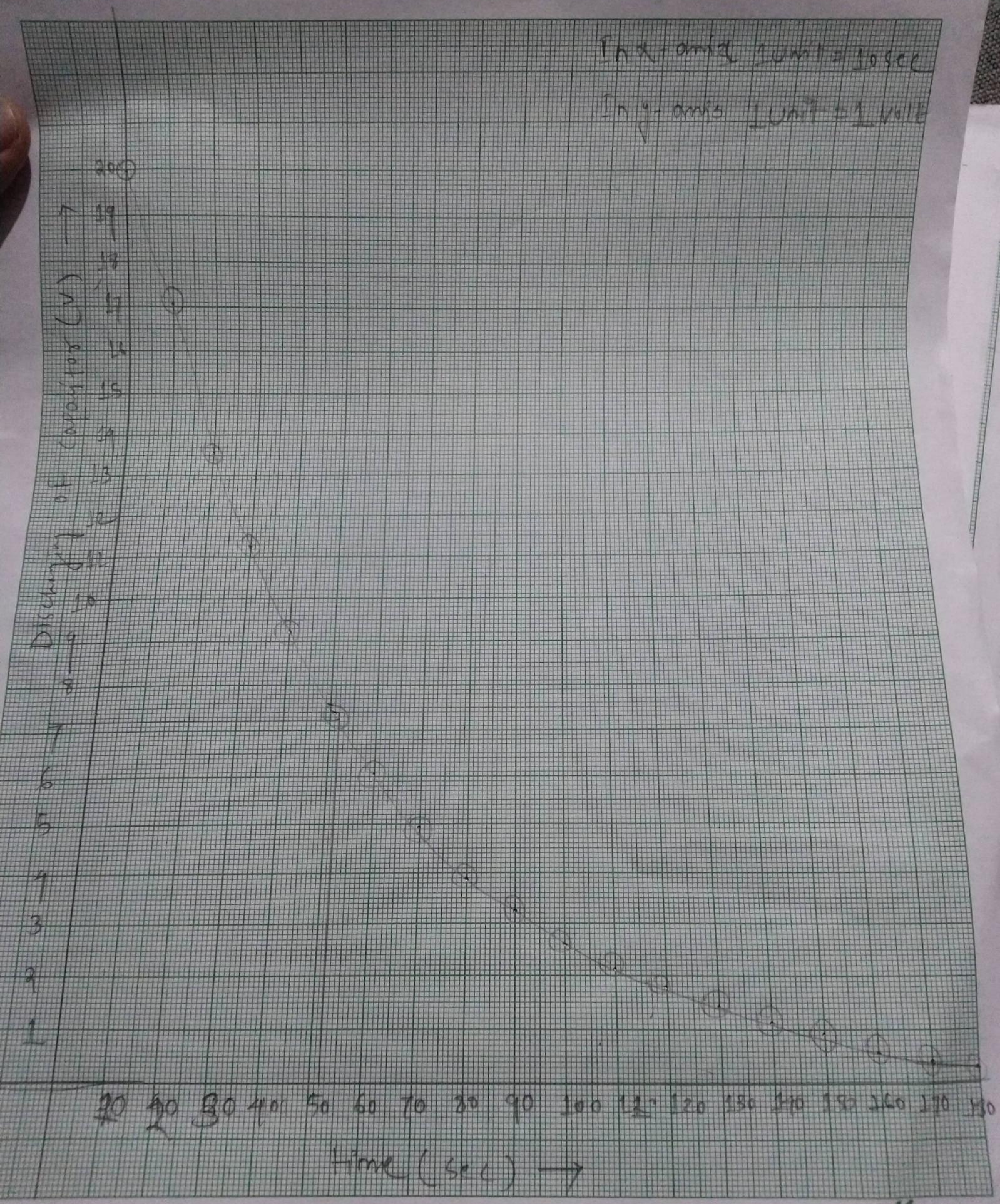


In x-axis 1unit = 10sec
In y-axis 1unit = 1 volt
Discharging of capacitor (V)
time (sec)

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

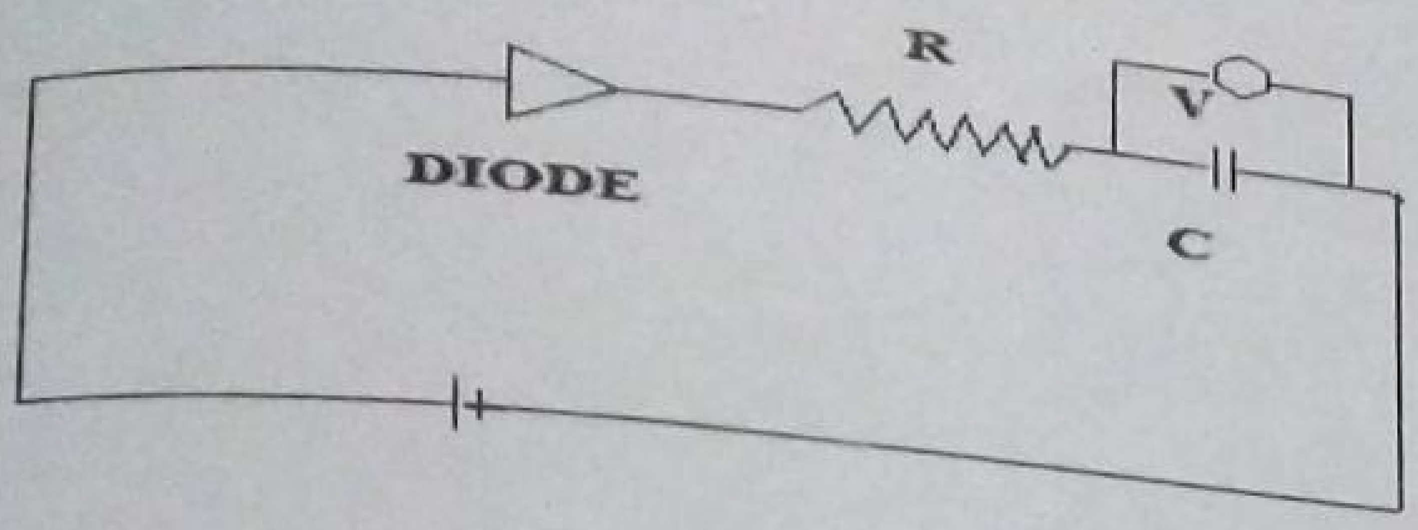
Observation:

R = 470K C = 100 μF RC = 47 sec

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	600	
2	30	4.82	22	630	
3	60	8.32	23	660	
4	90	10.91	24	690	
5	120	12.85	25	720	
6	150	14.74	26	750	
7	180	15.55	27	780	
8	210	16.56	28	810	
9	240	17.39	29	840	
10	270	18.03	30	870	
11	300	18.58	31	900	
12	330	18.99	32	930	
13	360	19.36	33	960	
14	390	19.72	34	990	
15	420	19.99	35	1020	
16	450	19.99	36	1050	
17	480	19.99	37	1080	
18	510	19.99	38	1110	
19	540	19.99	39	1140	
20	570	19.99	40	1170	

Circuit Diagram:



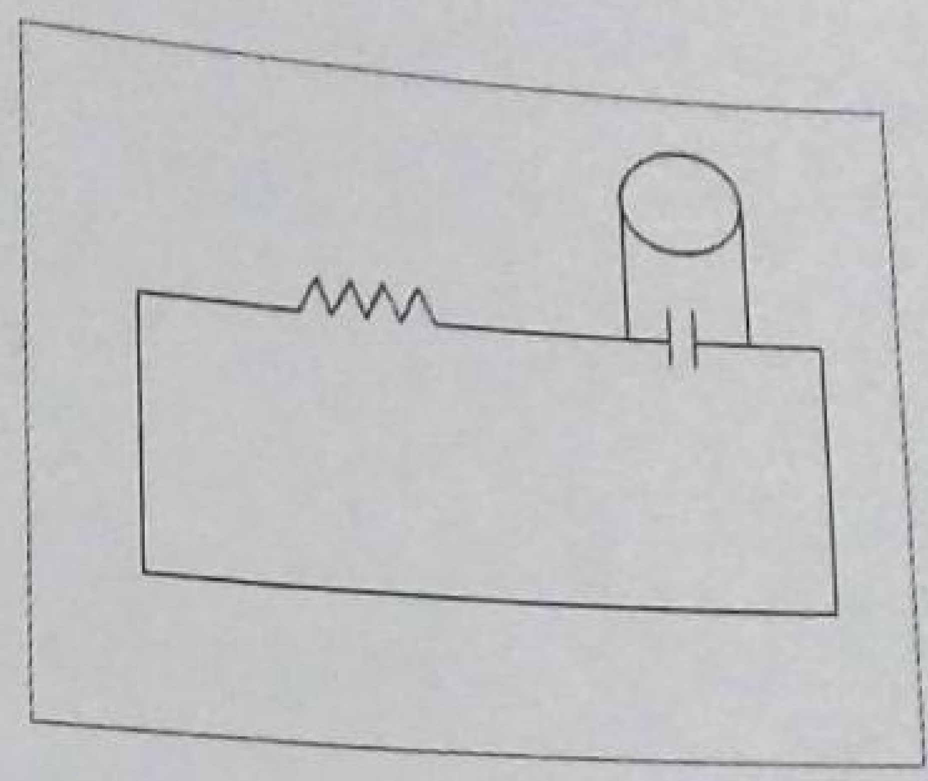


Table – 2: (Discharging of Capacitor)

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	3.24	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	0.51	37	360	
18	170	0.44	38	370	
19	180	0.31	39	380	
20	190	0.25	40	390	

Calculation:

$R =$ 470K, $C =$ 100uF,

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

Percentage of Error:

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

Conclusion: λ was found to be 52 from the graph with 10.6% error.

Marks Awarded

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

Signature of the student:

Regd No:

Group:

Branch:

Signature of the faculty

Diffraction grating using LASER

Experiment No.: 07

Date: 18.05.2020

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

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

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

$\lambda =$ Wavelength of light

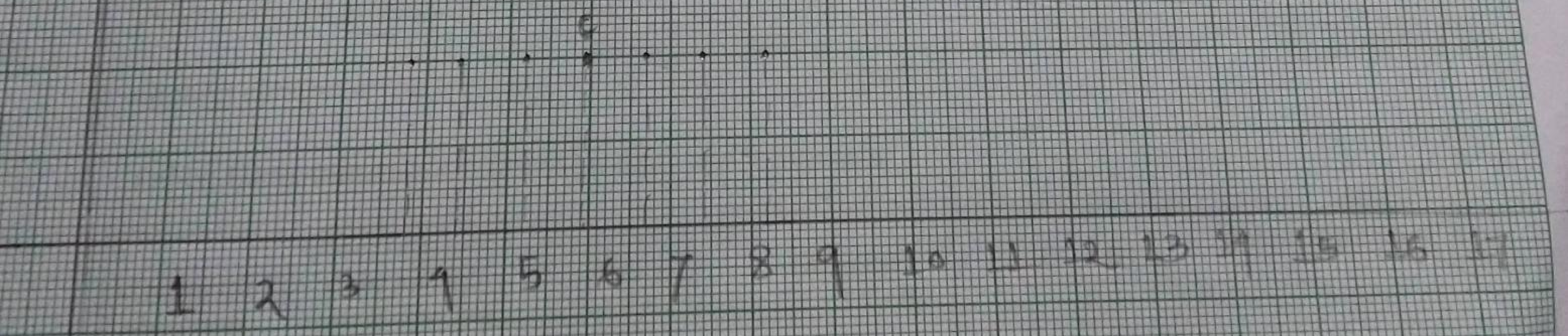
$n =$ Order of spectrum

So,

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

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

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


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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 cm distances the rider of 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 optical screen are adjusted so that well defined spectrum of LASER is obtained on the screen.

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

Observations:

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

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

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

Grating element = $(a + b) = \frac{1}{N} =$ $2.5/500 = 0.005$ cm per line

Table: (Determination of diffraction angle and wavelength)

Order of spectrum	Observation on right side of central maxima (A)	Observation on left side of 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, $\lambda_1 = \frac{(a+b)\sin\theta_1}{1}$ $= \frac{0.005 \times 0.0125}{1} = 6250 A^0$

For second order, $\lambda_2 = \frac{(a+b)\sin\theta_2}{2}$ $= \frac{0.005 \times 0.025}{2} = 6250 A^0$

For third order, $\lambda_3 = \frac{(a+b)\sin\theta_3}{3}$ $= \frac{0.005 \times 0.036}{3} = 6000 A^0$

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

$=$ 6166 cm

Percentage of Error:

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

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

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

$=$ 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 student:

Regd No:

Group:

Branch:

Signature of the faculty

Surface Tension

Experiment No. 08 **Date:** 19/05/2020

Aim:

To determine the surface tension of a given 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 rise of liquid in the tube is known as capillary rise. If the height through which liquid rises is 'h', the surface tension of the liquid (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 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. Do not use distilled water, as it is generally greasy. 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 two 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 also 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 (R_1 say).
e) Move the travelling microscope along the horizontal scale and bring it in front of the second 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 (R say). (R_1 – R) 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.

h) **Observation:**

Room temperature = 32°c

Density of water ρ at t^0 C = 1 gm.cc

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 in cm	VC	VSR in 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 4.37					$h_2 = (R_2 - R)$ = 1.80

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

Tube No.		MSR in cm	VC	VSR in 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	0.052 r_1
	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, $S = \frac{\rho g r}{2}\left(h + \frac{r}{3}\right)$

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

$S_2 = \frac{\rho g r_2}{2}\left(h_2 + \frac{r_2}{3}\right) =$ 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 20^0 C = 72.7 Dyne.cm^{-1}

The surface tension of water at 30^0C = 71.2 Dyne.cm^{-1}

The surface tension of water at 40^0C = 69.6 Dyne.cm^{-1}

at 32°C S = 71.2 dyne/cm

% of Error:

$$\frac{71.2 - 68.76}{71.2} \times 100 = 3.15\%$$

Conclusion:

Surface tension of water at 32 ^{0}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 student:

Regd No:

Group:

Branch:

Signature of the faculty

Rigidity Modulus

Experiment No: 09

Date: 20/05/2020

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

C = Restoring couple per unit angular twist

For equilibrium, twisting couple = restoring couple.

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

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

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

No Of Obs.	ICSR (I)	NCR (N)	FCSR (F)	Diff. (I - F)	PSR in cm [Pitch × N]	CSR in cm [(I – F) × L.C.]	Total in cm	Mean in cm
1								0.191
2								
3								
4								

Scanned by TapScanner

In x axis 1 unit = 250 gm
In y-axis 1 unit = 2 degree
L3 (75
m/α = 1500/27
L2 (50)
L1 (25)
m/α = 1500/10
M → (gm)
500
1000
1500
2000

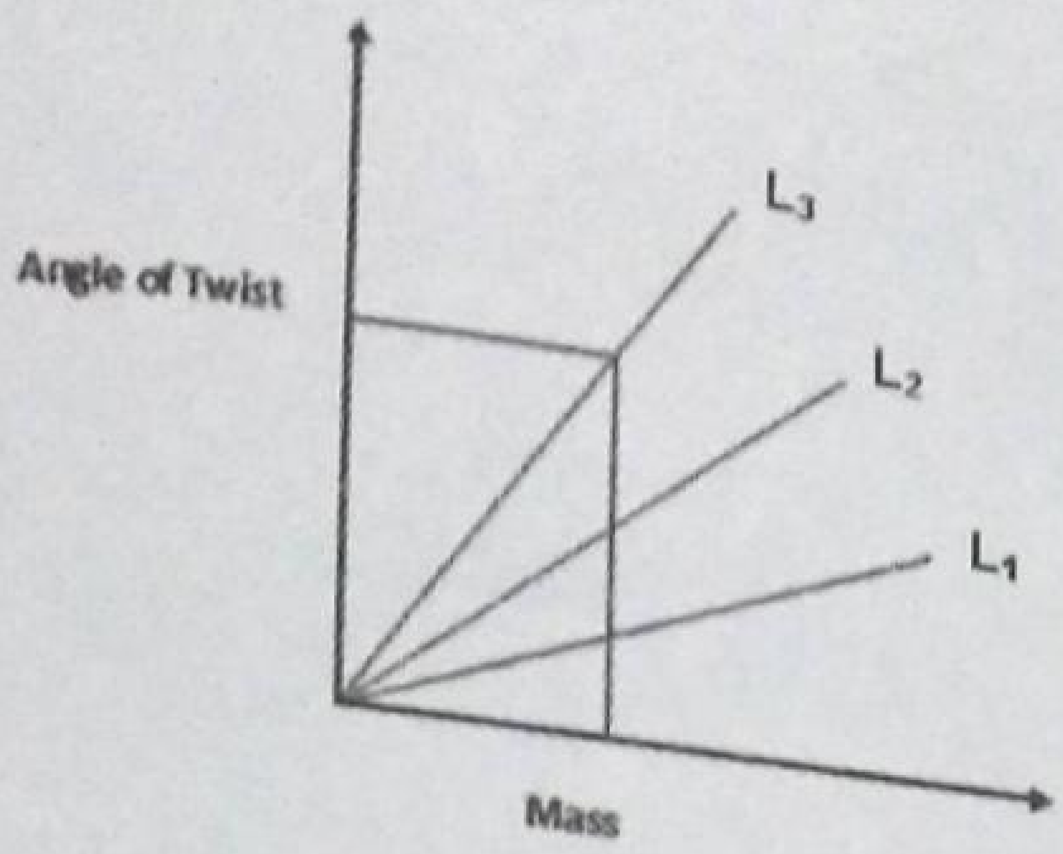
Table – 2: (Diameter of the cylinder using Vernier-calliper)

No of Obs.	MSR in cm	V.C.	VSR in cm	Total in cm	Mean in cm
1	3.6	2	0.02	3.62	3.62
2					
3					
4					

Table – 3: (Angle of Twist)

No of Obs.	Length in cm	Load in kg	Load increasing: Position of the pointer on scale θ_1 in degree	Load increasing: Change in position of the pointer on scale $d\theta_1$ in degree	Load decreasing: Position of the pointer on scale θ_2 in degree	Load decreasing: Change in position of the pointer on scale $d\theta_2$ in degree	Mean $\propto = \frac{d\theta_1+d\theta_2}{2}$ in degree
1	L_1 25	0	0	0	1	0	0
2		0.5	4	4	4	3	3.5
3		1.0	6	6	8	7	6.5
4		1.5	10	10	11	10	10
5		2.0	15	15	15	14	14.5
6	L_2 50	0	0	0	1	0	0
7		0.5	6	6	8	7	6.5
8		1.0	12	12	16	15	13.5
9		1.5	19	19	21	20	19.5
10		2.0	28	28	28	27	27.5
11	L_3 75	0	0	0	1	0	0
12		0.5	8	8	9	8	8.0
13		1.0	17	17	22	21	19
14		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

$= \frac{360 \times 25 \times 980 \times 3.62}{(3.14)^2 \times (0.191)^4} \times (150)$

$= 3.68 \times 10^{11}$ dyne/cm^2

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

$= \frac{360 \times 50 \times 980 \times 3.62}{(3.14)^2 \times (0.191)^4} \times 76.92$

$= 3.778 \times 10^{11}$ dyne/cm^2

$\eta = 3.79 \times 10^{11}$ dyne/cm^3.

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

$= \frac{360 \times 75 \times 980 \times 3.62}{(3.14)^2 \times (0.191)^4} \times 53.57$

$= 3.91 \times 10^{11}$ dyne/cm^2

Standard value:

Rigidity modulus of the copper wire = 4.55×10^{11} Dyne/cm^2

Rigidity modulus of the steel wire = 7.9 *to* 8.9 $\times 10^{11}$ Dyne/cm^2

% of Error:

$$\frac{4.55\times10^{11} - 3.79\times10^{11}}{4.55\times10^{11}} \times 100$$

$= 16.7\%$

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 student:

Regd. No:

Group:

Branch:

Signature of the faculty