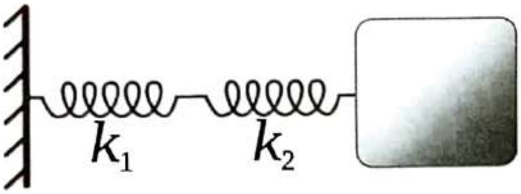
Observations

Two springs can be connected in series as shown in fig.



Two springs in parallel connection as shown in fig.

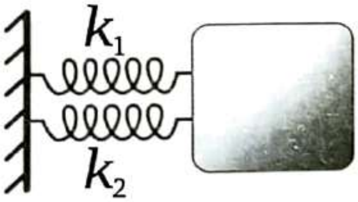


Table-1: Properties of springs and their combinations

Quantity	Spring parallel	Springs in series
Spring constant	$K_{equ} = K_1 + K_2$	$\frac{1}{k_{equi}} = \frac{1}{k_1} + \frac{1}{k_2}$
Elongation (Extension)	$X_{equ} = x_1 = x_2$	$X_{equ} = x_1 + x_2$
Force	$F_{equ} = F_1 + F_2$	$F_{equ} = F_1 = F_2$
Stored energy	$E_{equ} = E_1 + E_2$	$E_{equ} = E_1 + E_2$

Series and Parallel Combinations of Spring

EXPT. NO: **DATE:**

AIM: To determine the spring constants of given springs in series and parallel combination.

APPARATUS: Rigid support, given springs, Slotted weights, Scale etc.

PRINCIPLE: - Hook's law states that strain is directly proportional to stress within elastic limit. i.e.

$F = -kx$ where "k" is spring constant and "x" is the displacement of the spring due to force here force is equal to weight

Experimental procedure: - The experimental procedure is consists of the following steps.

Part-A: Determination of spring constant k_1 using spring-1

The spring-A is hooked to the stand and the scale is placed by the side.

The 0.050 kg slotted weight is hooked to the spring as shown in Figure-2, and when the spring is rest, the reading corresponding to the spring pointer is noted from the vertical scale beside the spring.

Trial is continued by adding another 0.050kg making total 0.01kg and the when the spring is stand still, the corresponding displacement is noted.

Trial is continued until the total mass is 0.30kg in steps of 0.050kg each time. The corresponding displacement is noted in Table-1.

From the table the average displacement for 50gm is calculated and the force acting on the spring is also calculated and presented in Table-1.

Spring constant of spring-1 is calculated using equation-1.

Part-B: Determination of spring constant k_2 using spring-2.

Experiment is repeated with spring-2 and the corresponding force on the spring and its displacement are tabulated in Table-2 and spring constant k_2 is determined using equation 2.

Part-C: Determination of k_{series} using spring-A and spring-1and 2

Removing all the mass from spring-1, spring-2 is now connected in series with the spring and experiment is repeated by placing 0.050kg slotted weight as shown in Figure-2. The mass and displacement are noted recorded in table 3.

Table-1: Force acting and spring displacement for Spring-1

Trails	Mass (m) kg	Displacement (x_1) m	Displacement corresponding to .050 kg
a	0.05	14.3	(a-a) = 0.0
b	0.10	16.2	(b-a) = 1.9
c	0.15	18.2	(c-b) = 2.0
d	0.20	20.1	(d-c) = 1.9
e	0.25	22.0	(e-d) = 1.9
f	0.30	24.0	(f-e) = 2
		Average x_1	1.61

Where a, b, c, d, e, f are the trails or observations.

$$k_1 = \frac{F_1}{x_1} = \text{0.304 N/m} \quad (1)$$

$$K_1 = \frac{mg}{x_1} = \frac{0.05 \times 9.8}{1.61}$$

$$K_1 = 0.304$$

Table-2: Force acting and spring displacement for Spring-2

Trails	Mass (m) kg	Displacement (x_2) m	Displacement corresponding to 0.05 kg
a	0.05	13.9	(a-a) = 0
b	0.10	14.2	(b-a) = 0.3
c	0.15	15.8	(c-b) = 1.6
d	0.20	17.7	(d-c) = 1.9
e	0.25	19.7	(e-d) = 2.0
f	0.30	21.5	(f-e) = 1.8
		Average x_2	1.26

$F_2 = k_2 x_2$ or

$$k_2 = \frac{F_2}{x_2} = \text{0.388 N/m} \quad (2)$$

$$K_2 = \frac{mg}{x_2} = \frac{0.05 \times 9.8}{1.26} = 0.388$$

Trial is continued by increasing the mass in steps of 0.05kg and the corresponding displacements are noted in Table-3. The spring constant of springs in series combination can be calculated using equation 3.

Part-D: Determination of $k_{parallel}$ using spring-1 and spring-2

The masses are removed from the spring and two springs are now connected in parallel as shown in Figure-3.

The mass is now applied to the small beam holding the spring and with 0.05kg slotted weight connected the displacement is noted on the scale by adjusting the scale to the spring pointer.

Trial is repeated by increasing the force by adding 0.050kg mass and in each case the displacement is noted and presented in Table-4. Effective Spring constant in the parallel combination is calculated using the equation 4.

Note: - Since we used both identical springs with same number of radius, turns and length the spring constant obtained are almost the same

m

Table-3: Force acting two springs in series and the displacements

Trails	Mass (m) kg	Displacement (x) m	Displacement corresponding to 50gm
a	0.05	22.1	(a-a) = 0
b	0.10	24.6	(b-a) = 2.5
c	0.15	28.3	(c-b) = 3.7
d	0.20	32.2	(d-c) = 3.9
e	0.25	36.0	(e-d) = 3.8
f	0.30	39.8	(f-e) = 3.8
Average x_{series}			2.95

$F_{series} = k_{series}\, x_{series}$ or

$k_{series} = \frac{F_{series1}}{x_{series}} =$ 0.166 N/m

$K_s = \frac{mg}{x_s} = \frac{0.05 \times 9.8}{2.95}$

$K_s = 0.166$ N/m (3)

When the two identical springs are in series then we have

$\frac{1}{k_{series}} = \frac{1}{k_1} + \frac{1}{k_2} = k = \frac{k_1 k_2}{k_1 + k_2} =$ 0.170 N/m

$= \frac{0.304 \times 0.388}{0.304 + 0.388}$

$= 0.170$ N/m.

Table-4: Force acting two springs in parallel and the displacements

Trails	Mass (m) kg	Displacement (x) m	Displacement corresponding to 50gm
a	0.05	14.5	(a-a) = 0
b	0.10	14.9	(b-a) = 0.4
c	0.15	15.3	(c-b) = 0.4
d	0.20	15.9	(d-c) = 0.6
e	0.25	16.7	(e-d) = 0.8
f	0.30	17.6	(f-e) = 0.9
	Average x_{series}		0.51

$F_{parallel} = k_{parallel}\, x_{parallel}$ or

$K_{parallel} = \frac{F_{parallel}}{x_{parallel}} =$ 0.960 N/m

$K_p = \frac{mg}{x_p} = \frac{0.05 \times 9.8}{0.51}$

$= 0.960$ N/m (4)

For parallel combination of two identical springs,

$P_{arallel} = k_1 + k_2 =$ 0.692 N/m

$P = 0.304 + 0.388$

$P = 0.692$ N/m

Results

The spring constant obtained are within the limits of experimental errors,

Spring constant k_1= ---0.304-----N/m
Spring constant k_2= ----0.388----N/m
Spring constant in series = ----0.166----N/m
Spring constant in parallel = --0.960----N/m

21/1/21

Viva

1. What is meant by periodic motion?
   A motion which repeats after every regular interval of time. For example motion of the all the planets around the sun, and satellites around the planets.
2. What is an oscillatory or vibratory motion?
   A bounded periodic motion.
3. What if the difference between periodic and oscillatory motion?
   A periodic motion repeats after regular interval of time but oscillatory is repeats after regular interval of time within well-defined limits.
4. What is simple harmonic motion?
   A simple harmonic motion is one in which the acceleration of the body is directly proportional to its displacement from the fixed point and always directed towards the fixed point.
5. What are the characteristics of S.H.M.?
   The characteristics of S.H.M are Displacement, amplitude, velocity, acceleration, time period, frequency and Phase difference etc.
6. State Hook's law for vibrating springs.
   Hook's law states that within elastic limit the tension in the spring is proportional to the extension of spring beyond its length. i.e. $T = -k\,x$ where T is the tension or force in the string, k is known as spring constant and x is known as displacement of the spring .
7. In how many ways springs arranged?
   In two ways horizontal and vertical combination.
8. What is the effective spring constant of springs when connected in series?
   The equivalent spring constant is given by
   $\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2} \dots\dots\dots\dots = \frac{1}{K_n}$ where $n = 1, 2, 3, 4, \dots\dots$
9. What is the effective spring constant of springs when connected in parallel?
   The equivalent spring constant is given by
   $K = K_1 + K_2 \dots\dots + K_n$ where $n = 1, 2, 3, 4, \dots\dots$
10. What is the expression for time period of oscillation of oscillating spring?
    In both the case $T = 2\pi\sqrt{\frac{mass}{stiffness\ factor}}$

Diagram

Magnetic field along the axis of the current carrying circular coil.

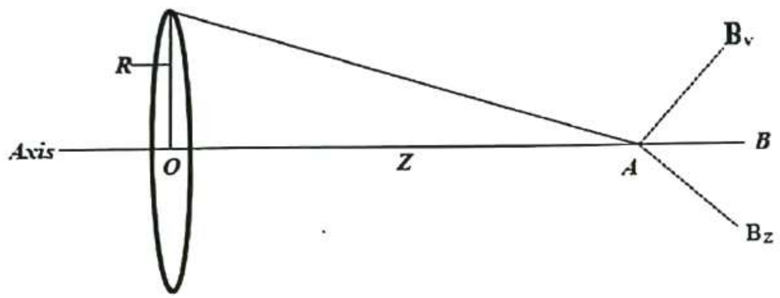
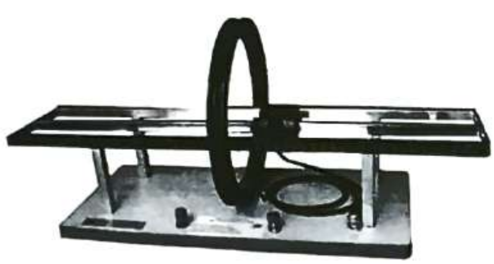
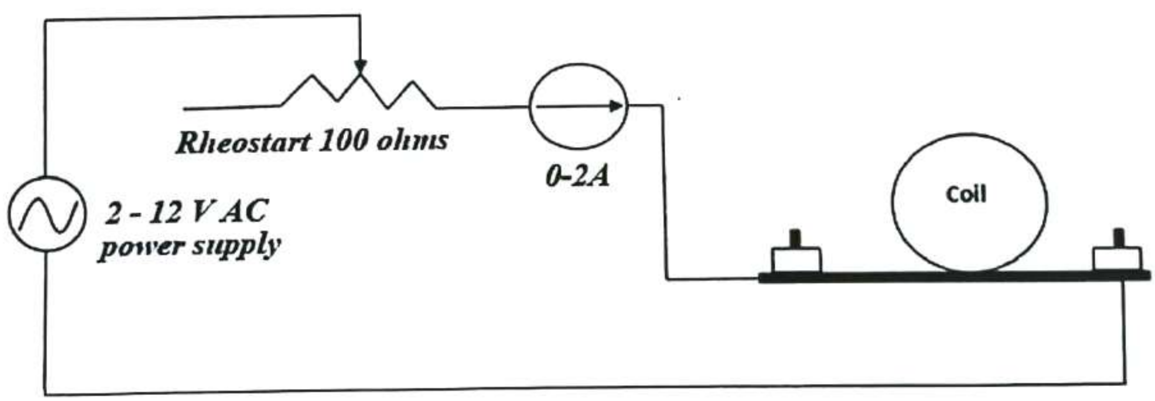


Figure-: Stewart - Gee apparatus with the search coil



Circuit Diagram



MEASUREMENT OF MAGNETIC FIELD ALONG THE AXIS OF A CIRCULAR CURRENT CARRYING COIL

EXPT. NO: **DATE:**

Aim: - To determine the magnetic field along the axis of the circular current carrying coil.

Apparatus: - Digital Stewart-Gee apparatus, AC power supply 2-12V, ~~AC ammeter 0-2A~~, ~~Rheostat 100Ω, digital Vernier, and LCR meter.~~

Theory

Experimental procedure

The experimental set up is as shown in fig. Using Stewart-Gee apparatus, AC power supply, digital AC current meter, ~~and rheostat~~ are connected ~~series~~ as shown in circuit diagram ~~(There is no need to align the instrument along the magnetic meridian)~~.

The search coil cable is connected to the digital AC current meter along the axis of the instrument and it is switched on.

The current in the field coil is now adjusted to 1A and voltage is set to 12V. The field at the center of the coil is recorded from the LCD display as,

(At the center $x = 0$, ~~V_{rms} = ---------- V~~, B_{pp} = ---------gauss.)

The search coil is now moved to the left of the center by 1cm and the flux, induced e.m.f are noted as

At the center $x = 1$ cm, ~~V_{rms} = ---------- V~~, B_{pp} = ---------gauss.

The experiment is repeated by moving the search coil in steps of 1 cm, recording the e.m.f. and the flux each time. The readings obtained are recorded in the table.

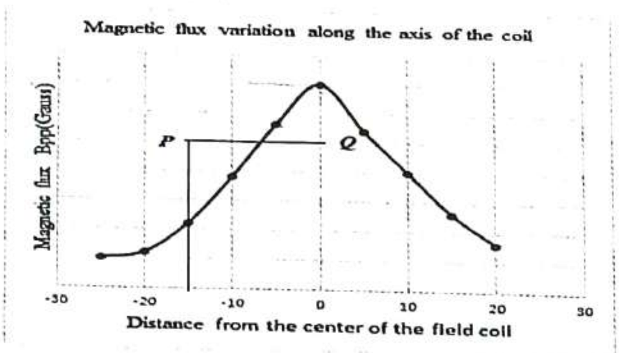
A graph is plotted by taking distance along X-axis and magnetic flux along Y-axis as shown in nature of the graph.

Note: - The curve is no exactly symmetrical about the vertical axis. This may be due to the slight realignment of the search coil.

Tabular column

Distance from the center of the coil 'a' in cm	Induced e.m.f. V_{rms} in V	Magnetic field B_{pp} in Gauss	Distance from the center of the coil 'a' in cm	Induced e.m.f. V_{rms} in V	Magnetic field B_{pp} in Gauss
Left hand side of the coil			Right hand side of the coil		
0		84.2	0		84.2
1		83.3	1		84.1
2		81.1	2		83.1
3		77.8	3		80.9
4		73.9	4		78.0
5		69.9	5		74.2
6		65.7	6		70.2
7		61.0	7		66.5
8		57.3	8		61.3
9		52.2	9		58.2
10		47.1	10		51.7
11		42.2	11		47.5
12		36.8	12		42.2
13		35.3	13		39.1
14		31.1	14		36.0
15		28.4	15		34.2
16		25.9	16		30.6
17		23.7	17		26.1
18		22.8	18		23.3
19		20.6	19		20.9
20		18.4	20		18.9

Nature of the graph



Result: - The variation of magnetic field intensity along the axis of current carrying circular coil has been studied and the nature of graph plotted.

2/8/21

Viva

1. What is magnet?
   A magnet either natural or artificial is one which exhibits two properties one is attractive properties i.e. which attracts magnetic materials second directive property i.e. when it suspended freely in horizontal plane always comes to rest in north and south direction.
2. What are the laws of magneto statics?
   Like poles repeals and unlike poles attracts.
   The force of attraction or repulsion between two isolated magnetic poles is directly proportional to the pole strengths and inversely proportional to square of the distance between the poles.
   $F = k\frac{m_1 m_2}{r^2} = \left(\frac{\mu_0}{4\pi}\right)\frac{m_1 m_2}{r^2}$ Where μ_0 is called absolute permeability of free space and is equal to $4\pi \times 10^{-7}$ H/m.
3. What is pole strength?
   A pole strength of a magnetic pole is numerically equal to 10^7 times the force in newton that it exerts on a unit North Pole (North Pole of 1 Am) placed at a distance of 1 m from it in air or vacuum.
4. What is SI unit of pole strength?
   Ampere-meter = A-m.
5. What is magnetic field?
   A magnetic field is region within which a magnetic pole experienced a force. Even any moving charged particle also experienced by force.
6. What is null point?

   In a combined magnetic field the null point is that point at which the magnetic field is zero.
7. What is a line of force in magnetic field?
   A line of force in magnetic field is the path along which an isolated north pole moves or tends to move.
8. Define magnetic flux density.
   The number of lines of force passing normally through unit area of cross section around a point is called magnetic flux density at that point. The SI unit is Wb/m^2 = Tesla
   Magnetic flux density is a measure of magnetic field.
9. Define magnetic field or magnetic flux density.
   Magnetic flux density or magnetic field B at a point is defined as the force in newton acting on a north pole of strength 1 Am kept at that point.
10. What is magnetic moment?
    The magnetic moment is a quantity that represents the magnetic strength and orientation of a magnet that produces a magnetic field.
11. Define intensity of magnetic field.
    The intensity of magnetic field or magnetic field strength at any point is defined by the relation $H = \frac{B}{\mu_0}$
12. What is the magnetic effect of electric current?

A current carrying conductor produces magnetic field in the surrounding region is known as magnetic effect of electric current.

13. How direction of magnetic field due to electric current defined?
    By Amperes swimming rule and Maxwell's right hand screw rule
14. State Biot-Savarts's law.
    The magnetic intensity dH at a point A due to current I flowing through a small element dl is Directly proportional to current (I), Directly proportional to the length of the element (dl), Directly proportional to the sine of angle θ between the direction of current and the line joining the element dl from point A., Inversely proportional to the square of the distance (x) of point A from the element dl.

$$dH = \frac{\mu_0 \mu_r}{4\pi} x\ Idl\ Sin\theta / x^2$$

$$dH = k\ x\ Idl\ Sin\theta / x^2$$

$$dH \propto Idl\ Sin\theta / x^2$$

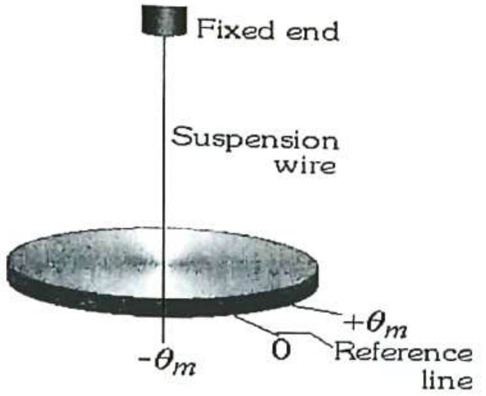
Where k is constant and depends on the magnetic properties of the medium.

$$K = \mu_0 \mu_r / 4\pi$$

μ_0 = absolute permeability of air or vacuum and its value is 4 x 10^{-7} Wb/A-π
μ_r= relative permeability of the medium.

15. What is the expression for magnetic field at the center of a circular coil carrying a current?
    The magnetic field at the center of the current carrying circular coil is given by
    $B = \left(\frac{\mu_0}{4\pi}\right) \times \frac{2\pi n l}{r}$ Tesla or Wb/m
16. How the magnetic field varies along the axis of the current carrying circular coil carrying current?
    The field at the center of the coil is maximum and decreases with of distance on either side of the coil along the axis of the coil.
17. What is the relationship between Gauss and Tesla?
    1 Gauss = 10^{-4} Tesla

DIAGRAM



OBSERVATIONS

i. Circumference of the disc, $C = 49 \times 10^{-2}$ m
ii. Radius of the disc, $R = C/2\pi = 7.79 \times 10^{-2}$ m
iii. Mass of the disc, $M = 0.57$ Kg
iv. Moment of inertia of the disc = $I = MR^2/2 =$ 1.729×10^{-3}
v. Radius of the wire = r = 0.44 mm = 0.44×10^{-3} m

To find time period of torsional oscillations:

Trial No	Length of the wire (l) $\times 10^{-2}$ m	Time for 10 oscillations in seconds			Period T=t/10 In seconds	(l/T^2)	Mean (l/T^2) In ms^{-2}
		t_1	t_2	Mean t			
1	39	47	47	47	4.7	0.017	
2	34	44	44	44	4.4	0.017	
3	26	39	39.	39	3.9	0.017	
4	23	36	36	36.	3.6.	0.017	0.017

Rigidity modulus of the material of a given wire $\eta = (8\pi I/r^4)\,(l/T^2)_{mean}$

$$\eta = \left(\frac{8\pi I}{r^4}\right)\left(\frac{l}{T^2}\right)_{mean}.$$

$$= \frac{8 \times \pi \times 1.729 \times 10^{-3}}{(0.44 \times 10^{-3})^4}\left(0.017\right)$$

$$= 1.9709 \times 10^{10}$$

TORSIONAL PENDULUM

EXPT. NO: **DATE:**

AIM: To determine Rigidity modulus of the material of a given wire using Torsional pendulum.

APPARATUS: Torsional pendulum, stop watch, screw gauge, Thread, scale, etc.

PROCEDURE: The circumference C of the disc is measured using a thread and a scale and the radius R of the disc is calculated using the relation, $R = C/2\pi$.

The mass M of the disc is found by using a balance and moment of inertia of the disc about an axis passing through its center and perpendicular to the disc is calculated using the formula $I = MR^2/2$.

Least count of the given screw gauge is calculated and its zero error is noted. The radius of the given wire is calculated using the screw gauge and the readings are tabulated.

Suspend the disc using the given wire as shown in the experimental arrangement. Adjust the length "l" of the wire from the torsion head and note its value. Allow the disc to execute torsion oscillations and using a stop watch note the readings in the tabular column. He time period of oscillation T is calculated. The experiment is repeated to find the time period for different lengths and l/T^2 is calculated for each trial. The mean (l/T^2) is calculated.

Finally rigidity modulus η is calculated using the formula,

$$\eta = (8\pi I/r^4)\,(l/T^2)_{mean}$$

RESULT: Rigidity modulus of the material of a given wire η = ...1.9709 X 10^{10}... N m^{-2}

Viva Questions:

1. **What is torsional pendulum?**

Ans It is a heavily circular disc suspended from one end of a fine wire attached to its centre.

2. **Define rigidity modulus.**

Ans It is defined as the ratio of the tangential stress to the shearing strain.

3. **What is inertia?**

Ans The property of a body due to which it opposes any change in its state of rest or of uniform motion.

4. **What is moment of inertia?**

Ans The inability of a body to rotate by itself.

5. **What is torsional oscillation?**

Ans Oscillation of a body under the action of a torque.

6. **What is period?**

Ans Time taken for one oscillation.

7. **If the length of suspended wire increased, what happens to period?**

Ans Period also increases.

8. **What is the unit of moment of inertia?**

Ans g-cm^2 (in CGS system), Kg-m^2 (in MKS and SI system).

Observations

The length of the cantilever is measured from the fixed end till the end of open end using meter scale

Length of the cantilever= l =-----------cm = ----------------m

Using digital Vernier the thickness (t) and breadth (b) of the cantilever beam is measured.

b = ----------mm =----------m   t =---------mm = ----------------m

Table-1: Depression of the beam for different mass

Serial number	Mass (gm)	Digital travelling microscope reading (mm)
1	0	
2	50	
3	100	
4	150	
5	200	
6	250	
7	300	
8	350	

A graph is drawn taking mass m along the X axis and depression x along Y-axis as shown in Figure-2. From the straight line graph the slope is determined

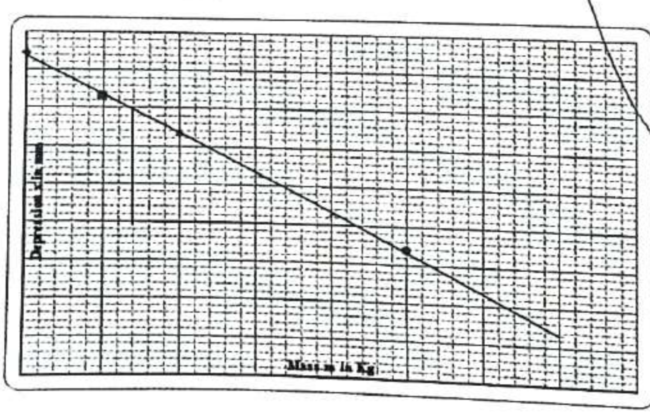


Figure: - Variation of depression with load

YOUNG'S MODULUS BY SINGLE CANTILEVER
(Non-uniform bending)

EXPT. NO: **DATE:**

AIM: To determine the young's modulus of material of aluminum beam by single cantilever method.

APPARATUS: Aluminum beam, slotted weight 7x50gms, digital travelling microscope, digital Vernier calipers and half meter scale etc.

Principle: - The non-uniform bending of the beam is monitored using a digital travelling microscope. The depression of the beam for different force is measured and young's modulus is calculated using equation

$$Y = \frac{4mgl^3}{bxd^3}$$

Where Y is the young's modulus, m is mass hanging at the open end, g =9.8m/s^2, l is the length of the cantilever, b is breadth of the beam, d is the thickness of the beam and x is the depression at the open end of the cantilever

In equation all the parameters can be measured directly using digital Vernier and meter scale, except the ratio m/x. To measure m/x, digital travelling microscope is used.

Experimental procedure

The digital travelling microscope reading is set to around 5.00mm by rotating the fine movement know of the travelling microscope.

Now the microscope is placed in front of the cantilever with the horizontal telescope is about 2-3 inches from the pointer on the cantilever.

Now the vertical coarse adjustment of travelling microscope is loosened and the horizontal telescope is positioned in line with the pointer.

The telescope is adjusted to see clearly the pointer and it is coincided with the horizontal cross wire and reading is noted.

0.050kg weight hanger is now loaded to the cantilever due which the cantilever bend the pointer in the microscope moves up.

The microscope fine screw is adjusted such that the pointer again coincide with the horizontal cross wire and travelling microscope reading is noted in Table-1.

Vernier - 7
Hanging pan

$$slope = \frac{\Delta y}{\Delta x} = \frac{x}{m} = ------ = ------ m/kg$$

Therefore $\frac{1}{Slope} = \frac{m}{x} =$ ------------m/kg

Young's modulus is calculated using equation

$$Y = \frac{4gl^2}{bd^3} \times \frac{1}{slope} = ------N/m^2 = ------ Pa$$

To find the LC of the travelling microscope.

Smallest division on the vernier scale N_1 = 0.05 cm

No. of division on the vernier scale N_2 = 50 div

Least count of travelling Microscope N_1/N_2 = 1×10^{-3} cm.

TR = MSR + (VSR × LC)

$$Y = \frac{4gl^3}{bd^3} \times \frac{1}{slope}$$

$$= \frac{4 \times 9.8 \times (21.5 \times 10^{-2})^3}{3 \times 10^{-2} \times (2.33 \times 10^{-3})^3} \times 39.682.$$

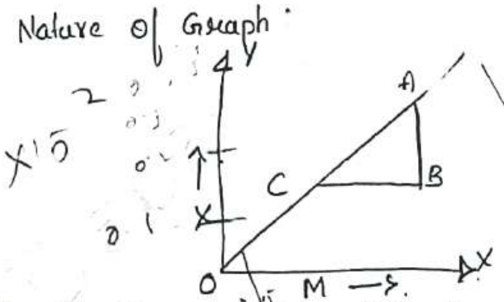
$$= 4.073 \times 10^{10} \ N/m^2$$

Trial is repeated by increasing weight in steps of 0.050kg and in each case the pointer is again coincided with the horizontal cross wire and corresponding depression is noted in the travelling microscope and recoded in Table-1

Trial is continued till 0.350kg and each case coinciding the pointer to the horizontal cross wire the depression is noted.

Sl No	Load M in kg.	Reading of Travelling Microscope						Mean X $X = \frac{x_1+x_2}{2}$	Depression X in cm	Depression X in m.
		Load increasing			Load decreasing					
		MSR	VSR	TR x_1	MSR	VSR	TR x_2			
1	Dead Load	5.15	10	5.16	5.20	10	5.21	a = 5.185	(a-a) = 0	0
2	0.05	5.05	15	5.065	5.05	17	5.067	b = 5.066	(a-b) = 0.119	0.119×10^{-2}
3	0.10	4.95	40	4.99	4.95	2	4.952	c = 4.971	(a-c) = 0.214	0.214×10^{-2}
4	0.15	4.80	4	4.804	4.80	14	4.814	d = 4.809	(a-d) = 0.376	0.376×10^{-2}
5	0.20	4.70	6	4.706	4.70	2	4.702	e = 4.704	(a-e) = 0.481	0.481×10^{-2}
6.	0.25	4.55	4	4.554	4.55	4	4.554	f = 4.554	(a-f) = 0.631	0.631×10^{-2}

Nature of Graph:



Slope $= \frac{AB}{BC}$

Result: - ~~Young's modulus of Aluminum by non-uniform bending= --------N/m² = ---------GPa~~

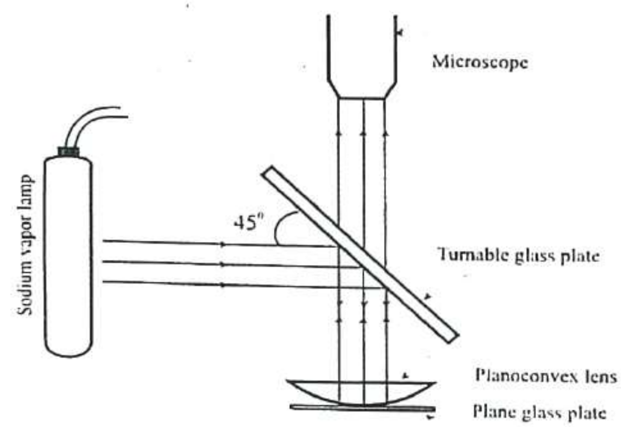
Young's modulus of the given bar by cantilever method is

$Y = \underline{4.073 \times 10^{10}}$ N/m²

Viva

1. **What is elasticity?**
   The property of body, it tends to regain its original shape and size after removal of deforming forces.
2. **State Hook's law.**
   Hook's law states that within elastic limit the stress is directly proportional to the strain.
3. **How many types of elastic moduli are there and mention the names?**
   There are three types. They are (i) Young's modulus (ii) Rigidity modulus and (iii) Bulk modulus.
4. **What is the difference between elastic body and plastic body?**
   If the body resists deformation and recover its original shape completely on the removal of the deforming forces is called elastic body and if the body is completely retains its altered size is called plastic body.
5. **Define Young's modulus and mention its unit?**
   It is a ratio of longitudinal stress (Force per unit area) to the longitudinal strain (Change in length per unit length) within elastic limit is called Young's modulus. Its unit is Newton/meter^2
6. **Define stress and what its units.**
   The restoring force per unit area of the body is called stress. Its unit is Newton/m^2
7. **Define strain and write its units.**
   The ratio of change in any dimension of a body to the original dimension is called strain. It has no units
8. **How many types of stress are there?**
   There are three types of stress 1) Longitudinal stress 2) Volume strain 3) Shearing stress
9. **How many types of strain are there define them.**
   There are three types of strain 1) Longitudinal strain 2) Volume strain 3) Shearing strain
   1) Longitudinal strain: When a change of length takes place, the strain is known as longitudinal strain. It measured by a change in length per unit length.
   2) Volume strain: The change in volume per unit volume is called volume strain.
   3) Shearing strain: The change in an angle of a body is called shearing strain.
10. **What is least count?**
    The smallest value of a physical quantity which can be measured accurately with in an instrument is called least count.
11. **What is meant by elastic limit?**
    There is maximum value for the deforming forces beyond which the body causes to be elastic. This maximum value of deforming forces is called elastic limit of the body.
12. **Define Rigidity modulus.**
    The ratio of tangential force per unit area to the angular deformation produced is called rigidity modulus.
13. **Define Bulk modulus.**
    It is the ratio of volume stress to the volume strain. Its unit is N/m^2

Ray diagram



NEWTONS RINGS SETUP

Fig. 1

OBSERVATIONS

Smallest division on the main scale N_1 = 0.1 cm.

Number of divisions on the vernier scale N_2 = 100 div.

Least count of traveling microscope N_1/N_2 = 0.001 cm.

TR=MSR+ (VSRxLC)

Ring number	TRAVELLING MICROSCOPE READINGS								
	LEFT SIDE			RIGHT SIDE					
	MSR cm	VSR	TR (x_1) cm	MSR cm	VSR	TR (x_2) cm	Diameter in cm $D=(x_1 \sim x_2)$	Diameter in m D 10^{-2}m	D^2 m $\times 10^{-4}$
10	2.3	72	2.37	1.9	96	1.99	0.38	0.38	0.144
8	2.3	67	2.36	1.9	5	1.90	0.46	0.46	0.211
6	2.2	51	2.25	1.9	23	1.92	0.33	0.33	0.108
4	2.2	33	2.23	1.9	41	1.94	0.29	0.29	0.084
2	2.2	17	2.21	1.9	64	1.96	0.25	0.25	0.062

White light → Mercury light
Sodium light → Yellow

NEWTON'S RINGS

EXPT. NO: **DATE:**

AIM: To find the wave length of sodium light and radius of curvature of Plano convex lens by measuring diameter of Newton's rings.

APPARATUS: Traveling microscope, Sodium vapor lamp, Newton's rings apparatus, Magnifying lens,

Principle: - Superposition of two or more waves is called interference there are two types of interference namely

1. Constructive interference
2. Destructive interference

From the theory of interference at this film
Newton's rings are formed due to interference between the waves reflected from the top and bottom surfaces of the air film formed between the Plano convex lens and the glass plate.
From the theory of thin film, we have
Path difference between reflected and refracted rays

Bright rings

D α $\sqrt{(2n-1)}$

Diameters of the bright rings are α to the roots of odd natural numbers as (2n-1) is odd no.

Dark rings

$D^2=4n\lambda R$

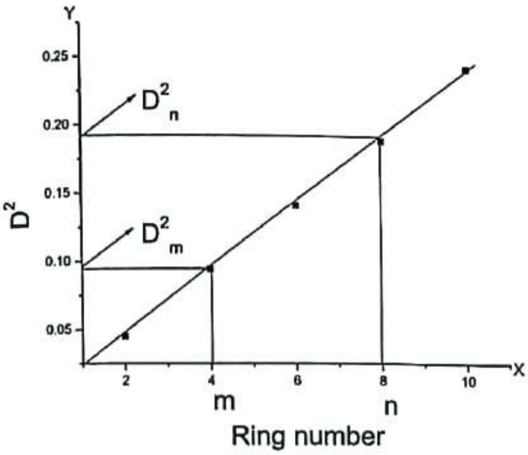
D α $\sqrt{n}$

Diameters of the dark rings are α to square square roots of natural numbers

PROCEDURE:

The surface of the Plano convex lens and the glass plates are thoroughly cleaned. The Plano-convex lens is placed over the glass plate. The apparatus is set up as shown in the figure.
Light from the sodium vapor lamp is made to fall on the glass plate, which is kept inclined at an angle of 45^0 to the horizontal. The beam gets reflected from the top and bottom surfaces of the thin air film enclosed between the surfaces of the convex-lens and the glass plate due to interference between these two rays, alternate dark and bright rings are formed, a T.M. is kept vertically above the ring system. The T.M. is focused on the ring system. Its position is adjusted so that the point of intersection of the cross wires is at the center of the ring system. The T.M. is moved by means of the tangential screw, from central dark spot to the left hand side, counting the number of dark rings. Vertical cross wire is made to lie on 10^{th} dark ring. The readings of the MSR and VSR are taken. The TM is moved towards the right side of the cross wire is made to lie on 8^{th} ,6^{th} , 4^{th} and 2^{nd} dark rings and the corresponding readings are taken. After reaching the center of the ring system the microscope is moved towards the right side of the center dark spot .Now cross wire is adjusted for 2^{nd}, 4^{th} , 6^{th} , 8^{th} and 10^{th} dark rings and note down the readings. The TM is always

Nature of the graph



The wave length of the sodium source can be calculated by the following formula, with the given radius of the curvature of the palno convex lens R = 1m

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

The radius of curvature of the plano convex lens can be calculated with given wave length of the sodium source =λ= 5893Å= 5893 x10^{-10}m

Radius of curvature $R = \dfrac{D_n^2 - D_m^2}{4\lambda(n-m)}$, moved in the same direction to avoid the error due to back lash, then difference between two readings at left and right of the same rings will gave diameter of the ring. Find out the wave length and radius of curvature of Plano convex lens using the following formulas.

Wave length $\lambda = \frac{D_n^2 - D_m^2}{4R(n-m)}$, Radius of curvature $R = \frac{D_n^2 - D_m^2}{4\lambda(n-m)}$,

$$\lambda = \frac{0.21\times10^{-4} - 0.10\times10^{-4}}{4\times1\,(8-4)}$$

$$R = \frac{0.21\times10^{-4} - 0.10\times10^{-4}}{4\times5893\times10^{-10}(8-4)}$$

$$\lambda = \frac{0.11\times10^{-4}}{16}$$

$$\boxed{R = 1.66m}$$

$$\boxed{\lambda = 6.875\times10^{-7}m}$$

RESULTS:

1. Wave length of sodium vapor lamp: λ= 6875 A° m.
2. Radius of curvature of given Plano convex lens: = 1.66 m.

Viva

1. **How do you get Newton's rings?**

Ans When a beam of light is made to fall normally on the combination of plano convex lens and a plane glass plate, concentric circular rings are observed these rings are known as Newton's rings.

2. **Where the rings are formed actually?**

Ans The rings are formed in the air film between the glass plate and the lens. They are called localized rings.

3. **Why the rings are circular?**

Ans The rings are circular because the air film is symmetrical about the point of contact of lens and glass plate.

4. **Why the glass plate is kept 45^0 with vertical?**

Ans Because the glass plate inclined at 45^0 makes the rays normally incident on the combination of lens and plate.

5. **What happens if we use white light instead of monochromatic light?**

Ans We will get some colored rings with a white light source.

6. **What will happen if a liquid is introduced between the lens and plate?**

Ans The rings will contract because its diameter will decrease.

7. **What is meant by radius of curvature?**

Ans Radius of curvature is the radius of the sphere of which the lens forms a part.

8. **On what factors diameter of the ring depend?**

Ans It depends on i) Refractive index of the medium enclosed between the lens and glass plate. ii) The radius of curvature of the plano convex lens. iii) The wavelength of the source used.

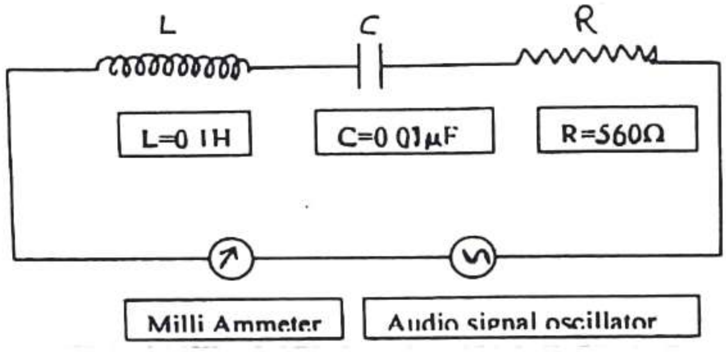
9. **In the Newton's rings system the rings get closer as we move away from the center why it is so?**

Ans The diameter D of dark ring proportional to square of the natural number i.e.$D\alpha n^2$
The diameter D of bright ring proportional to square root of the odd natural number i.e. $D\alpha\sqrt{2n-1}$, Hence diameter of the rings does not increases in the same proportion as the no of rings increases.

10. **Why the central spot is dark in the ring system? How it will look when viewed by transmitted light.**

Ans At the point of contact the path difference between the two interfering beams is equal to $\lambda/2$. Since it is the condition for minimum intensity, the central spot will appear dark. When viewed by transmitted light, the central spot will appear bright.

CIRCUIT DIAGRAM



Given L=0.1H, C= 0.01 μF R= ~~560Ω~~ 0.75 KΩ

The resonant frequency is also calculated using the equation

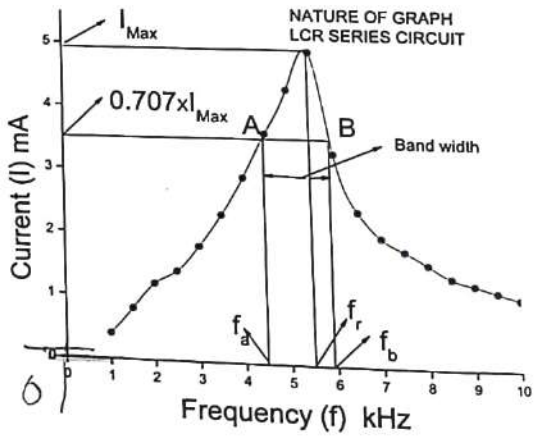
$$f_r = \frac{1}{2\pi\sqrt{LC}} \quad \text{·Sumop} \quad = \frac{1}{2\pi\sqrt{0.1 \times 0.01 \times 10^{-6}}} = 5032.92$$

f_r= 5032.92 Hz

TABULAR COLUMN LCR SERIES CIRCUIT

Sl.No.	Frequency (f) in kHz	Current in mA.
1	1.0	0.81
2	1.5	1.28
3	2.0	1.87
4	2.5	2.62
5	3.0	3.70
6	3.5	5.40
7	4.0	8.32
8	4.5	12.64
9	5.0	13.45
10	5.5	9.97
11	6.0	7.29
12	6.5	5.72
13	7.0	4.67
14	7.5	3.94
15	8.0	3.40
16	8.5	3.01
17	9.0	2.67
18	9.5	2.41
19	10	2.19

Nature of the graph



$0.707 \times I_{max}$

0.707×13.45

$=$

SERIES AND PARALLEL "LCR" CIRCUITS

EXPT. NO: **DATE:**

AIM: To draw frequency response curve of a series and parallel LCR circuits, hence to calculate resonant frequency, Band width and Quality factor.

APPARATUS: An audio signal oscillator, a resistance box, an inductor coil, capacitor, ammeter & connecting wires etc.

SERIES LCR CIRCUIT

PRINCIPLE:

The inductive reactance $\mathbf{X_L = 2\pi fL}$ and capacitive reactance $\mathbf{X_C = 1/(2\pi fC)}$ varies with the applied frequency of the supply voltage in the circuit. At a particular frequency f_r, the inductive reactance become equal to capacitive reactance in the circuit. The frequency corresponds to this situation is referred to as resonant frequency (f_r). *The total impedance of the circuit becomes equal to the resistance i.e Z=R in the circuit, which is minimum.* Hence, the *maximum current flows through the circuit* at resonance due to this reason the series LCR resonance circuit is referred as Acceptor circuit. The resonant frequency is given by the equation $\mathbf{X_L = X_C}$.

PROCEDURE:

When LCR connected end to end with AC source they are said to be in series

1. The circuit connection is made as shown in the circuit diagram.
2. The frequency of audio signal oscillator is set to 1kHz & the corresponding reading in the milli ammeter is noted.
3. The frequency of the audio signal oscillator is increased in steps of 0.5 kHz up to 9.5 kHz & the corresponding milli ammeter readings are recorded.
4. A graph is drawn between current (along Y-axis) & frequency (X-axis). From the graph the resonant frequency (f_r) is measured.

The resonant frequency is also calculated using the equation

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$ **Given L=0.1 H, C= 0.01 μF.**

QUALITY FACTOR:

The readings including f_r and I_{max} are plotted in a graph with frequency in KHz along X-axis, and the current in mA along the Y-axis. A resonance curve as shown in graph will be obtained in which f_r and I_{max} are marked The line is drawn along x-axis at
(I_{max} x 0.707).

From the above graph find f_a and f_b and calculate band width ($\Delta f = f_b - f_a$)

Now calculate quality factor using the following equation from graph

$\Delta f = (f_b - f_a)$.

$Q_{graphical} = f_r / \Delta f$,

For Given L = 0.1 H, C = 0.01 μF & R = ~~560 Ω~~ 0.75 kΩ . theoretically quality factor is calculated using the relation $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ $= \frac{1}{0.75 \times 10^{3}} \sqrt{\frac{0.1}{0.01 \times 10^{-6}}}$

Q_{Theory} = 4.21

Given L = 0.1 H, C = 0.01 μF & R = ~~560 Ω~~. 0.75 kΩ .

The resonant frequency can calculated using the equation for parallel resonant circuit as follows

Parallel :

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \quad = \frac{1}{2\pi}\sqrt{\frac{1}{0.1 \times 0.01 \times 10^{-6}} - \frac{(0.75 \times 10^{3})^2}{(0.1)^2}}$$

f_r = 4889.32 **Hz**

Find
follow
the re

RESU

1.

2.

3.

4.

5.

6.

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Find f_a and f_b and calculate band width ($\Delta f = f_b - f_a$), Now calculate quality factor using the following equation from graph **$Q_{graphical} = fr/\Delta f$, where, $\Delta f = (f_b - f_a)$.** Verify this theoretically using the relation $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ **Given L = 0.1 H, C = 0.01 μF & ~~R = 560 Ω~~.** 0.75 KΩ.

$Q = 4.21$

$Q_{graph} = \frac{fr}{\Delta f}$ $\Delta f = f_b - f_a = 5.6 - 4.1 = 1.5$ KHz.

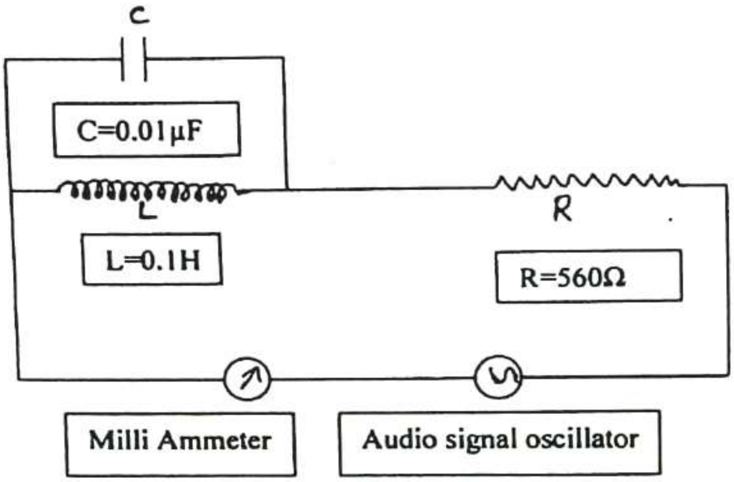
$= \frac{5}{1.5}$

$= 3.34$ KHz

RESULTS:

1. Resonant frequency f_r = 5 kHz (from graph)
2. Resonant frequency f_r = 5.032 kHz (from calculation)
3. Band width of the circuit = Δf ....1.5.... kHz (from graph)
4. Quality factor of the circuit Q= 3.34 (from graph)
5. Quality factor of the circuit Q= 4.21 (from calculation)
6. The inductance of the coil L = 0.1 H

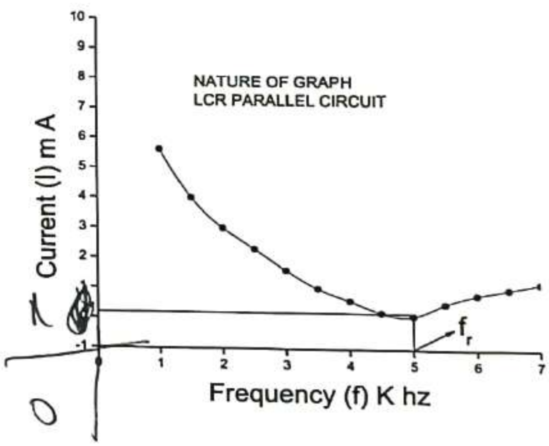
CIRCUIT DIAGRAM



TABULARCOLUMN LCR PARALLEL CIRCUIT

Sl.No.	Frequency (f) in kHz	Current in mA.
1	1.0	10.86
2	1.5	8.42
3	2.0	6.45
4	2.5	4.88
5	3.0	3.60
6	3.5	2.56
7	4.0	1.70
8	4.5	1.06
9	5.0	0.78
10	5.5	0.97
11	6.0	1.40
12	6.5	1.89
13	7.0	2.40
14	7.5	2.86
15	8.0	3.35
16	8.5	3.81
17	9.0	4.30
18	9.5	4.72
19	10	5.14

Nature of the graph



PARALLEL LCR CIRCUIT:

PRINCIPLE:

The inductive reactance & capacitive reactance connected in parallel at resonant frequency the inductive reactance exceeds the capacitive reactance. Hence $X_L > X_C$. Thus, the resultant impedance of the circuit becomes maximum hence the current in the parallel circuit becomes minimum. Due to the above reason the parallel LCR circuit is referred to be rejected circuit.

PROCEDURE:

When L & C are connected in parallel with series resistance & an AC source they are said to be in parallel

1. The circuit connections are made as shown in the circuit diagram.
2. The frequency of audio signal oscillator is set to 1 kHz & the corresponding reading in the milliammeter is noted.
3. The frequency of the audio signal oscillator is increased in steps of 0.5 kHz up to 9.5 kHz & the corresponding milliammeter readings are recorded.
4. A graph is drawn between current (along Y- axis) & frequency (along X-axis). From the graph the resonant frequency f_r is measured.

The resonant frequency is also calculated using the equation

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

Given L = 0.1 H, C = 0.01 µF & R = ~~560 Ω~~. 0.75 kΩ

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{0.1 \times 0.01 \times 10^{-6}} - \frac{(0.75 \times 10^{3})^2}{(0.1)^2}}$$

f_r : 5032.92 Hz.

The inductance of the coil can be calculated by using the relation

$$L = \frac{1}{4\pi^2 f_r^2 C} = \frac{1}{4\pi^2 \times (5032.92)^2 \times 0.01 \times 10^{-6}}$$

$L =$ 0.1 H

RESULTS:

1. Resonant frequency f_r = ----------5.----------kHz (from graph)
2. Resonant frequency f_r = ----------5.032.----------kHz (from calculation).

Viva:

1. What is capacitor? Define capacitance.

Ans Capacitor or condenser:- An electric condenser which can store a charge. Capacitance:- capacitance of a conductor is defined as a ratio of charge per volt. i.e.C=Q/V

2. What is an inductor?

Ans The e.m.f. induced in a circuit due to a changing electric current in the circuit.

3. What do you mean by resonance?

Ans It is the phenomenon of making a particle to vibrate with its natural frequency under th influence of another vibrating particle with the same frequency is called resonance.

4. What do you mean by sharpness of resonance?

Ans The sharpness of resonance is a measure of fall of current amplitude from its maximu value at resonant frequency on either side of it.

5. What is meant by Henry, Ohm & Faraday?

Ans Henry:- It is the S.I. unit of self and mutual inductance, 1 Henry = 1 Weber/Ampere. Ohm a It is defined as the resistance of a column of mercury 106.3 cm long having a mass 1444 gram & a uniform cross sectional area at 0^0c. A resistance having a p.d. of 1 volt when o ampere of current is passed through it is unit of electrical resistance. Faraday:- It is th quantity of electricity required to liberate or deposit 1 gram equivalent of an ion.

6. What is meant by resonance frequency?

Ans The frequency at which both reactance's X_L & X_C becomes equal is called resona frequency i.e. $X_L = X_C$

7. What is Q – factor?

Ans The ratio of V_L or V_C with applied voltage at resonant frequency is called voltage Magnification and denoted by Q – factor, $Q=V_L/v = 1/R \times \sqrt{LC}$

8. What is bandwidth?

Ans Bandwidth = $f_2 - f_1$.

9. How do you obtain cut off frequency in series and parallel?

Ans In series cut off frequency = $I_{max} / \sqrt{2}$. In parallel cut off frequency = $I_{max} \times \sqrt{2}$

10. Explain the variation of current in two circuits.

Ans In series:- total impedance of a circuit is equal to resistance Z=R which is minimum, hen maximum current flows through the circuit at resonance. In parallel:- $X_L > X_C$, impedance maximum & current minimum.

11. What is impedance?

Ans It is a measure of the resistance offered by a circuit to an a.c.

12. How do you identify the resonance in a circuit?

Ans The current is maximum at resonant frequency in a series circuit. The Current will b minimum at resonant frequency in parallel circuit.

Observations.

Diagrams

Figure-2 shows the complete experimental setup. A fixed screen is graduated in millimeter with 2mm pitch, i.e. the distance between two vertical lines on the screen is 2mm. Figure-2 shows the complete experimental set-up.

The X-Y bed consisting of a scale is fitted along the X-axis with zero coinciding with the screen. On this X axis a needle fixed above the scale which moves along with the chuck indicates the distance 'f' between the fixed screen and chuck holding the OFC. The Y motion is used to adjust the spot at the center of the graduated screen. Figure-3 shows the X-Y bed and Figure-4 shows the OFC cable used.
Figure-1 shows the NA and the angle θ.

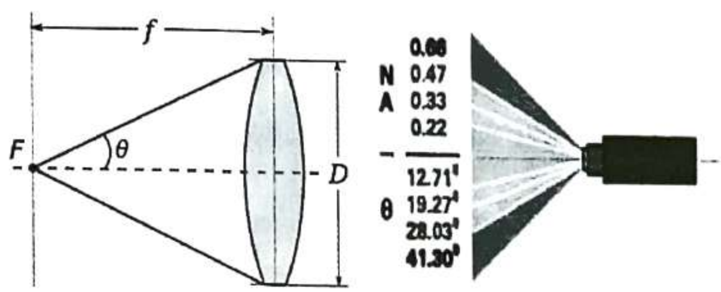


Figure-1: Laser light emerging from the cable and forming a divergent cone of rays

Distance between the chuck and the fixed graduated scale f = ------cm = -------m

Diameter of the circular spot = D =--------------m

$\tan\theta = D/2f$

The value of '**θ**' is calculated and presented in Table-1. NA can be calculated as follows.

$\theta = \tan^{-1}(D/2f)$

N.A. = $\sin\theta$

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NUMERICAL APERTURE OF AN OPTICAL CABLE

EXPT. NO: **DATE:**

AIM: Determination of angle of acceptance and numerical aperture of an optical fiber.

APPARATUS: Optical Fiber Cable (OFC) of length1.5m (IEEE 1394 fire wire cabl semiconductor diode laser- red 625nm, X-Y bed carrying a screen and a movable chuck

PRINCIPLE: - Numerical aperture of a cable is defined as sine of the half angle of the co generated due to the divergence of signal rays, as shown in Figure 1.

N.A. = Sinθ

In Figure-1, light coming out of an OFC falls on a screen, kept at a *distance 'L'* from it, on whi an image of the laser spot is seen. This spot and the emerging light form a cone. If '*D*' *is t diameter of the circular spot and* 'f' *is distance between the screen and the OFC* then

$$\tan\theta = \frac{D/2}{f} = \frac{D}{2f}$$

By measuring D and f, the value of tan θ can be determined; hence the numerical aperture can calculated from the equation

$$NA = \sin\theta = \tan^{-1}(D/2f).$$

Experimental procedure

The optical cable is coupled to the laser and it is ensured that the laser light comes out of the ot end of the cable. The other end of the cable is tied to the chuck fixed on the X-Y bed.

The chuck carrying the OFC is brought close to the graduated screen and the laser spot is seen the graduated screen. By adjusting the fine motion screw of the microscopic bench, the spot si is reduced to 8mm. Spot size = D= 8mm

The distance between the fixed screen and chuck carrying the OFC is noted on the graduated sca fixed along the X-axis.

The experiment is repeated by increasing the size of the spot to 10mm, 12mm, 14mm, 16m 18mm, 20mm, 22mm, 24mm, 26mm, and the corresponding value of 'f' is noted. This is do until the spot becomes sufficiently bright and clear. The readings obtained are tabulated in Table

The experiment is repeated with another cable of 1m length and the readings obtained are tabulat in Table 1. A graph is plotted D versus f and the variation is a straight line given in Figure-2.

Table-1: Variation of D and f

Cable	D(mm)	f(mm)	tan θ	θ°	Sin θ
Cable-1= 1.5m	8				
	10				
	12				
	14				
	16				
	18				
	20				
	22				
	24				
	26				
				Average value of NA	
Cable-2 = 1m	18				
	22				
	24				
	28				
	32				
				Average value of NA	

Nature of the graph

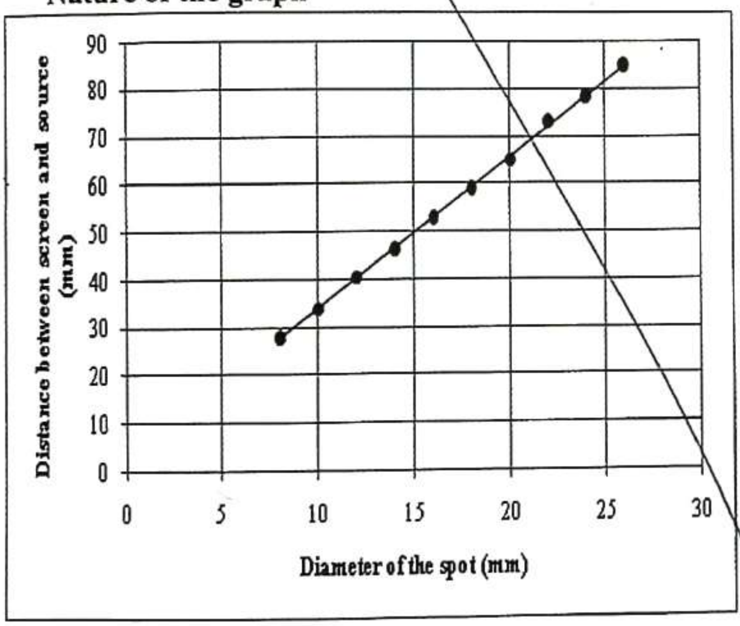


Figure-2: Diameter of the spot versus distance from the screen

Note: - Numerical Aperture is constant for a given OFC. It is a fundamental parameter which required for any communication system employing an OFC. An X-Y bed with heavy bed was found to be ideally suitable for this measurement and we have obtained quite consistent results for the two fibers used.

Cable-1, which has smaller value of NA, is of better quality. Cable-2, with almost double the NA is of inferior quality. As expected, higher attenuation of sound was found in the case of the second cable (with higher value of NA) compared to the first cable.

Sl no	Cable	f in cm	f in mm	D in mm (image diameter)	$\theta = \tan^{-1}\left(\frac{D}{2f}\right)$	NA = sinθ
1	1.5m	5-2 = 3	30	4×2 = 8	7.59	0.132
2	"	6-2 = 4	40	5×2 = 10	7.12	0.123
3	"	7-2 = 5	50	6×2 = 12	6.84	0.119
4	"	8-2 = 6	60	7×2 = 14	6.65	0.115
5	|	9-2 = 7	70	8×2 = 16	6.51	0.113
6	|	10-2 = 8	80	9×2 = 18	6.41	0.111
7	|	11-2 = 9	90	10×2 = 20	6.34	0.110
	|	12-2 = 10	100	11×2 = 22	6.27	0.109
8	"	13-2 = 11	110	13×2 = 26	6.74	0.117
9	|	14-2 = 12	120	14×2 = 28	6.65	0.115
10		15-2 = 13	130	15×2 = 30	6.58	0.114

Results:-

(1). Numerical aperture of the fiber optic cable-1, NA= 0.116
Acceptance angle cable-1, θ° = 6.671

(2). Numerical aperture of the fiber optic cable-2, NA=----------
Acceptance angle cable-2, θ° =----------

9×2

Viva:-

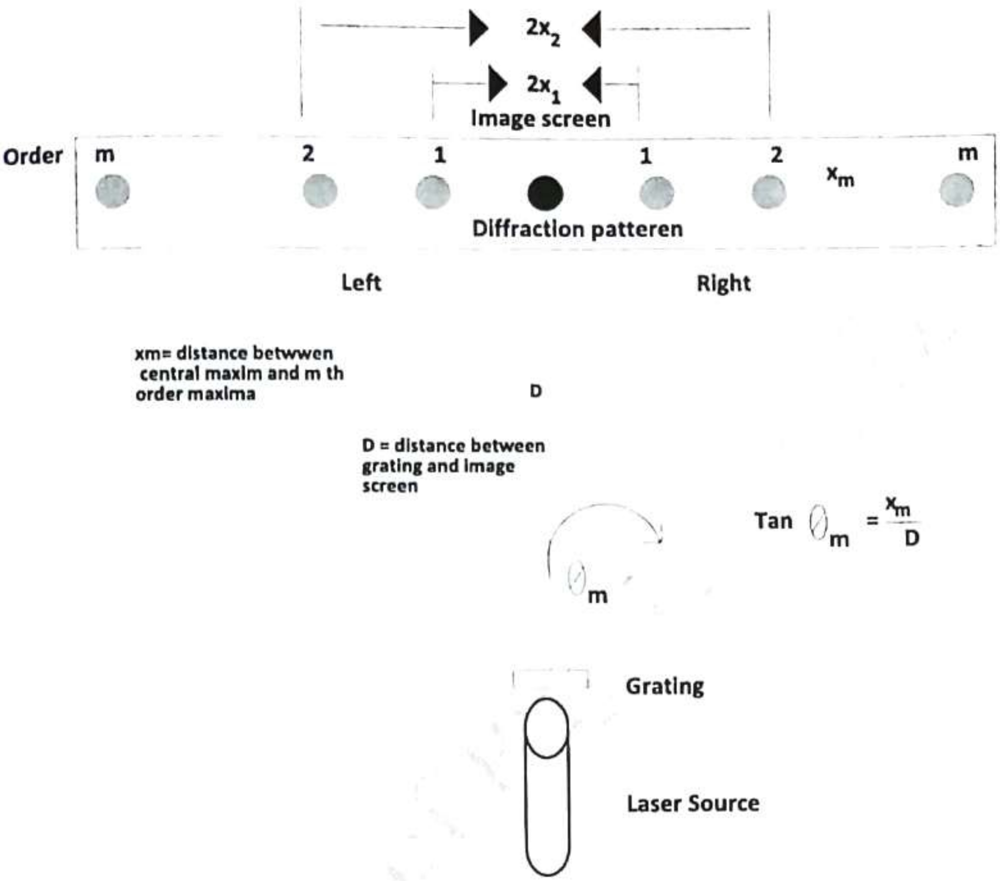
1. What is optical fiber?
   Optical fiber is a transparent dielectric media which can able to guide visible or IR light through long distance.
2. On which principle optical fiber works?
   It works on the principle of Total internal reflection.
3. Define critical angle.
   It is the angle of incident for which angle of refraction is equal to 90°
4. State Snell's law.
   The ratio of angle of incident to angle of refraction is constant and is equal to refractive index
5. What is angle of acceptance?
   It is the maximum angle of a ray surrounding the axis of optical after refraction into the core of an optical fiber under goes total internal reflection.
6. What is acceptance cone in optical fiber?
   Acceptance cone is derived by rotating the ray of light around the axis of optical fiber by keeping angle of acceptance constant. Any signal light ray enters into core of an optical fiber undergoes TIR, and any signal light ray which enters into the core of an optical fiber out the cone of acceptance does not undergoes TIR.
7. What is numerical aperture of an optical Fiber?
   The Numerical Aperture (NA) is a measure of light gathering capability of an optical fiber. The NA is related to the acceptance angle θ_o
   N.A. = $\sin\theta_o$
   Which indicates the size of a cone of light that can be accepted by the fiber.
8. What are the types of optical fiber?
   There are **three types** of fiber optical cable viz **(1) single mode (2) multimode and (3) graded index multimode optical fiber.**
9. What if fractional index change?
   It is the ratio of difference of the refractive indices of the core and cladding to the refractive index of core of an optical fiber.
10. What is V number in fiber optics?
    The V number is a dimensionless parameter which is often used to calculate the number of modes of an optical fiber.
11. What is refractive index profile?
    It is the curve which indicates the variation of refractive index of an optical fiber with respect to the radial distance.
12. What is the difference between single and multi-mode optical fiber?
    The dimensions (Geometry) and ray diagram,
    Only in case of graded index multi-mode optical fiber all the parameters i.e. geometry, refractive Index profile and ray diagram also changes.
13. What is attenuation?
    The loss in the strength of signal light when it is propagating through core of an optical fiber over a long distance in the homogenous medium is known as attenuation.
14. What are the factors which effects the attenuation of an optical?
    The attenuation of an optical fiber is due to: - absorption of signal light due to Impurities (presence of TM Ions such as iron cobalt copper etc in the fiber material), hydroxyl ions,

intrinsic absorption, Rayleigh scattering, unburnt starting material, micro crystallites, presence of air bubbles, microscopic and macroscopic radiation.

15. What are the applications of the optical fibers?
    In data link cables, local area network, submarine cables, sensing device etc
16. What are advantages of optical fiber cable over metallic cables?

Metallic cables	Optical fiber cable
Diameter = 76mm	Diameter = 13 mm
Twisted copper wires = 900	Fiber strands = 12
Transmission = 21000 channels	Transmission = 3 lakh channels
Weight of 1 m cable = 7 kg/m	Weight of 1 m cable = 0.06 kg/m

RAY-DIAGRAM


2x2
2x1
Image screen
Order
m
2
1
1
2
xm
m
Diffraction patteren
Left
Right
xm= distance betwwen central maxim and m th order maxima
D
D = distance between grating and image screen
Tan θm = xm/D
θm
Grating
Laser Source

RAO BAHADUR Y.MAHABALLESWARAPPA ENGINEERING COLLEGE, BELLARY
DEPARTMENT OF PHYSICS

DIFFRACTION GRATING

EXPT. NO: **DATE:**

AIM: To determine the wavelength of LASER source using diffraction grating.

APPARATUS: 625nm diode laser, Indian assembled 100LPI (lines per inch), 250LPI, 500L gratings, image screen.

PROCEDURE:

Semiconductor laser, grating stand and screen is kept horizontally on a table and the laser sou is switched on. The grating is kept on a grating stand and it is adjusted such that it is normal to incident laser beam. After adjusting for normal incidence, the laser light is exposed to the grat and it is diffracted by it. The diffracted laser spots are seen on the screen which is kept behind other side of the grating, The distances of spots of different orders from the centre spot(x_m) measured.

The wavelength of the laser light is calculated using the formula

$$m\lambda = d\sin\theta$$

In the above equation all the parameters are known except θ. The angle θ can be fo experimentally by measuring accurate distance D between grating and screen and distance betw the consecutive maxima x_m(which is nothing but the distance of mth order diffraction pattern fr the centre 0th order). Different order of diffraction is the result of different incident angle θ. He to specify 'θ' for particular order it has been rewritten as θ_m, which indicate the diffraction an for mth order. Therefore, the mth order diffraction angle is given by

$$\theta_m = \tan^{-1}\left(\frac{x_m}{D}\right).$$

Number of lines on grating =500 lines per inch.

Number of lines per cm (d) =2.54/500 =5.08x10^{-3} lines per cm (1 inch=2.54cm)

$= 5.08 \times 10^{-3} \times 10^{-2}$ m.

$= 5.08 \times 10^{-5}$ m

TABULAR COLUMN

Distance between grating element and the screen **(D) =55 cm Mean λ**

Sl. No	Order of diffraction (m)	Readings of the diffracted patterns				Mean θ_m	$\lambda = \frac{d\sin\theta_m}{m}$ in Å
		Left side		Right side			
		Distance from central spot X_m	$\theta_m = \tan^{-1}\left(\frac{X_m}{D}\right)$	Distance From Central spot X_m	$\theta_m = \tan^{-1}\left(\frac{X_m}{D}\right)$		
	1	0.8	0.83	0.8	0.83	0.83	7.35×10^{-7}
	2	1.5	1.56	1.5	1.56	1.56	6.91×10^{-7}
	3	2.2	2.9	2.2	2.9	2.9	8.56×10^{-7}
	4	2.9	3.01	2.9	3.01	3.01	6.66×10^{-7}
	5	3.6	3.74	3.6	3.74	3.74	6.62×10^{-7}
	6	4.3	4.47	4.3	4.47	4.47	6.59×10^{-7}

$\theta_m = \tan^{-1}\left(\frac{x_m}{D}\right)$

1. $\theta_m = \tan^{-1}\left(\frac{0.8}{55}\right)$

$\theta_m = 0.83$

2. $\theta_m = \tan^{-1}\left(\frac{1.5}{55}\right)$

$\theta_m = 1.56$

3. $\theta_m = \tan^{-1}\left(\frac{2.2}{55}\right)$

$\theta_m = 2.29$

4. $\theta_m = \tan^{-1}\left(\frac{2.9}{55}\right)$

$\theta_m = 3.01$

5. $\theta_m = \tan^{-1}\left(\frac{3.6}{55}\right)$

$\theta_m = 3.74$

6. $\theta_m = \tan^{-1}\left(\frac{4.3}{55}\right)$

$\theta_m = 4.47$

$$\lambda = \frac{d \sin \theta_m}{m}$$

1. $$\lambda_1 = \frac{5.08 \times 10^{-5} \sin(0.83)}{1}$$

$$\lambda_1 = 7.35 \times 10^{-7} \text{ m.}$$

2. $$\lambda_2 = \frac{5.08 \times 10^{-5} \sin(1.56)}{2}$$

$$\lambda_2 = 6.91 \times 10^{-7} \text{ m}$$

3. $$\lambda_3 = \frac{5.08 \times 10^{-5} \sin(2.9)}{3.}$$

$$\lambda_3 = 8.56 \times 10^{-7} \text{ m.}$$

4. $$\lambda_4 = \frac{5.08 \times 10^{-5} \sin(3.01)}{4}$$

$$\lambda_4 = 6.66 \times 10^{-7} \text{ m.}$$

5. $$\lambda_5 = \frac{5.08 \times 10^{-5} \sin(3.74)}{5}$$

$$\lambda_5 = 6.62 \times 10^{-7} \text{ m}$$

6. $$\lambda_6 = \frac{5.08 \times 10^{-5} \sin(4.4}{6}$$

$$\lambda_6 = 6.59 \times 10^{-7} \text{ m.}$$

$$\lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + \lambda_6}{6.}$$

$$\lambda = \frac{42.69 \times 10^{-7}}{6} = 7.115 \times 10^{-7} \text{ m.}$$

$$\lambda = \frac{7.115 \times 10^{-7}}{10^{-10}} = 7115 \text{ A}^{0}$$

RESULT: The wavelength of the semiconductor laser source calculated using diffraction grating and λ =........7115........ Å.

21/1/21

Viva:

1. **What do you mean by diffraction of light?**

Ans A beam of a light bends round the corner of the obstacles (edges of opaque lines of the grating) enters into the geometrical shadow. This phenomenon is called diffraction.

2. **What are the differences between the interference & diffraction?**

Ans a) Interference is the result of interaction of light coming from two different wave front originating from the same source whereas diffraction is the result of interaction of light coming from different parts of the same wave front. b) The width of the fringes in interference are always equal where as in diffraction they never be equal.

3. **How many types of diffraction are there? Name them how they are obtained.**

Ans a) Fresnel's diffraction:- Fresnel's diffraction is obtained by placing the source & the screen at finite from the aperture of obstacle having sharp edges. b) Fruanhoffer diffraction:- It is obtained by placing source and screen at infinity.

4. **What is meant by grating constant?**

Ans The distance between any two successive slits is called grating constant.

5. **Mention one of the applications of diffraction grating.**

Ans It is used to measure wavelength of different color.

6. **Whether mercury source is monochromatic?**

Ans No, it is not a monochromatic source.

7. **Whether intensity of diffraction pattern varies? Explain.**

Ans Intensity varies from maximum to minimum. As the order of the spectrum increases the intensity decreases.

8. **What is the condition to have diffraction by grating?**

Ans The width of lines drawn on glass plates should be equal to wave length of used light.

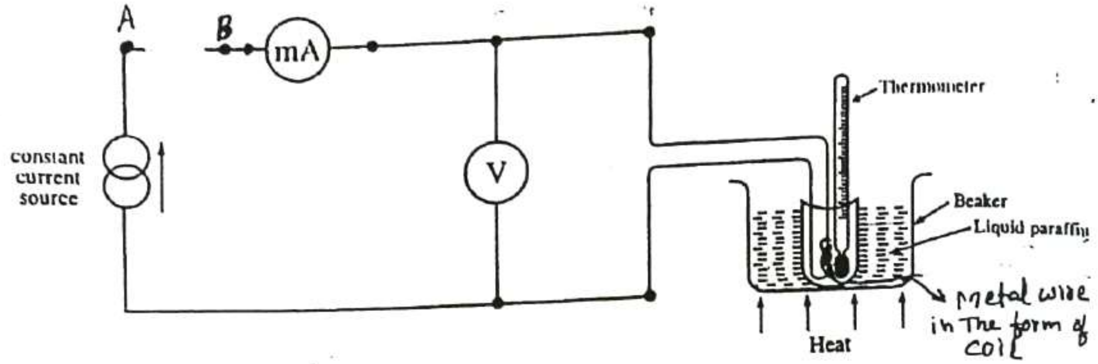
9. **What happens when the number of lines N per inch increased or decreased?**

Ans If N increased we get few order number of bands separated by large angle. If N decreased we get several order number of bands separated by small angle.

10. **What do you mean by diffraction of light?**

Ans When light passes by the edge of an opaque obstacle it bends slightly in to geometrical shadow. This property of light waves of bending round corners is called diffraction of light.

CIRCUIT DIAGRAM



TABULAR COLUMN

usually current remains Same

Sl. No.	Temperature 't' in ^{0}C	Temperature in ^{0}K T=(t+273)	Voltage In mV	Current In mA	Resistance In ohm $R=\frac{V}{I}$
1	85	~~385~~ 358	30.0	47.3	0.634
2	80	353	29.7	47.3	0.627
3	75	348	29.4	47.3	0.621
4	70	343	28.8	47.3	0.608
5	65	338	28.3	47.2	0.599
6	60	333	27.8	47.2	0.588
7	55	328	27.5	47.2	0.582
8	50	323	27.1	47.2	0.574
9	45	318			
10	40	313			
11	35	308			

FERMI ENERGY

EXPT. NO: **DATE:**

AIM: To determine Fermi energy of a given copper wire.

APPARATUS: Digital voltmeter, digital ammeter, copper wire, heating arrangement, heating coil, connecting wires, etc.

Principle: "Fermi level" is the term used to describe the top of the filled electronic energy levels at absolute zero temperature. Energy of the electron in Fermi level is Fermi energy. The Fermi energies of metals are of the order of few electron volts

Fermi energy is given by the equation,

$$E_F = \left[\frac{ne^2\pi Ar^2}{L\sqrt{(2m)}}\right]^2 x\left(\frac{\Delta R}{\Delta T}\right)^2$$

Where the constant $A = \lambda_F \times T$, where T is the reference temperature of the wire in Kelvin, r is the radius of the wire

PROCEDURE:

About 3.6 meters length copper wire is taken and its radius is determined and cross sectional area is calculated. Its mass number and density are noted from Clark's table.

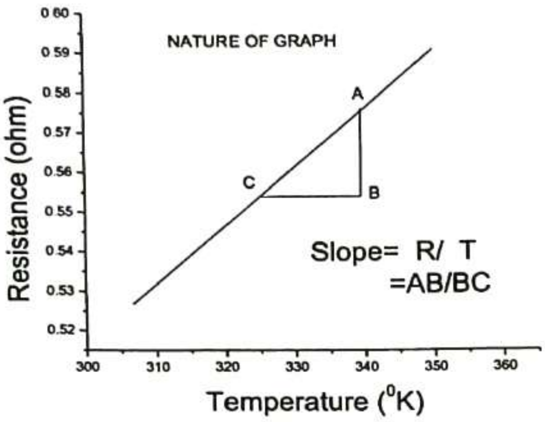
The wire is wound over an insulating tube (20-30mm dia) to form a coil. The coil is immersed in pre heated liquid paraffin as shown in the experimental setup. The two end of the coiled wire is connected to a power supply through a milli ammeter. And milli voltmeter is connected across the coil.

A thermometer is immersed in the beaker containing liquid paraffin and coil. When the thermometer attains steady temperature the temperature is noted.

The power supply is switched on and voltage and currents are noted In Table. The liquid is allowed to cool and power supply is switched off until another steady temperature is reached.

Trial is repeated by taking reading in the interval of 5 degree and until the temperature reach 45 degree. At each temperature the voltages and currents measured are noted in Table.

A graph is drawn by taking temperature T in °K along X-axis and resistance R in ohm along Y axis as shown in Figure. The slope of straight line is calculated.



$\frac{\Delta R}{\Delta T}$ is the slope of the straight line obtained by plotting resistance of the metal against absolute temperature of the metal.

Calculations

$$\text{Fermi energy } E_F = \left[\frac{ne^2\pi Ar^2}{L)(2m)}\right]^2 x\left(\frac{\Delta R}{\Delta T}\right)^2 \text{ J or eV}$$

Where n, A, πr^2, L are constants given below

n= 8.464×10^{28}/kg mol, A= 7.4×10^{-6}, $\pi r^2 = 0.212 \times 10^{-6}$ m², L = 3.58 m, m = 9.1×10^{-31}kg, e = 1.602×10^{-19} C

$E_F = 4.99 \times 10^{-13} \times (\text{slope})^2$ J

Here from graph slope is 0.853

$$E_F = 4.99 \times 10^{-13} \times (\text{slope})^2$$

$$= 4.99 \times 10^{-13} \times (1.707 \times 10^{-3})^2$$

$$E_F = 4.99 \times 10^{-13} \times 2.913 \times 10^{-6}.$$

$$\boxed{E_F = \frac{1.453 \times 10^{-18}}{1.602 \times 10^{-19}} \text{ eV}} = 9.069$$

RESULTS: Fermi energy of copper wire is ...8.069...eV

7/12/21

Viva questions of Fermi energy

1. **Define Fermi energy.**

Ans The energy of the highest occupied level at zero degree absolute temperature.

2. **Define mean free path.**

Ans It is the average distance traveled by the conduction electrons between any two successive collisions with the lattice ions.

3. **On what factors the Fermi energy depends.**

Ans Fermi energy depends on electron concentration.

4. **Define Fermi temperature.**

Ans The temperature at which the average thermal energy of the free electron in a solid becomes equal to the Fermi energy at 0^0K.

5. **Define density of states.**

Ans The number of available states per unit volume per unit energy centered at given E in valence band.

6. **What are valence electrons?**

Ans The electrons in the outermost orbit of any atom of any element are called valence electrons.

7. **Explain the variation of resistivity with temperature.**

Ans In case of metal as the temperature increases the resistivity of the metal also increases.

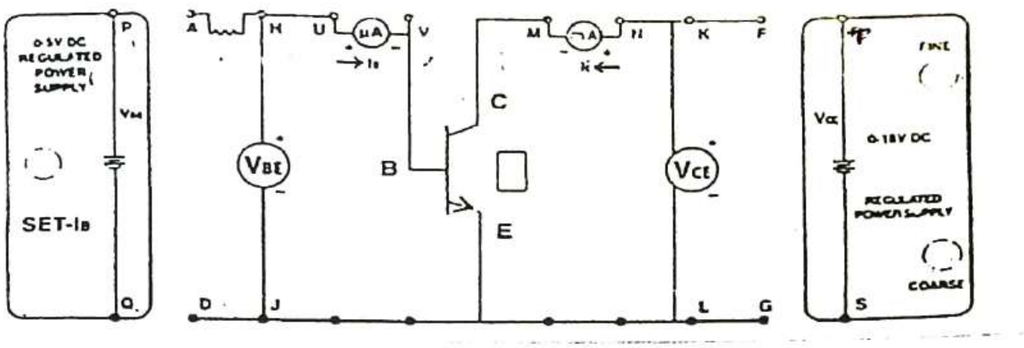
8. What is fermi factor?

The Fermi function f(E) gives the probability that a given available electron energy state will be occupied at a given temperature.

9. **Write the difference between classical and quantum theories.**

	Classical free electron theory	Quantum free electron theory
1.	The energy values of free electrons are not quantized and are continuous.	The energy values of the free electrons are quantized and are discreet values.
2.	Classical free electrons obey Maxwell's – Boltzmann Statistics.	Quantum free electrons obey Fermi-Dirac statistics.

CIRCUIT DIAGRAM



TABULAR COLUMN

1) INPUT CHARACTERSTICS 2) TRANSFER CHARACTERSTICS 3) OUTPUT CHARACTERSTICS

V_{BE} –I_B for constant V_{CE} I_B – I_C for constant V_{CE} V_{CE} - I_C for constant I_B

(Keeping V_{CE}=1volt)   (Keeping V_{CE}=1volt)   (Keeping I_B= 50 μA)

Sl. No.	V_{BE} (volts)	I_B (μA)	Sl. No.	I_B (μA)	I_C (mA)	Sl. No.	V_{CE} (V)	I_C (mA)
1	0.10	0	1	10	1	1	0.1	5
2	0.20	0	2	20	3	2	0.2	8
3	0.30	0	3	30	5	3	0.3	9
4	0.40	0	4	40	7	4	0.4	9
5	0.50	0	5	50	9	5	0.5	9
6	0.55	1	6	60	11	6	0.6	9
7	0.60	5	7	70	13	7	0.7	9
8	0.65	19	8	80	14	8	0.8	9
9	0.70	46	9	90	16	9	0.9	9
10	0.75	81	10	100	18	10	1.0	9
11	0.80	100	11	110	20	11		

TRANSISTOR CHARACTERISTICS

EXPT. NO : **DATE :**

AIM: To plot the characteristics curves of the given transistor and hence to determine the input resistance, output resistance and the amplification factor

APPARATUS: Transistor regulated variable power supply, voltmeter, milli & micro Ammeters, etc.

THEORY:

A transistor is a three terminal semiconductor device. The three terminals are the emitter, base & collector. There are two types: - 1) npn transistor 2) pnp transistor. One type of semiconductor is sandwiched between the two types of same semiconductor. The emitter is always heavily doped in order to provide a large supply of electrons.

The base is lightly doped to minimize the recombination that occurs in it between the electrons and the holes.

The collector will be having a large area in order to efficiently gather the charge carriers. The number of electrons that leave the emitter is a function of purely of the base-emitter voltage. It is the collector which receives almost all of them.

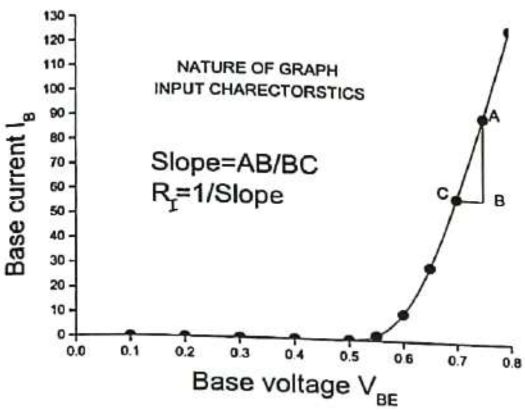
PROCEDURE:

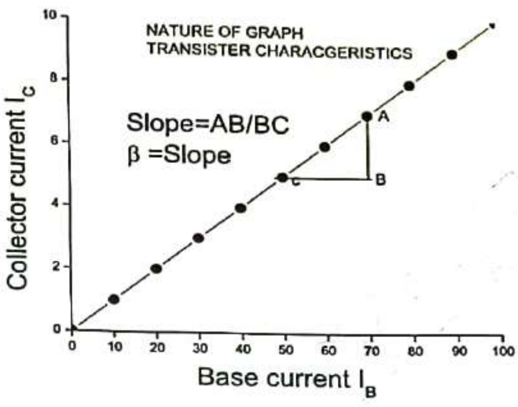
The circuit for transistor characteristics is rigged as follows:

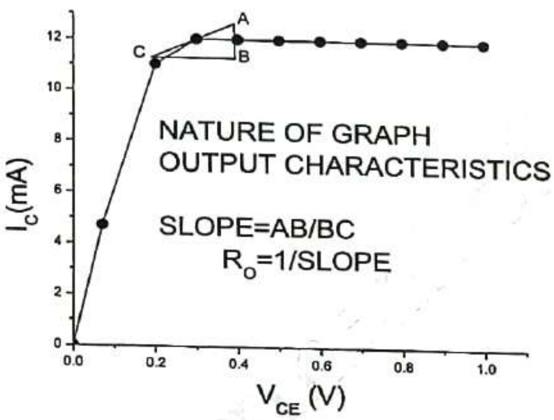
1. Connect the sockets, P is connected to A, Q is connected to D, T is connected to F & S is connected to G.
2. Across the terminals U & V micrometer is connected with proper polarity.
3. Across the terminals M & N millimeter is connected with proper polarity.
4. The transistor is mounted on the socket.

I. INPUT CHARACTERISTICS:

1. The circuit connections are made as described above.
2. The voltmeter is connected across the terminal K & L to set collector emitter voltage V_{CE} = 1 volt. The voltage can be set by the knobs coarse and fine.
3. Now the terminal is disconnected from K-L terminals and connected across J-H terminal to measure base emitter voltage V_{BE}.
4. By varying V_{BE} like 0.1, 0.2, 0.3 -----up to 0.8. by adjusting SET – I_B knob. The corresponding base current I_B is noted and tabulated in the table.
5. A graph is drawn by taking V_{BE} along X- axis & I_B along Y- axis. This is the input characteristics curve. From this curve find input resistance.


NATURE OF GRAPH
INPUT CHARECTORSTICS
Slope=AB/BC
R_I=1/Slope
Base current I_B
Base voltage V_{BE}


NATURE OF GRAPH
TRANSISTER CHARACGERISTICS
Slope=AB/BC
β =Slope
Collector current I_C
Base current I_B


NATURE OF GRAPH
OUTPUT CHARACTERISTICS
SLOPE=AB/BC
R_O=1/SLOPE
I_C(mA)
V_{CE} (V)

II OUTPUT CHARACTERISTICS:

1. The voltmeter is connected across the terminals K and L.
2. The base is now set to 50μA, by adjusting set -I_B knob.
3. By varying V_{CE} 0.1,0.2, ….up to 1Volt and the corresponding collector current on the milli ammeter is noted and tabulated in table 3
4. A graph is drawn by taking V_{CE} along x-axis and I_C along y-axis. This is the output characteristic curve. From this curve find output resistance.

III. TRANSFER CHARACTERISTICS

1. With V_{CE} = 1 volt, I_B is set to 0, 10, 20, ----- up to 100 μA & record I_C & tabulate in Table.
2. A graph is drawn taking I_B along X-axis & I_C Y-axis. Find amplification factor.

RESULTS:-

1. Input resistance of a given transistor R_I = ---2173.91------------- Ω.
2. Amplification factor of a given transistor β = -----200---------------
3. Output resistance of a given transistor R_0 = ---------200--------------- Ω.

21/10/...

Viva:

1. **What is semiconductor? Explain with types.**

Ans Semiconductor is a substance whose resistivity lies in between conductors and insulators. A semiconductor is divided in to two types: 1. Intrinsic semiconductor (It is a s.c. in its pure form) 2. Extrinsic semiconductor (It is doped semiconductor) Depending upon impurity added extrinsic s.c. is divided in to two types. 1. p-type s.c. (When a small amount of trivalent impurity(ex: indium) is added to pure s.c. then it is p-type s.c.) 2. n-type s.c.(When a small amount of heptavalent impurity(ex: Arsenic) is added then it is n-type s.c.

2. **What is doping? Why it is needed?**

Ans The process of adding impurity to s.c. to achieve desired characteristic is doping. It is needed to normally to increase conductivity of s.c. generally for 10^8 atoms of s.c.impurity is added.

3. **What do you mean by transistor ? Why it is called so?**

Ans A transistor is a three terminal s.c. device. It consists of either thin layer of p-type s.c. sandwiched between two n-type s.c. or a thin layer of n-type s.c. sandwiched between two p-type s.c. There are three layer – middle layer is base and two outer layers are called emitter and collector. Transistor transfers signal current from low resistance to high resistance circuit. Since it transfers signal across resistor it is called transistor. The word transistor is TRANSfer resistor.

4. **What does an arrow in a transistor symbol indicates?**

Ans The emitter which is shown by an arrow indicates the direction of conventional current. In PNP transistor electrons flow out of the emitter towards +ve battery terminal, consequently the conventional current flows into the emitter as indicated an inward arrow. Here majority charge carriers are holes. In NPN transistor electrons flow out of the emitter as indicated an out going arrow. Here majority charge carriers are electrons.

5. **What are emitter, base & collector?**

Ans Emitter:- It's main function is to supply majority charge(electrons or holes) to base. Base:- It separates the input circuit of emitter from output circuit of the collector and thus forms two PN junctions between emitter and collector. Collector:- It's main function is only to collect majority carriers from emitter.

6. **Define current gain in transistor?**

Ans The current gain is the ratio of output current to input current. In common emitter configuration it is the ratio of change in collector current to change in base current is called current gain or current amplification factor.

7. **How many types of configurations or modes are there in transistor?**

Ans There are three modes or configuration. They are I) Common base mode(CB mode), II) Common collector mode(CC mode) & III) Common emitter mode(CE mode).

8. **Why CE mode is used more often in transistor?**

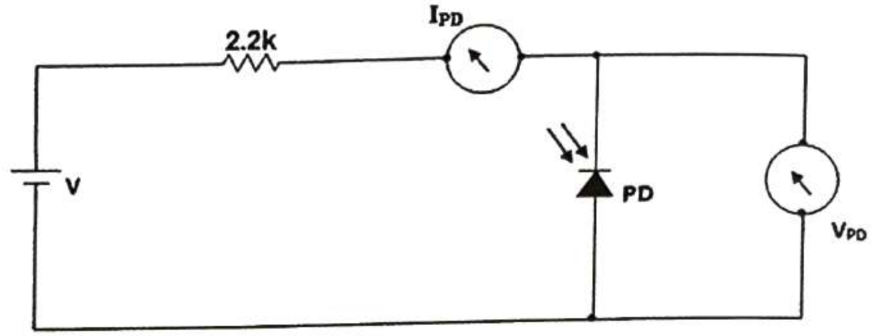
Ans Owing to high input impedance and high current gain and power gain, the common emitter circuits are more commonly used.

9. **Mention some of the applications of transistor?**

Ans Transistors can amplify electronic signals and can also be used as an oscillator. They are widely used in radio and T.V. receivers.

10. **What is biasing?**

Circuit diagram:

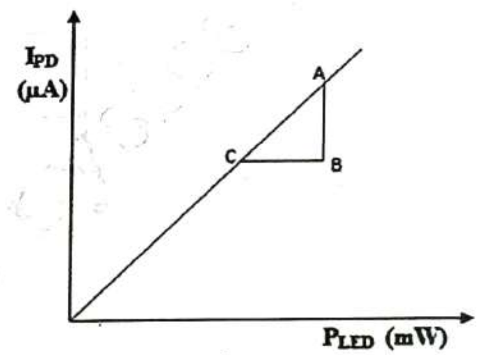


PD=-IV, I_{PD}=393μA

Pd = -1V.

P_{LED} (mW)	I_{PD} (μA)
10	144
11	149
12	170
14	182
16	198
17	211
18	250
21	291
24	317
30	374
38	455
50	545

Nature Graph



Responsivity of photo diode Slope $= \frac{AB}{BC} =$ 0.01

PHOTO DIODE

EXPT. NO:

DATE:

Aim: To study the I-V characteristics of photo diode in reverse bias and variations of photo current as a function of reverse voltage & intensity.

Apparatus: Photo diode expt. set up consisting of 0-3v regulated power supply 0-2 mA digital dc current meter, 0-2v digital dc voltmeter, site light LEC module, Photo Diode, LED etc.

Theory off the experiment

Introduction: Photodiodes are semi-conductor devices that respond to high energy particles and photons. Radiation-sensitive Junction is formed in a semi-conductor material whole resistivity changes when illuminated by light photons. The junction can be made to respond to the entire electromagnetic spectrum.

Responsivity (R_λ): The degree of response of a silicon photo diode to light is a measure of its sensitivity, and it is defined as the ratio of the photo current I_{PD} to the incident light power "P" at a given wavelength

$R_\lambda = \frac{I_{PD}}{P}$ Where I_{PD} is photo diode current P is the light input power. In other words, it is a measure of the effectiveness of the conversion of the light power into electrical current.

I-V CHARACTERISTICS:

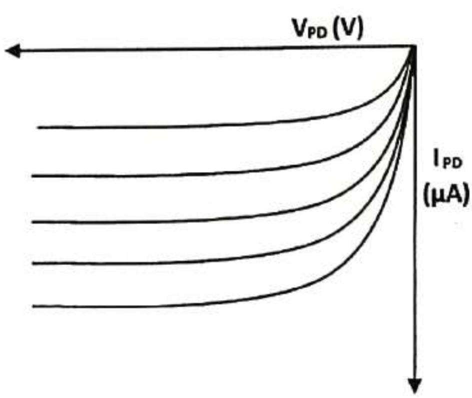
The current – voltage (I-V) characteristics of a photo diode when it is forward biased; there is an exponential increase in the current similar to rectifier diode. When a reverse bias voltage is applied, a small reverse saturation current appears.

NOTE: -As the applied reverse bias voltage increases there is a sharp increase in the photo current and the device will be damaged permanently. This voltage is called break down voltage. For this

Variation of PD voltage with current.

VPD (v)	I_{PD} (μA)				
	P_{LED}=10mw	P_{LED}=20mw	P_{LED}=30mw	P_{LED}=40mw	P_{LED}=50mw
~~0~~					
-0.1	3	8	10	11	14
-0.2	69	122	146	182	244
-0.3	132	261	333	402	411
-0.4	138	280	360	452	469
-0.5	139	283	367	456	472
-1.0	143	291	377	470	488

Nature of Graph: 2



diode magnitude of break down voltage voltages lies in the range 5-100v. Hence one should not apply too much reverse bias.

Experimental Procedure: The experiment consists of two parts

Part A: Determination of Responsivity.

Part B: Determination of I-V characteristics

Part A: Determination of Responsibility:

The circuit connections are given as shown in the circuit diagram. The reverse bias connection of photo diode means the positive terminal of the PD (p) is connected to the negative terminal of the power supply and negative of the PD is connected to positive terminal of the power supply.

1] The white light LED & PD are placed face to face 10cm apart. This is the industry standard for any LED measurements. And the light arrangement is switched on. LED power is set to 10mw by turning the knobs to its minimum position. After ensuring that the LED is glowing and while noting the PD current in the meter, the cover is placed so that any external light will not affect the readings.

2] The voltages across PD is set to -1v by varying 0-3v power supply. The PD current I_{PD} is noted V_{PD}= -1v, I_{PD}=393μA.

3] The LED power is increased to 11mw and V_{PD} is again set to -1v and the corresponding PD current is noted in table -1.

4] The trial is repeated by varying the input power to 12mw, 13mw etc, readings up to 50mw, in each case V_{PD} as set to -1v and I_{PD} is noted in Table-1.

5] A graph showing the variation of LED power on x-axis and PD current is drawn as shown in figure. A straight line graph is obtained, slope of which gives the value of responsivity.

Note: The external conversion efficiency of white LED is 0.66, hence by dividing responsivity by 0.66 gives the exact responsivity of PD

The quantum efficiency (QE) of photo Diode is 8.8%. The small QE value indicates that only 8.8% of the photons fall on the photo diodes and contribute to the photo current. This is because the light coming out of the LED is highly directional, forming a cone with solid angle only portion of light falls on Photo Diode.

PART B: DETERMINATION OF V-I CHARACTERISTICS OF PD

1] The LED power is set to 10-mw on the dial and V_{PD} is set to -0.10v and the corresponding I_{PD} is noted.

2] The trail is repeated by increasing V_{PD} in the suitable steps up to a maximum of -2v. The corresponding I_{PD} values are noted in table-2

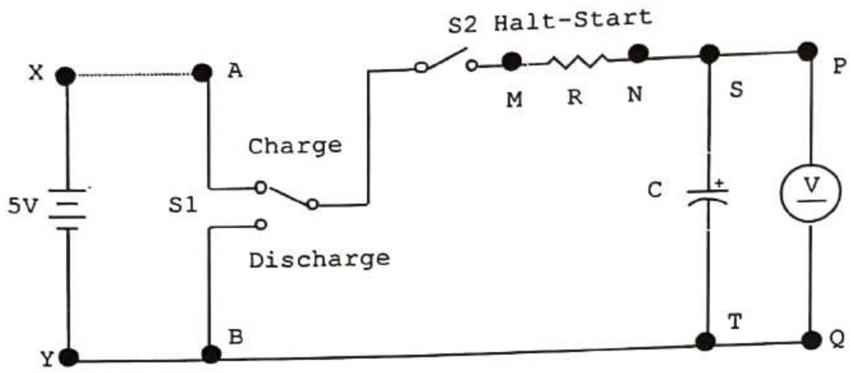
Result: The I-V characteristics of a given photo diode is studied and found Responsivity (R_λ) at 375nm = ..0.013.A/W

18/12/21

Viva

1. What is photo diode?
   A photodiode is a semiconductor device that converts light into an electrical current. The current is generated when photons are absorbed in the photodiode.
2. What is meant by responsivity?
   The responsivity (or radiant sensitivity) of a photodiode is the ratio of generated photocurrent and incident optical power (neglecting noise influences), determined in the linear region of response.
3. What is quantum efficiency?
   The "quantum efficiency" (Q.E.) is the ratio of the number of carriers collected by the Photo diode to the number of photons of a given energy incident on the Photo diode. The Quantum efficiency may be given either as a function of wavelength or as energy.
4. In photo diode experiment the reverse current depends on intensity of light or reverse voltage?
   Intensity of light.
5. How reverse resistance changed with respect to intensity of light?
   Decreases with increase of intensity of light
6. What is the result of the current voltage characteristics of photo diode?
   The photo current depends on intensity of light not on the reverse voltage.

CIRCUIT DIAGRAM



TABULAR COLUMN

Keeping Voltage = 10V

TABULAR COLUMN

Sl. No.	Time "t" in sec	For Capacitor C_1 R= 220 kΩ Voltmeter readings Charging	Discharging	For Capacitor C_2 R= 220 kΩ Voltmeter readings Charging	Discharging	For Capacitor C_3 R= 220 kΩ Voltmeter readings Charging	Discharging
1	0	0	4.11	0	4.04	0	3.75
2	15	2.01	2.05	1.18	2.95	0.82	3.23
3	30	3.08	1.06	2.03	2.05	1.33	2.73
4	45	3.59	0.53	2.62	1.54	1.73	2.34
5	60	3.84	0.27	3.05	1.10	2.09	1.98
6	75	3.97	0.15	3.33	0.79	2.40	1.68
7	90	4.03	0.08	3.55	0.58	2.64	1.44
8	105	4.07	0.04	3.70	0.42	2.86	1.22
9	120	4.08	0.03	3.81	0.30	3.05	1.03
10	135	4.09	0.02	3.89	0.22	3.21	0.88
11	150	4.10	0.01	3.95	0.17	3.33	0.75
12	165	4.10	0.01	3.99	0.12	3.44	0.64
13	180	4.10	0.01	4.02	0.09	3.54	0.54
14	195	4.11	0.01	4.04	0.07	3.62	0.47
15	210	4.11	0.01	4.04	0.05	3.63	0.40
16	235	4.11	0.01	4.04	0.04	3.75	0.31

DIELECTRIC CONSTANT

EXPT. NO: **DATE:**

AIM: To determine dielectric constant by using a DC charging and discharging circuit.

APPARATUS: Digital stop clock 0.1s resolution, digital dc voltmeter 0-20 V set of resistors and set of capacitors of known dimensions, dc power supply 5V

THEORY: A parallel plate condenser is formed by keeping two metallic plates parallel to each other. By applying a potential across the two plates an electric field is produced inside the space between the two plates. By placing an electrically insulated material within the plates the capacitance can be increased. The resulting capacitance of the parallel plate condenser is given by

$C = K\frac{\varepsilon_0}{d}A$ Where, C is the capacitance in Farad, K is dielectric constant

ε_0 is the permittivity $8.85\times10^{-12}\ Fm^{-1}$, A is the area of the plate

d is the distance between the plates or thickness of the dielectric material.

Charging and Discharging of a Capacitor

A capacitor can be charged using a resistor and a DC source. The capacitor will charge exponentially. The instantaneous voltage across the capacitor during charging is given by

$$V_{charge} = V_0\,(1-e^{-t/RC})$$

Figure -1 shows charging-discharge circuit arrangements using DC voltage source. When the switch is thrown to the discharge position the capacitor loses its charge hence it discharges through R. Therefore, the voltage across capacitor starts decreasing until it becomes zero. The instantaneous voltage across the capacitor during discharge is given by

$$V_{discharge} = V_o\,(e^{-t/RC})$$

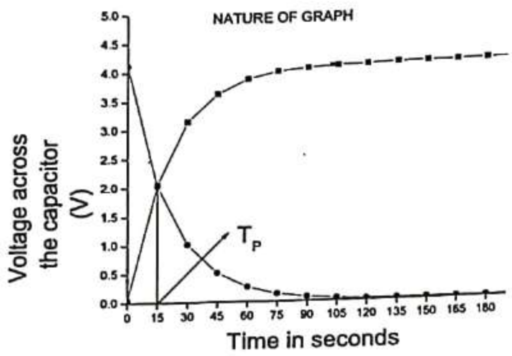
Where R is resistance in ohms
C is capacitance in Farad
t is the instantaneous time
V_o is the maximum voltage to which capacitor is charged

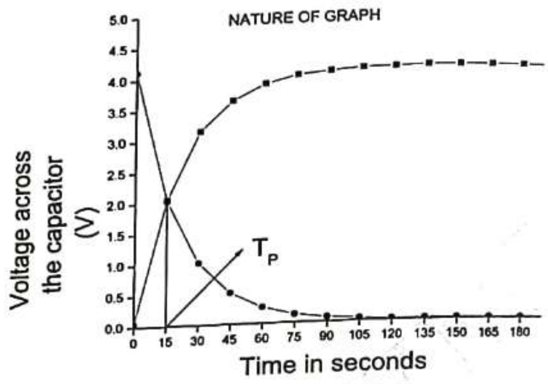
Figure-2 shows the charge-discharge curve. The charge-discharge curve intersects at a point P. At this instant of time T_p the voltage across the condenser is the same during charge and discharge process. Therefore, we have

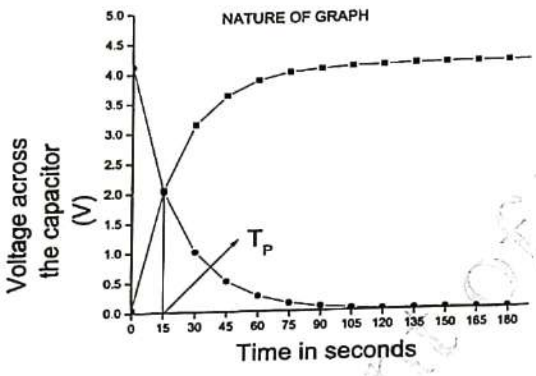
$$V_{Charge} = V_{discagrge}$$

$$(1-e^{-Tp/RC}) = (e^{-Tp/RC})$$

Nature Graph:







Dimensions of capacitors

Capacitor	C_1	C_2	C_3
Length(mm) L	114	183	251
Breadth (mm) B	5	6	6
Separation (mm) d	75	75	75

The capacitor dimensions are mentioned in mm in general.

i.e. $\frac{1}{2} = e^{-tp/RC}$

$\ln(\frac{1}{2}) = {}^{-T}{}_{P}/RC$

$RC = -T_P \ln 0.5$

$$C = \frac{0.693T_P}{R} \qquad \ldots 4$$

By physically measuring the dimensions of the capacitor dielectric constant can be determined.

$$K = \frac{T_p d}{0.693\varepsilon_0 AR} = \frac{1.44T_p d}{\varepsilon_0 AR} \qquad \ldots 5$$

Experimental Procedure

1. The circuit connections are made as shown in Figure. R selected as 47kΩ and Capacitor $C_1$is selected and connected to the circuit using patch cords.
2. The digital stop clock is reset by pressing reset button. The display indicates 00.0.
3. Switch ON the instrument, volt meter moves from zero to maximum charging voltage. Note down the maximum voltage and time i.e. charging time.
4. Now Switch OFF the instrument volt meter moves from maximum to zero. Note down the minimum voltage and time i.e. discharging time.
5. Experiment is repeated for different capacitance values. And the corresponding readings are noted in Table.
6. A graph is drawn taking time on X-axis and voltage along the Y-axis as shown in Figure-2. The charging and discharging curve intersects at a point P, where the voltage across the capacitor during charging and discharging. The time at which voltage across the capacitor during charging and discharging is noted.
7. The Dielectric constant is determined using above equation

For each capacitor calculate

Area = length x breadth = ----------m^2 for a given length and breadth

Given R = 220 KΩ Thickness = d = --75--m, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

T_P = ---------seconds (can be obtained from the graph).

Hence the dielectric constant of material can be calculated by using the following formula.

$$K = \frac{1.44 T_p \times d \times 10^{-6}}{\varepsilon_0 A R}$$

Calculations

$$K_1 = \frac{1.44 \times 15 \times 75 \times 10^{-6}}{8.85 \times 10^{-12} \times 114 \times 5 \times 220 \times 10^{3}} = 1.459.$$

$$K_2 = \frac{1.44 \times 30 \times 75 \times 10^{-6}}{8.85 \times 10^{-12} \times 183 \times 6 \times 220 \times 10^{3}} = 1.515$$

$$K_3 = \frac{1.44 \times 60 \times 75 \times 10^{-6}}{8.85 \times 10^{-12} \times 251 \times 6 \times 220 \times 10^{3}} = 2.209$$

Result:

The dielectric constant of capacitor C_1 is = 1.459

The dielectric constant of capacitor C_2 is = 1.515

The dielectric constant of capacitor C_3 is = 2.209.

25/2/21

Viva Questions:

9. **What do you mean by dielectric material?**

Ans Dielectric material is a non-conducting material which serves as a charge storage aid under certain circumstances.

10. **How many types of dielectric materials are there?**

Ans There are two types of dielectric materials. They are Polar dielectric and Non-polar dielectric.

11. **What are polar and non-polar dielectric materials?**

Ans Polar dielectrics: - Dielectrics in which permanent dipoles are present.
Non-polar dielectrics: - in which dipoles are formed due to applied electric field.

12. **What do you mean by dielectric constant?**

Ans The ratio of capacitance of the material in air to the capacitance of capacitor in vaccum.

13. **What is a capacitor?**

Ans Capacitor is a device to store charges.

14. **Name the types of capacitors.**

Ans Types of capacitors:- Paper capacitors, Mica capacitors, Electrolytic capacitors.

15. **How the charge storage capacity of the capacitor increased?**

Ans The capacitance of a capacitor is larger when there is dielectric material is between the plates.

16. **Name the types of the polarization mechanisms.**

Ans Types of Polarization mechanisms are – Electronic polarization, Ionic polarization, Orientation polarization, Space-charge polarization.

17. **Define half charging time.**

Ans In graph the charging & discharging curves meet at a point & that point is known as half charging point & the time is half charging time.

18. **On what factors dielectric constant depends?**

Ans Dielectric constant depends on capacitance of material & capacitance of vacuum.

19. **Define resistance.**

Ans The property of a material which opposes the flow of current.

Define time constant of RC circuits.

Ans The product RC is called the time constant.

20. What is the effect of applied electric field on polar and non-polar dielectrics?

Ans all the dipoles will be aligned in the field dirrction.

21. What is meant by displacement current

: Fermi Energy :

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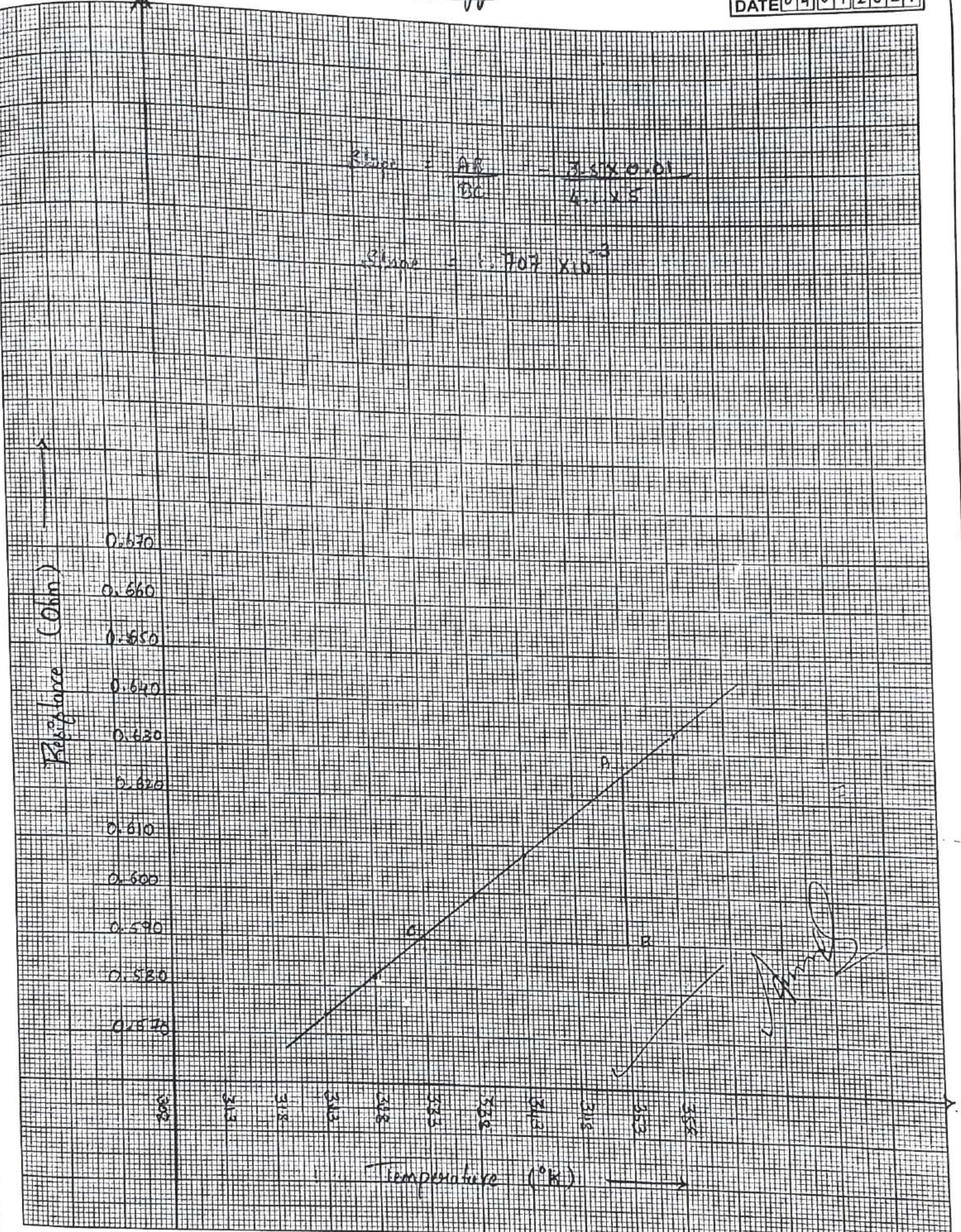
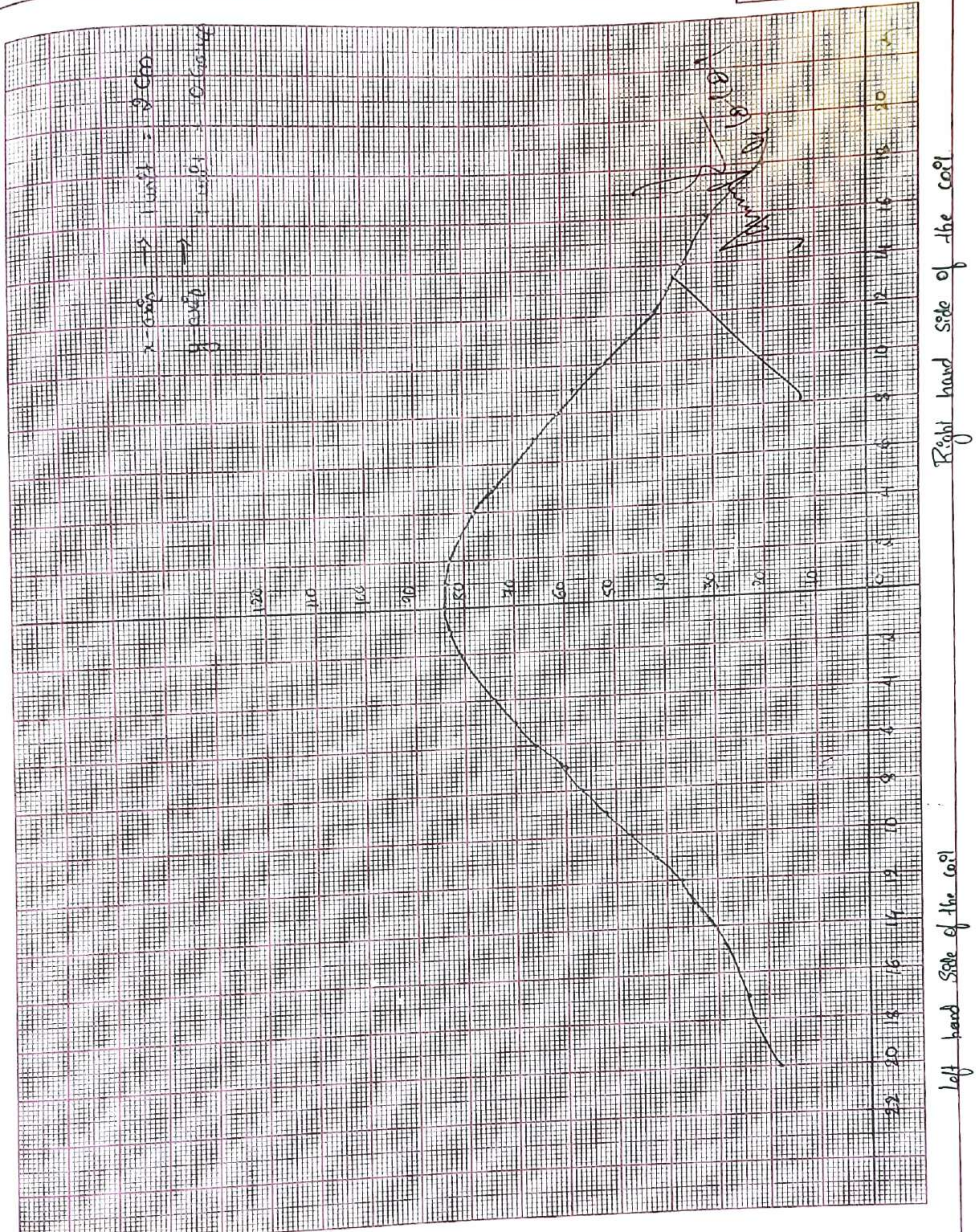


: Measurement of magnetic field along the axis of
Circular current carrying coil :



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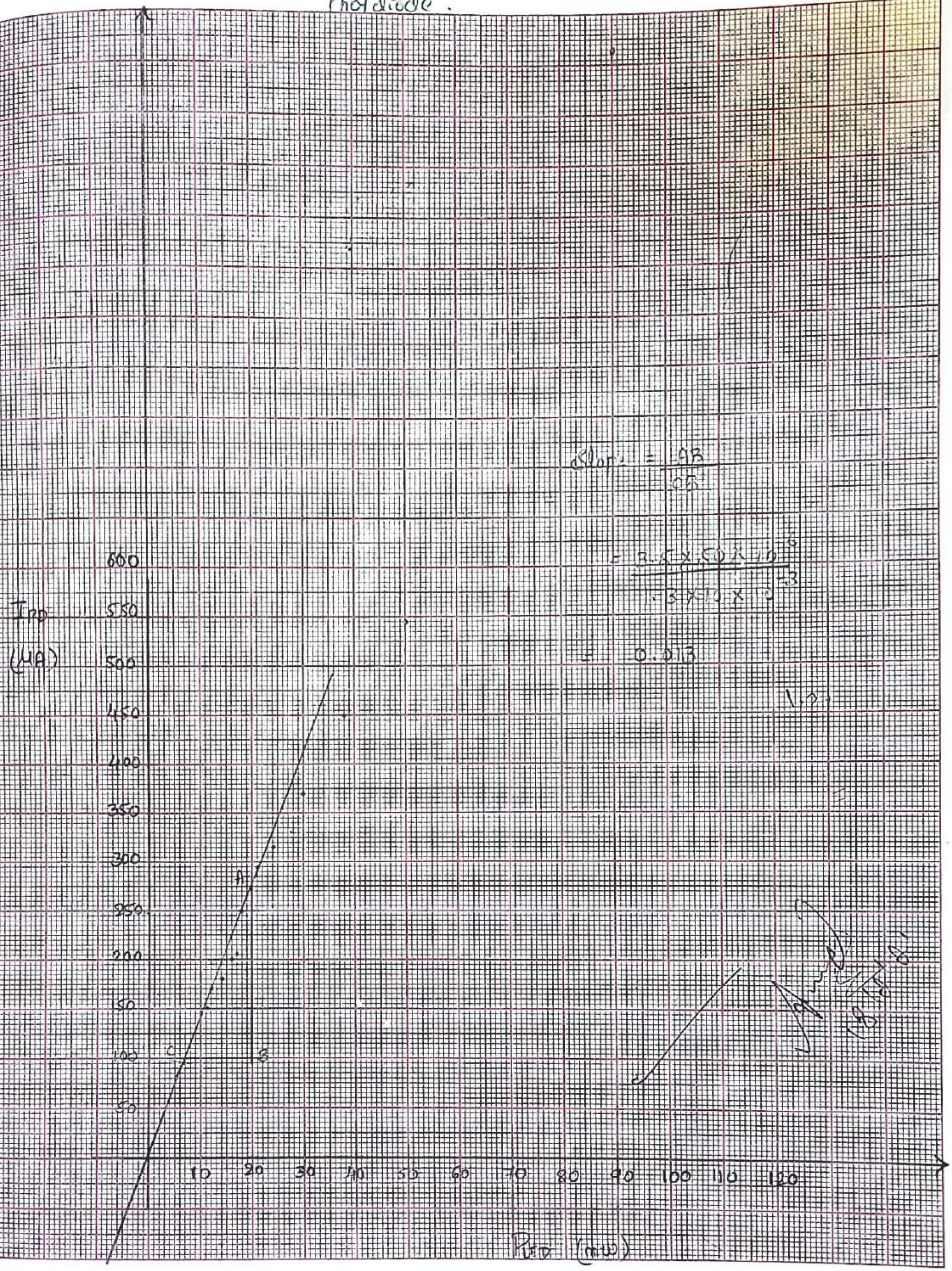
Photodiode.



$$\text{Slope} = \frac{AB}{CB}$$

$$= \frac{3.5 \times 50 \times 10^{-6}}{1.3 \times 10 \times 10^{-3}}$$

$$= 0.013$$

1.7

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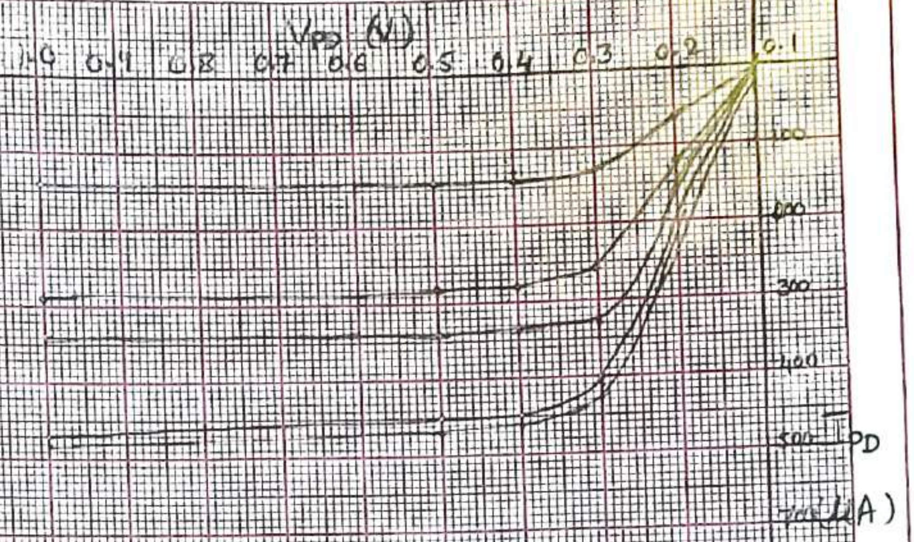
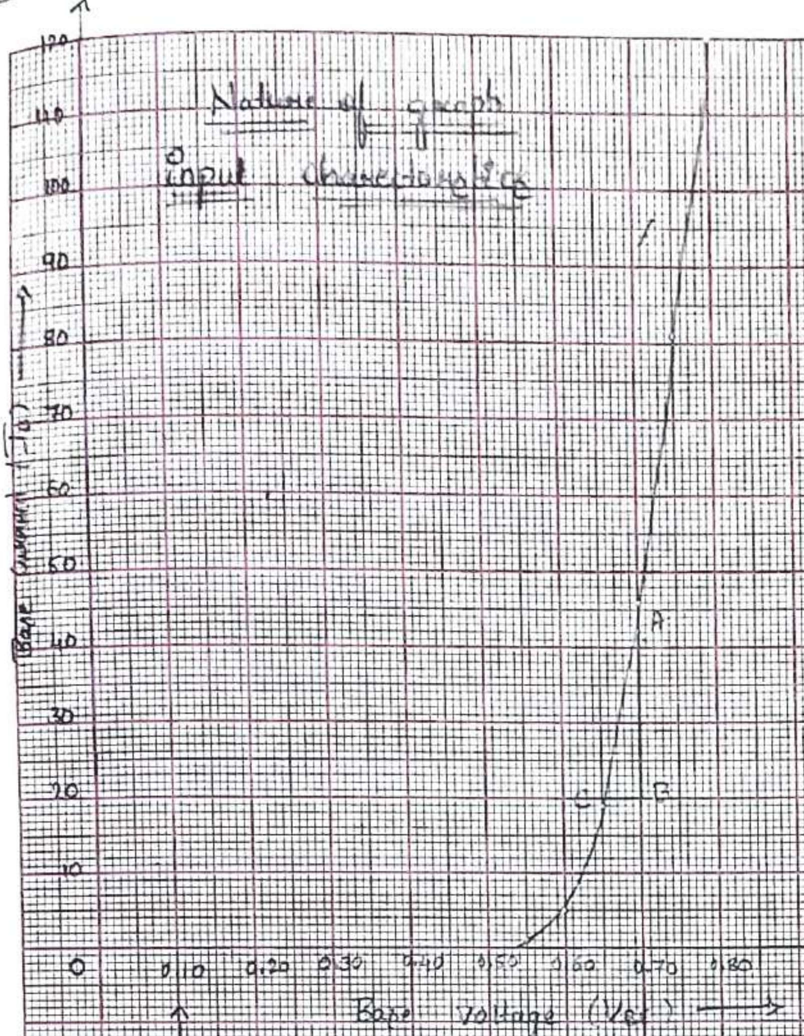


Nature of graph

Input characteristic



y-axis = 1 unit = 10 μA

x-axis = 1 unit = 0.10 V

$$\text{Slope} = \frac{AB}{BC}$$

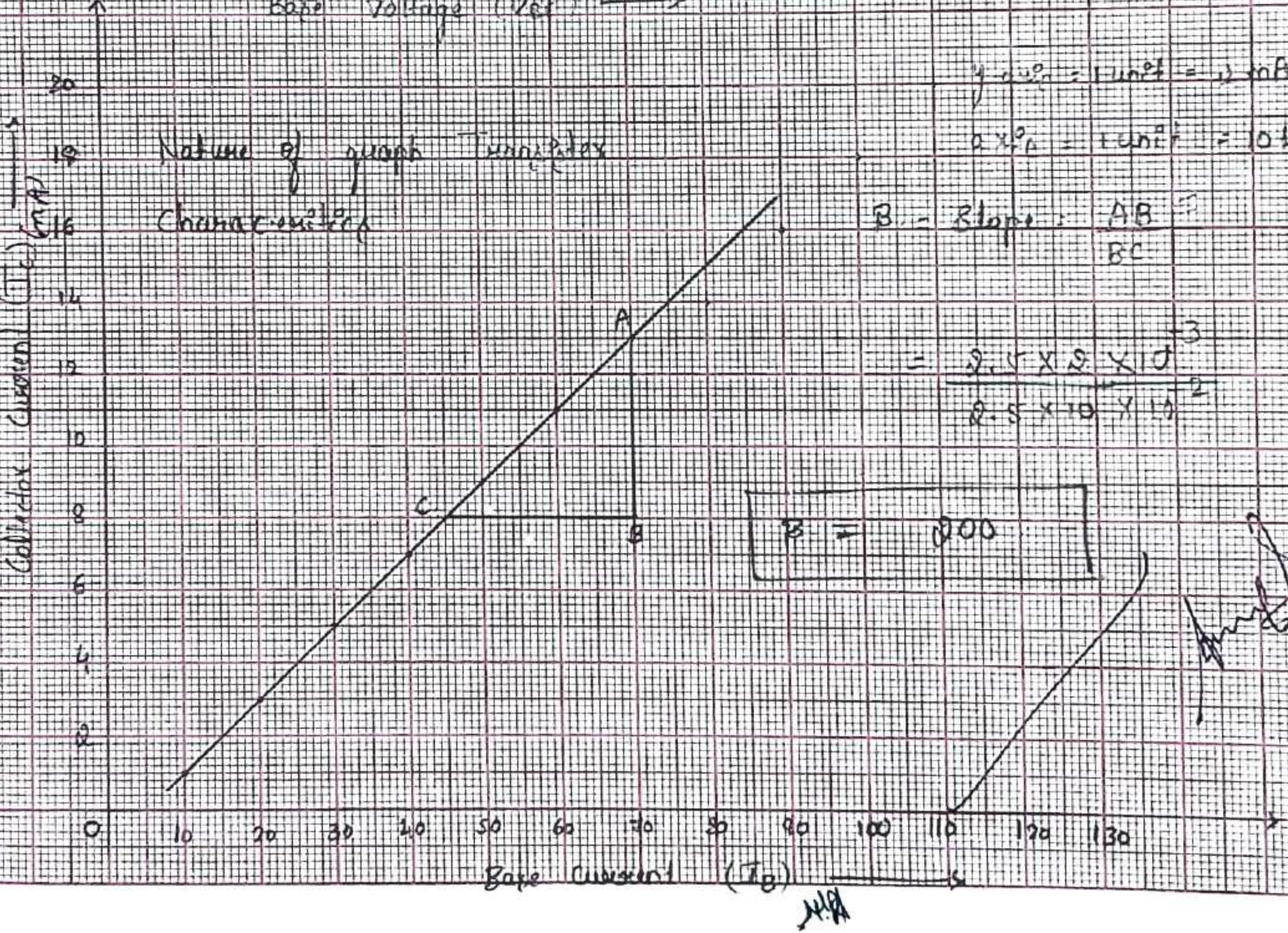
$$= \frac{2.3 \times 10 \times 10^{-6}}{0.5 \times 0.10}$$

$$= 4.6 \times 10^{-4}$$

$$R_i = \frac{1}{\text{Slope}} = \frac{1}{4.6 \times 10^{-4}}$$

$$\boxed{R = 2173.7\ \Omega}$$

Nature of graph Transistor Characteristic



y-axis = 1 unit = 2 mA

x-axis = 1 unit = 10 μA

$$\beta = \text{Slope} = \frac{AB}{BC}$$

$$= \frac{2.5 \times 2 \times 10^{-3}}{2.5 \times 10 \times 10^{-2}}$$

$$\boxed{\beta = 200}$$

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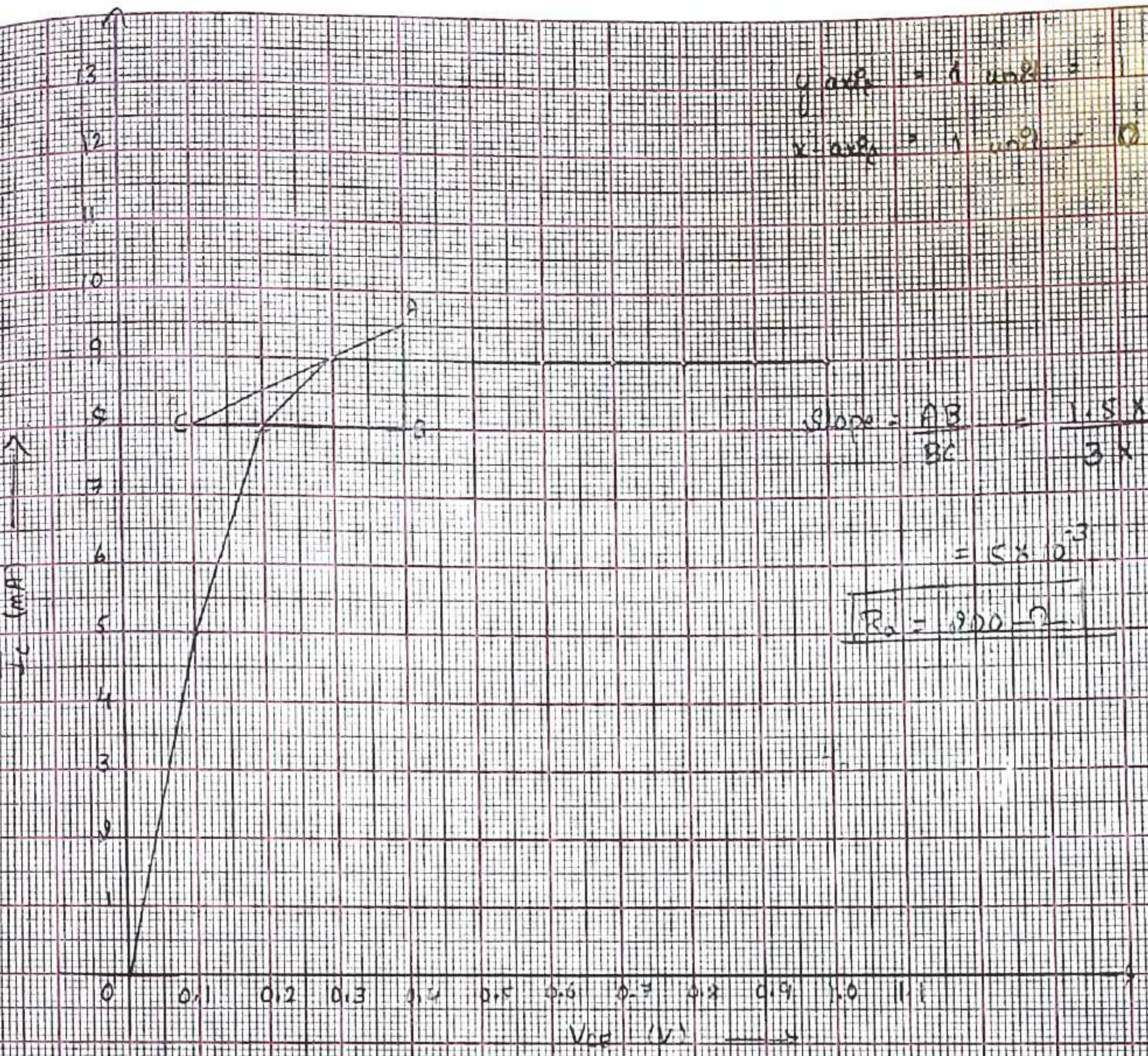
y axis = 1 unit = 1 mA

x axis = 1 unit = 0.1 V



$$\text{Slope} = \frac{AB}{BC} = \frac{1.5 \times 10^{-3}}{3 \times 0.1}$$

$$= 5 \times 10^{-3}$$

$$\boxed{R_o = 200\ \Omega}$$

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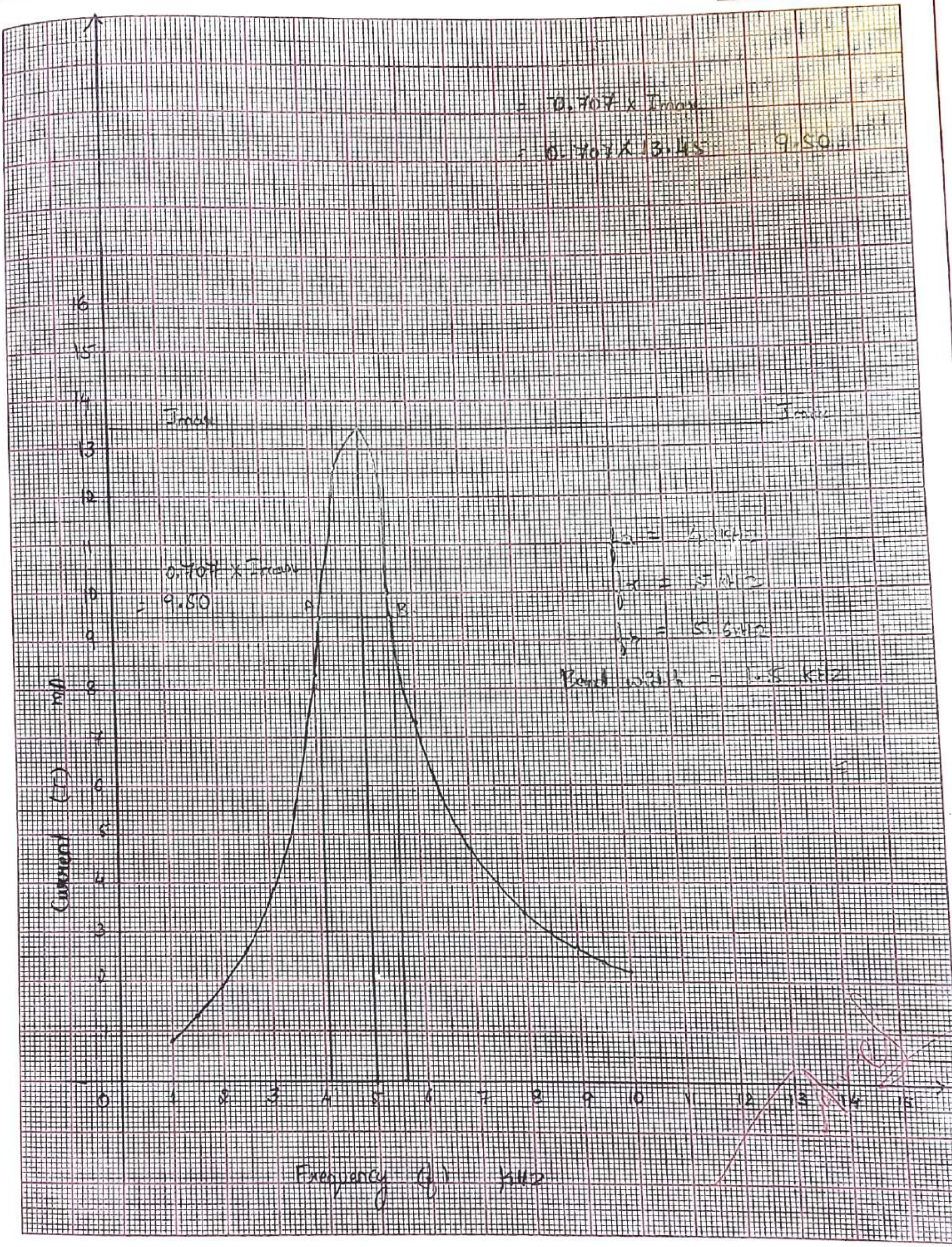
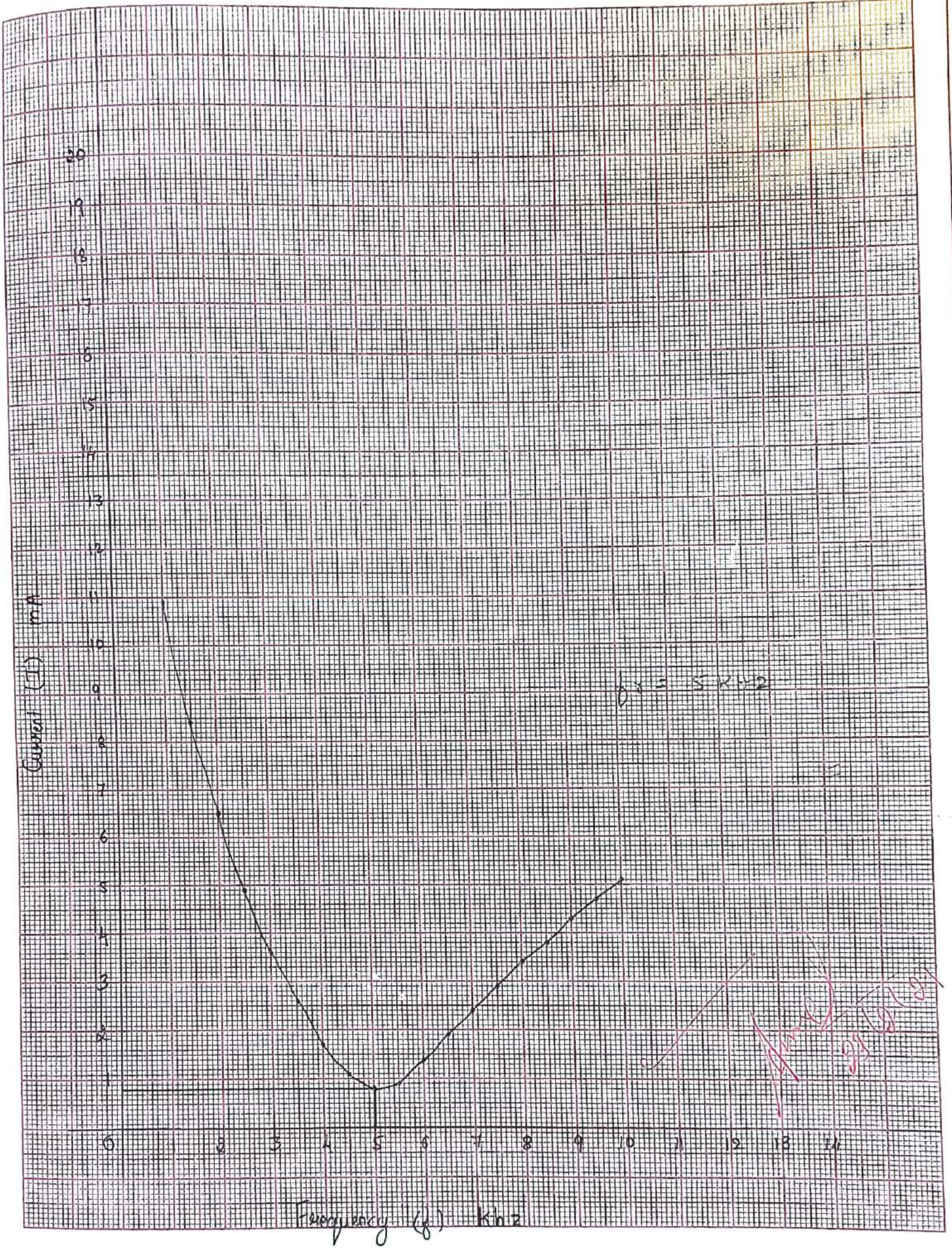


= 0.707 x Imax
= 0.707 x 13.45 = 9.50
Imax
Imax
0.707 x Imax
= 9.50
A
B
f_L = 4 KHz
f_r = 5 KHz
f_h = 5.5 KHz
Band width = 1.5 KHz
Current (I) mA
Frequency (f) KHz
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


Current (I) mA
Frequency (f) KHz
f_0 = 5 KHz

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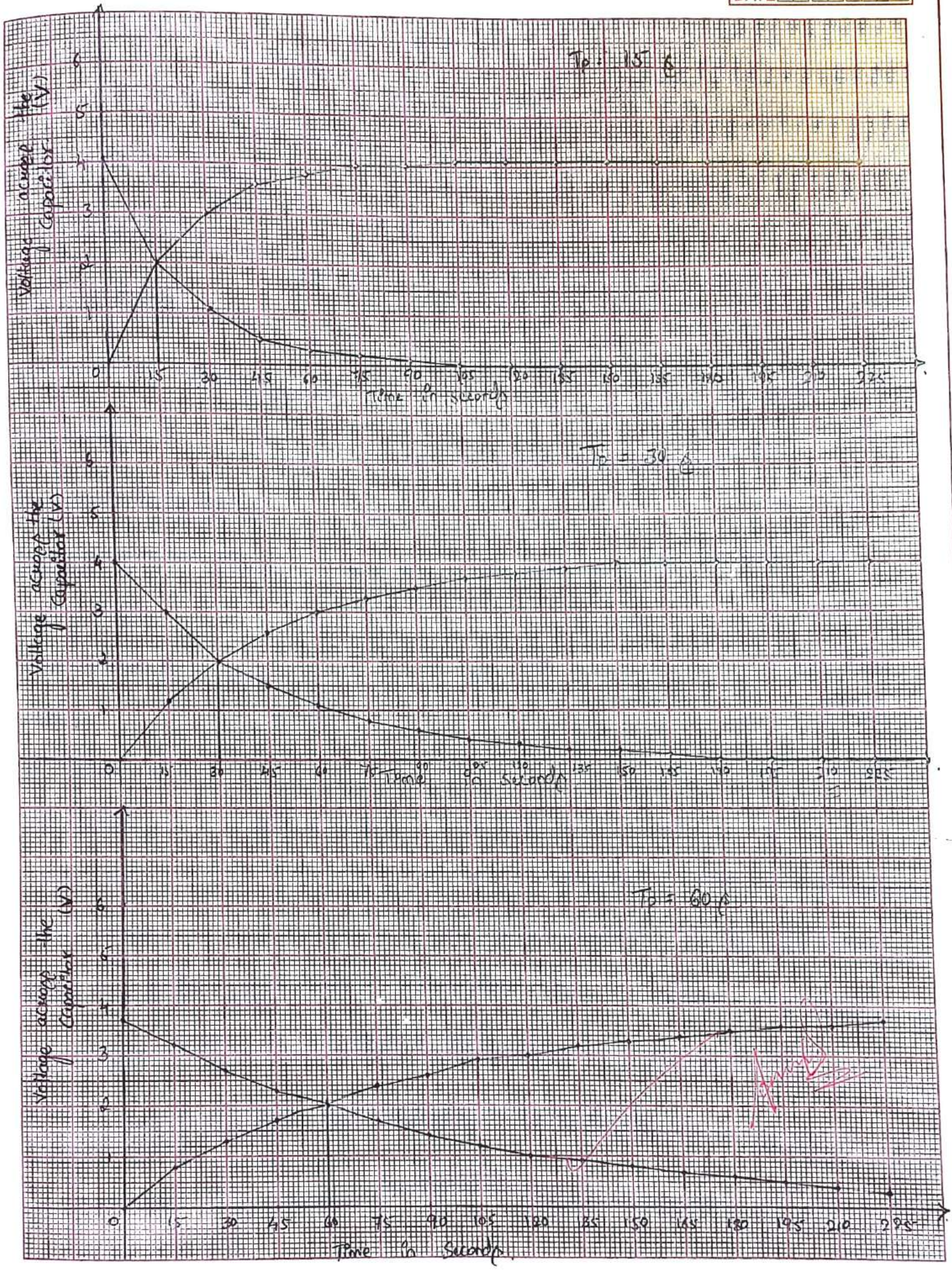

Tp = 15 s
Voltage across the Capacitor (V)
Time in seconds
Tp = 30 s
Voltage across the Capacitor (V)
Time in seconds
Tp = 60 s
Voltage across the Capacitor (V)
Time in seconds

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