

VEMU INSTITUTE OF TECHNOLOGY

P.KOTHAKOTA, CHITTOOR DIST – 517 112



DEPARTMENT OF HUMANITIES & SCIENCES

APPLIED PHYSICS

LABORATORY MANUAL FOR I Year B.Tech
(ECE, CSE & EEE Branches)



DEPARTMENT OF HUMANITIES & SCIENCES

APPLIED PHYSICS LAB MANUAL

VEMU INSTITUTE OF TECHNOLOGY

P.KOTHAKOTA, CHITTOOR DIST – 517 112

Name	
Reg. No.	
Branch/Section	

Prepared by: Dr. U. SASIKALA
Mr. V. SREEDHAR

SYLLABUS

(Common to ECE, CSE & EEE Branches)

APPLIED PHYSICS LABORATORY: EXPERIMENTS

1. Determination of thickness of the thin wire using Wedge Method.
2. Determination of radius of curvature of a plano convex lens using Newton's rings.
3. Determination of wavelength of mercury spectrum lines using a diffraction grating in normal incidence method.
4. Determination of dispersive power of a diffraction grating.
5. Determination of resolving power of a grating.
6. Determination of Dielectric constant of dielectric material using charging and discharging of capacitor.
7. Magnetic field along the axis of a circular current carrying coil - Stewart & Gee's method.
8. **Determination of the self inductance of the coil using Anderson's bridge.**
9. Study the variation of B verses H by magnetizing the magnetic material (B-H curve).
10. Determination of acceptance angle and numerical aperture of an optical fiber.
11. Determination of Hall voltage and Hall coefficient of a given semiconductor using Hall effect.
12. **Determination of energy gap of a semiconductor.**

CONTENTS

APPLIED PHYSICS LAB

S.No	EXPERIMENT	PAGE No.
1.	Determination of thickness of the thin wire using Wedge Method	1-4
2.	Determination of radius of curvature of a plano convex lens using Newton's rings	5-9
3.	Determination of wavelength of mercury spectrum lines using a diffraction grating in normal incidence method	10-13
4.	Determination of dispersive power of the given prism	14-17
5.	Determination of resolving power of a grating	18-21
6.	Determination of Dielectric constant of dielectric material using charging and discharging of capacitor	22-25
7.	Magnetic field along the axis of a circular current carrying coil - Stewart & Gee's method	26-31
8.	Determine the self inductance of the coil using Anderson's bridge	32-34
9.	Study the variation of B versus H by magnetizing the magnetic material (B-H curve)	35-38
10.	Determination of acceptance angle and numerical aperture of an optical fiber	39-41
11.	Determination of Hall voltage and Hall coefficient of a given semiconductor using Hall effect	42-47
12.	Determination of energy gap of a semiconductor	48-51

LABORATORY INSTRUCTIONS

1. While entering the Laboratory, the students should wear shoes and lab uniform. Female Students should tie their hair back.
2. The students should bring their observation note book, practical manual, record note book and calculator and necessary stationary items for the lab classes without which the students will not be allowed for doing the practical.
3. The student should not perform unauthorized experiments.
4. All the equipments should be handled with utmost care. Any damage will be charged.
5. At the end of practical class the apparatus should be arranged neatly.
6. Each experiment after completion should be written in the observation note book and should be corrected by the lab in charge on the same day of the practical class.
7. Each experiment should be written in the record note book only after getting signature from the lab in charge in the observation note book.
8. Record note book should be submitted in the following after completion of experiment.
9. 100% attendance should be maintained for the practical classes.

EXPT-1**Date:****DETERMINATION OF THICKNESS OF THE THIN WIRE USING WEDGE METHOD****Aim:** To determine the thickness of given wire by Wedge method using travelling microscope.**Apparatus:**

1. Travelling microscope
2. Plane glass plates
3. Reading lens
4. Sodium vapour lamp
5. Thin wire (or) hair (or) a piece of paper
6. Black paper
7. Reading lens
8. Retard stand

Formula:

$$\text{Thickness of thin wire, } t = \frac{\lambda d}{2\beta}$$

Where λ = wavelength of sodium light = 5893 Å

d = distance of the object from edge of the wedge

β = fringe width

Procedure:

1. A small piece of paper, wire or hair is introduced between two glass plates at one end as shown in figure.
2. This set up is carefully kept on a black paper and placed on the platform of travelling microscope. The air wedge thus formed is illuminated normally by monochromatic light (sodium vapour lamp).
3. The glass plate which is fixed at 45° is helpful in dividing the light into parts. The microscope is adjusted and focused until the parallel fringes are formed. Starting from one side coincide the cross wires tangential to the parallel fringes and note the reading for every 5 fringes (5^{th} , 10^{th} , 15^{th} etc.,) upto 25^{th} fringe.
4. Fringe width β is determined from tabular column and thickness of the wire is determined by using the formula: $t = \frac{\lambda d}{2\beta}$

Diagram:

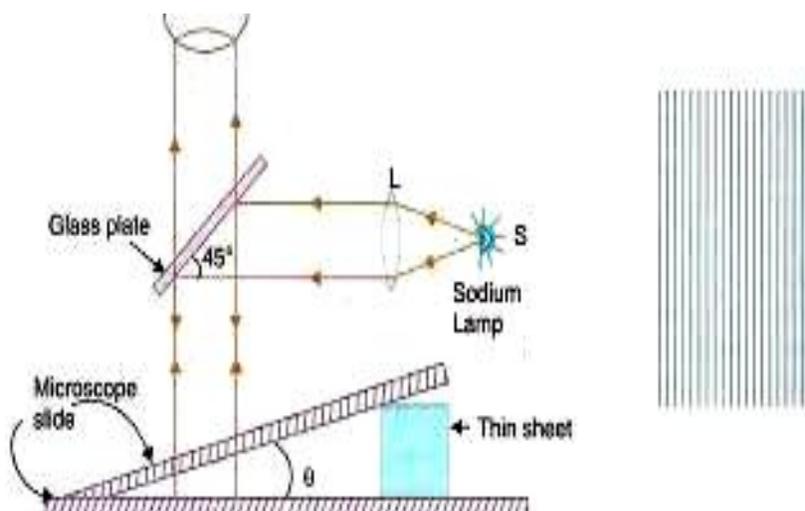


Fig: Wedge method

Least count: 0.001 cm

S.No.	Fringe no.	Microscope reading			Total (a+b) cm	Width of 5 fringes (5β) cm	Fringe width (β) cm
		MSR a (cm)	VSR n	Fraction $b=n \times LC$ (cm)			
1.	0						
2.	5						
3.	10						
4.	15						
5.	20						
6.	25						

Calculations:

Precautions:

1. The microscope should move in one direction from left to right (or) right to left, so the back lash error is avoided.
2. To achieve good accuracy in the measurement of 't' should be repeated twice or thrice.

Result:

Thickness of the given foil is = ----- cm

EXPT-2

Date:

DETERMINATION OF THE RADIUS OF CURVATURE OF THE GIVEN PLANO- CONVEX LENS USING NEWTON'S RINGS

Aim: To determine the radius of curvature of the given plano convex lens using Newton's rings.

Apparatus:

1. Plane glass plate,
2. Plano convex lens,
3. Black sheet,
4. Travelling microscope,
5. Retard stand,
6. Reading lens,
7. Sodium vapour lamp.

Formula:

The radius of curvature of the plano convex lens

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

Where D_m = Diameter of m^{th} dark ring – cm

D_n = Diameter of n^{th} dark ring – cm

λ = wavelength of sodium light = 5893 Å

m, n = number of chosen rings

Procedure:

1. A glass plate is kept on a black paper. The given plano convex lens is placed on the plane glass plate. Another glass plate is arranged at 45° to the horizontal above the plano convex lens with the help of retard stand.
2. The above unit is kept on the travelling microscope platform and under the microscope.
3. Parallel beam of monochromatic light is incident on the plane glass plate at 45° and hence a beam is incident on the plano convex lens.
4. A path of the incident light is reflected by the plano convex lens and a path of light is transmitted which is reflected from the surface of the plane glass plate. Hence, interference fringes are formed in between the glass plate and the bottom of the plano convex lens which can be observed through the microscope.

5. The microscope is moved to the one side (say left side) and the vertical cross wire is made tangential to the 18th, 15th etc., up to 3rd ring. The horizontal scale reading of the travelling microscope is noted.
6. The vertical cross wire is made tangential to the other side (say right side) of the rings 3rd, 6th etc., up to 18th ring. The horizontal scale readings are noted in the tabular form.
7. From the tabular form, the value of D_m^2 , D_n^2 are calculated.
8. The radius of the curvature of the given plano convex lens is determined using the formula

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

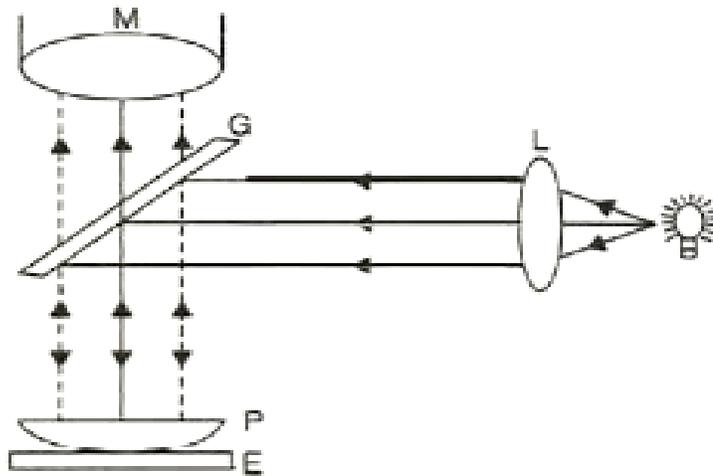


Fig. 1: Newton's ring apparatus

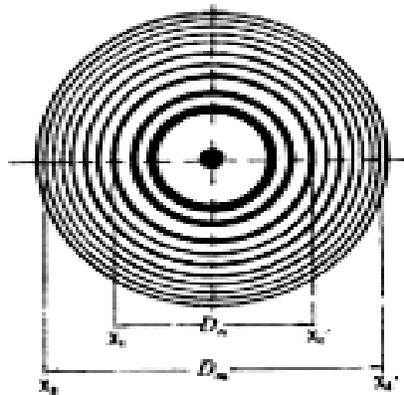
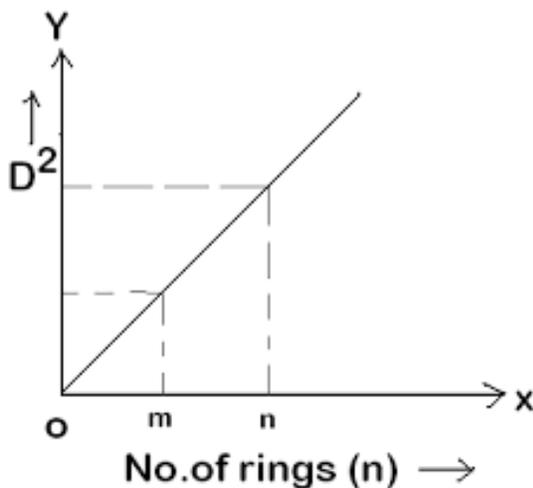


Fig. 2: Newton's Rings

Graph:

A graph is drawn by taking number of rings on x-axis and D^2 value on y-axis. The graph is a straight line passing through the origin. From the graph D_m^2 , D_n^2 are calculated then 'R' can be known from the formula.



Precautions:

1. Microscope should be moved only in one direction to avoid backlash error.
2. Slow motion of tangential screw should be used while taking the readings.
3. The readings of central black spot need not be considered.

Table 1: Calculation of D^2

Least Count : 0.001 cm

S.No	Ring no.	Travelling Microscope readings								Diameter of the ring $D = (x-y)$ cm	D^2
		Left				Right					
		MSR a (cm)	VC (n)	$b = n \times$ Lc	Total $x = (a+b)$ cm	MS R a (cm)	VC (n)	$b = n \times$ Lc	Total $y = (a+b)$ cm		
1.	18										
2.	15										
3.	12										
4.	9										
5.	6										
6.	3										

Table 2:

S.No.	Ring No. nth	D_n²	Ring No. mth	D_m²	D_m² - D_n²
1.	18		9		
2.	15		6		
3.	12		3		

Calculations:

Result:

The radius of curvature of the given plano convex lens is determined

From experiment, $R = \text{----- cm}$

From graph, $R = \text{----- cm}$

EXPT-3

Date:

DETERMINATION OF THE WAVELENGTH OF MERCURY SPECTRUM LINES USING A PLANE TRANSMISSION GRATING-NORMAL INCIDENCE METHOD

Aim: To determine the wavelength of mercury spectrum lines using a plane transmission grating in normal incident position.

Apparatus:

1. Spectrometer
2. Plane Transmission Grating
3. Spirit Level
4. Mercury Vapour Lamp

Formula:

$$\lambda = \frac{\sin\theta}{Nn} \text{ \AA}$$

$$N = \frac{\sin\theta_g}{\lambda_{gN}}$$

Where λ = wavelength of spectral line in \AA

θ = angle of diffraction in degree

n = order of the spectrum (1)

N = number of lines per cm on the grating

λ_g = wavelength of given spectral lines

θ_g = Angle of diffraction of green colour

Procedure:

1. After the preliminary adjustments of the spectrometer are made, the slit is determined with the mercury vapour lamp.
2. The grating is mounted on the prism table with the help of clamps.
3. The telescope is kept exactly opposite to the collimator at 0° and 180° , in this position, the vernier table is fixed with screws.
4. Now the telescope is turned to 90° then the grating is adjusted, such that the reflected image of the slit is made to coincide with the vertical cross wire of the telescope. At this position the vernier readings are 90° and 270° .
5. Then the prism table is rotated further 45° such that the plane of the grating is parallel to the collimator.

6. Now the grating is fixed in the normal incidence position. Then the telescope is rotated to the left side to observe the spectrum. Now the vertical cross wire is made to coincide with the red spectral line and the readings V_1 and V_2 are noted.

7. The experiment is repeated for other spectral lines (red to violet) and the readings are tabulated in tabular form.

8. Now the telescope is rotated to the right side and the experiment is repeated as above from violet to red and the readings V_1^1 and V_2^1 are noted in tabular form.

9. From the tabular form the wavelength of the spectral lines are calculated by using the formula:

$$\lambda = \frac{\sin\theta}{Nn} \text{ \AA}$$

Diagram:

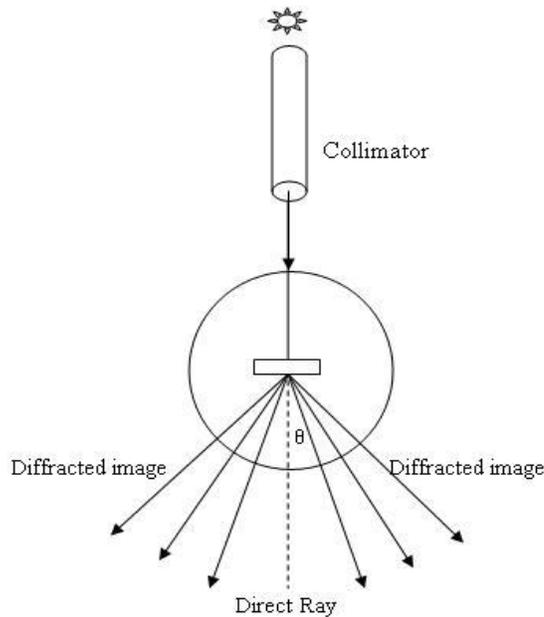


Fig. : Normal incidence method – Diffraction grating

Determination of wavelength of different spectral lines:

$$\begin{aligned} \text{Least count (LC) of spectrum} &= \frac{\text{Value of MSR}}{\text{No. of VSR}} \\ &= \frac{\left(\frac{1}{2}\right)^1}{30^1} \\ &= 1^1 \end{aligned}$$

Table

S. No	Colour	Readings on the spectrometer				Difference between vernier readings			Angle θ	$\lambda = \frac{\sin\theta}{Nn}$ (\AA)
		Left		Right		$V_1 \sim V_1^1$	$V_2 \sim V_2^1$	Mean (2θ)		
		V_1	V_2	V_1^1	V_2^1					
1.	Red									
2.	Yellow									
3.	Green									
4.	Blue									
5.	Violet									

Precautions:

1. The grating should be arranged in normal incidence position.
2. Micrometer screw should be used for fine adjustment of the telescope.
3. Read both the verniers to eliminate any errors due to non-coincidence of the center of the circular scale with the axis of rotation of the telescope.

Calculations:

Result:

The wavelength of the different spectral lines are determined and they are approximately equal to the standard values.

EXPT-4

Date:

DETERMINATION OF THE DISPERSIVE POWER OF A PLANE TRANSMISSION GRATING

Aim: To determine the dispersive power of a plane transmission grating in normal incident position.

Apparatus:

1. Spectrometer
2. Plane Transmission Grating
3. Spirit Level
4. Mercury Vapour Lamp

Formula:

Dispersive power of grating,

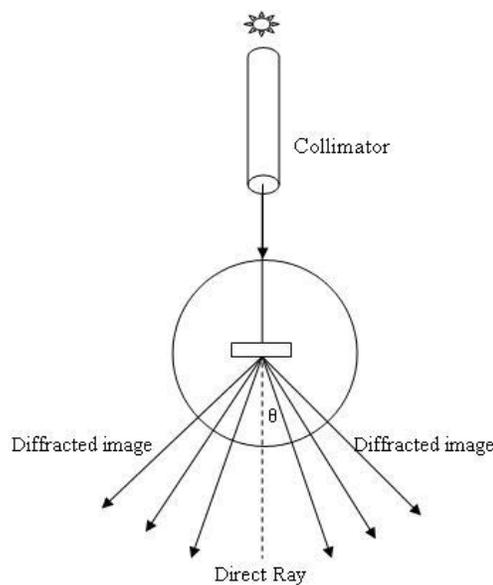
$$\frac{d\theta}{d\lambda} = \frac{Nn}{\cos\theta} \text{ degree/cm}$$

Where θ = angle of diffraction in degree

n = order of the spectrum (1)

N = number of lines per cm on the grating

Diagram:



Procedure:

1. After the preliminary adjustments of the spectrometer are made, the slit is determined with the mercury vapour lamp.
2. The grating is mounted on the prism table with the help of clamps.
3. The telescope is kept exactly opposite to the collimator at 0° and 180° , in this position, the vernier table is fixed with screws.
4. Now the telescope is turned to 90° then the grating is adjusted, such that the reflected image of the slit is made to coincide with the vertical cross wire of the telescope. At this position the vernier readings are 90° and 270° .
5. Then the prism table is rotated further 45° such that the plane of the grating is parallel to the collimator.
6. Now the grating is fixed in the normal incidence position. Then the telescope is rotated to the left side to observe the spectrum. Now the vertical cross wire is made to coincide with the red spectral line and the readings V_1 and V_2 are noted.
7. The experiment is repeated for other spectral lines (red to violet) and the readings are tabulated in tabular form.
8. Now the telescope is rotated to the right side and the experiment is repeated as above from violet to red and the readings V_1^1 and V_2^1 are noted in tabular form.
9. From the tabular the dispersive power of the grating is calculated by using the formula:

$$\frac{d\theta}{d\lambda} = \frac{Nn}{\cos\theta} \text{ degree/cm}$$

Precautions:

1. The grating should be arranged in normal incidence position.
2. Micrometer screw should be used for fine adjustment of the telescope.
3. Read both the verniers to eliminate any errors due to non-coincidence of the center of the circular scale with the axis of rotation of the telescope.

Table

S. No	Colour	Readings on the spectrometer				Difference between vernier readings			Angle θ	$\frac{d\theta}{d\lambda} = \frac{Nn}{\cos\theta}$ degree/cm
		Left		Right		$V_1 \sim V_1^1$	$V_2 \sim V_2^1$	Mean (20)		
		V_1	V_2	V_1^1	V_2^1					
1.	Red									
2.	Yellow									
3.	Green									
4.	Blue									
5.	Violet									

Calculations:

Result:

The dispersive power of the given plane transmission grating =

EXPT-5

Date:

**DETERMINATION OF THE RESOLVING POWER OF A PLANE TRANSMISSION GRATING
USING SPECTROMETER**

Aim: To determine the resolving power of a plane transmission grating using spectrometer arranged for normal incidence.

Apparatus: Spectrophotometer, diffraction grating, mercury vapour lamp, reading lens etc.

Formula: Resolving power of a grating is its ability to show two neighbouring spectral lines in a spectrum as separate. If λ and $\lambda+d\lambda$ are the wavelengths of two neighbouring spectral lines then the resolving power of the grating is the ratio of $\frac{\lambda}{d\lambda}$.

By Rayleigh's criterion for resolution, when the two spectral lines are just resolved then,

$$\text{Resolving power of grating} = \frac{\lambda}{d\lambda}$$

Diagram:

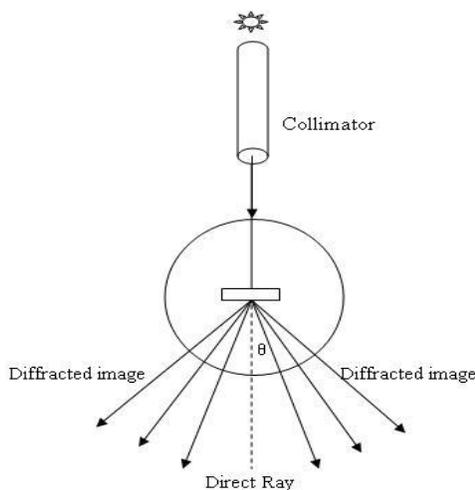


Fig: Resolving power of a diffraction grating

Procedure:

1. After the preliminary adjustments of the spectrometer are made, the slit is determined with the mercury vapour lamp.

2. The grating is mounted on the prism table with the help of clamps.
3. The telescope is kept exactly opposite to the collimator at 0° and 180° , in this position, the vernier table is fixed with screws.
4. Now the telescope is turned to 90° then the grating is adjusted, such that the reflected image of the slit is made to coincide with the vertical cross wire of the telescope. At this position the vernier readings are 90° and 270° .
5. Then the prism table is rotated further 45° such that the plane of the grating is parallel to the collimator.
6. Now the grating is fixed in the normal incidence position. Then the telescope is rotated to the left side to observe the spectrum. Now the vertical cross wire is made to coincide with the red spectral line and the readings V_1 and V_2 are noted.
7. The experiment is repeated for other spectral lines (red to violet) and the readings are tabulated in tabular form.
8. Now the telescope is rotated to the right side and the experiment is repeated as above from violet to red and the readings V_1^1 and V_2^1 are noted in tabular form.
9. From the tabular form the resolving power of the spectral lines are calculated by using the formula: $\frac{\lambda}{d\lambda}$

Precautions:

1. The grating should be arranged in normal incidence position.
2. Micrometer screw should be used for fine adjustment of the telescope.
3. Read both the verniers to eliminate any errors due to non-coincidence of the center of the circular scale with the axis of rotation of the telescope.

Determination of wavelength of different spectral lines:

$$\begin{aligned}
 \text{Least count (LC) of spectrum} &= \frac{\text{Value of MSR}}{\text{No. of VSR}} \\
 &= \frac{\left(\frac{1}{2}\right)^1}{30^1} \\
 &= 1^1
 \end{aligned}$$

Table

S. No	Colour	Readings on the spectrometer				Difference between vernier readings			Angle θ	$\lambda = \frac{\sin\theta}{Nn}$ (\AA)
		Left		Right		$V_1 \sim V_1^1$	$V_2 \sim V_2^1$	Mean (20)		
		V_1	V_2	V_1^1	V_2^1					
1.	Yellow 1									
2.	Yellow 2									

To calculate resolving power of grating:

Wavelength of yellow1, $\lambda_1 =$ _____ \AA

Wavelength of yellow2, $\lambda_2 =$ _____ \AA

Mean wavelength $\lambda = \frac{\lambda_1 + \lambda_2}{2} =$ _____ \AA

Change in wavelength $d\lambda = \lambda_2 - \lambda_1 =$ _____ \AA

Resolving power of the grating $\frac{\lambda}{d\lambda} =$

Calculations:

Result: Resolving power of the given grating =

EXPT-6

Date:

DETERMINATION OF THE DIELECTRIC CONSTANT OF THE DIELECTRIC MATERIAL

Aim: To determine the dielectric constant of the dielectric material of the given capacitor by the method of charging and discharging.

Apparatus: Power supply, capacitor, resistor, voltmeter etc.

Formula:

Dielectric constant of the dielectric material

$$K = \frac{dT_{1/2}}{0.693\epsilon_0 AR}$$

Where d = Thickness of dielectric material (m)

$T_{1/2}$ = Time require for 50% charge or discharge (s)

A = area of the dielectric material (m²)

R = Resistance of resistor in series with the capacitor (W)

Procedure: The terminals of the capacitor are shorted using a wire to remove the charges that are already stored.

Charging mode: Circuit connections are made as shown in the figure. The voltage across the capacitor for time T=0 is noted as zero. The Toggle switch is closed to position 'A' to initiate charging of the capacitor and simultaneously a timer is started. The voltage (V) across the capacitor is noted for every 5 second until the voltage across the capacitor becomes almost constant. The readings are tabulated.

Discharging mode: The stop-clock is reset to zero. The voltage across the capacitor corresponding to time T=0 is noted. Now the toggle switch is closed to position 'B' to initiate discharging of the capacitor and simultaneously the timer is started. The voltage (V) across the capacitor is noted for every 5 second until the voltage across the capacitor becomes almost constant. The readings are tabulated.

Circuit Diagram:

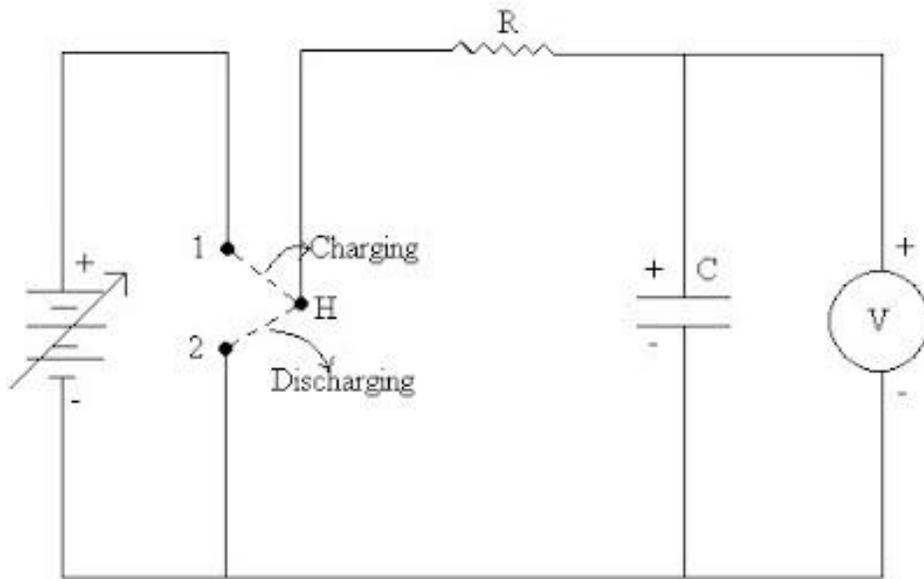
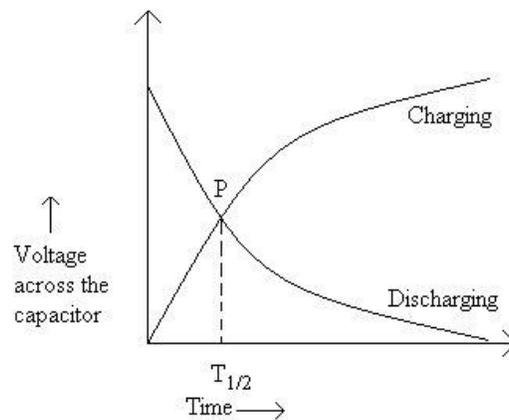


Figure 1

Model Graph:



A plot of Voltage (V) against Time (T) is made on the same graph for both charging and discharging of the capacitor. Two intersecting curves are obtained as shown in the figure. The time corresponding to the intersection of the curves called $T_{1/2}$ is determined. It is the time required to charge a capacitor to a value half the maximum amount of charge. Given the length (l) and breadth (b) of the dielectric material the area (A) is calculated. Given its thickness (T), the dielectric constant of the material of the given capacitor is calculated using the formula

$$K = \frac{dT_{1/2}}{0.693\epsilon_0 AR}$$

Calculations:

Dielectric constant of the dielectric Material is given by $K = \frac{dT_{1/2}}{0.693\epsilon_0 AR}$

Result: Dielectric constant of the dielectric material is, $K =$

EXPT-7

Date:

DETERMINATION OF VARIATION OF THE INTENSITY OF MAGNETIC FIELD USING STEWART & GEE'S TYPE OF TANGENT GALVANOMETER

Aim: To study the variation of the intensity of magnetic field along the axis of a current carrying circular coil using Stewart & Gee's type of tangent galvanometer.

Apparatus:

1. Stewart & Gee's tangent galvanometer
2. Magnetic compass
3. Ammeter
4. Commutator
5. Battery eliminator
6. Rheostat
7. Plug key
8. Connecting wires

Formula:

1. The magnetic field along the axis of a current carrying coil is given by

$$B = \frac{2\pi n i r^2}{10(d^2+r^2)^{3/2}} \text{ Gauss}$$

Where n = no. of turns of the coil = 50

i = current flowing through the coil (Amp) = 0.2 A

r = Radius of the coil (cm) = 10.1 cm

d = distance of magnetic needle from the center of the coil towards east and west

2. At the center of the magnetometer the flux density 'B' due to the current in the coil and the horizontal component of the earth's flux density B_H act at right angles to each other, so that the deflection ' θ ' is given by

$$B = B_H \tan\theta$$

Where B_H = horizontal component of the earth's magnetic field = 0.38 Gauss

θ = Average angle of deflection of the magnetic needle

Circuit Diagram:

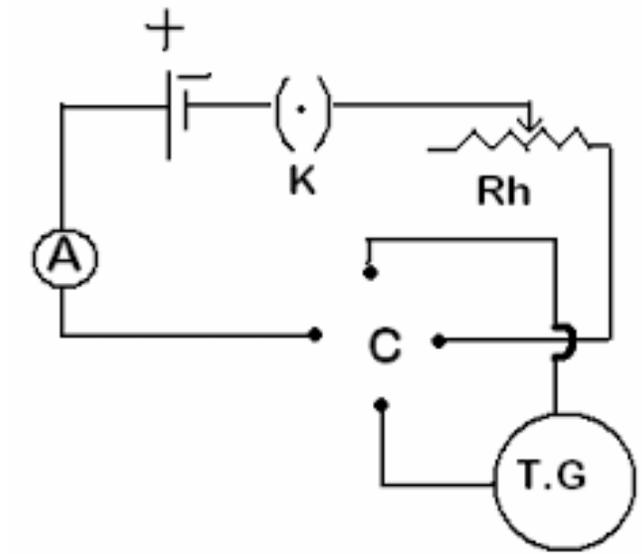
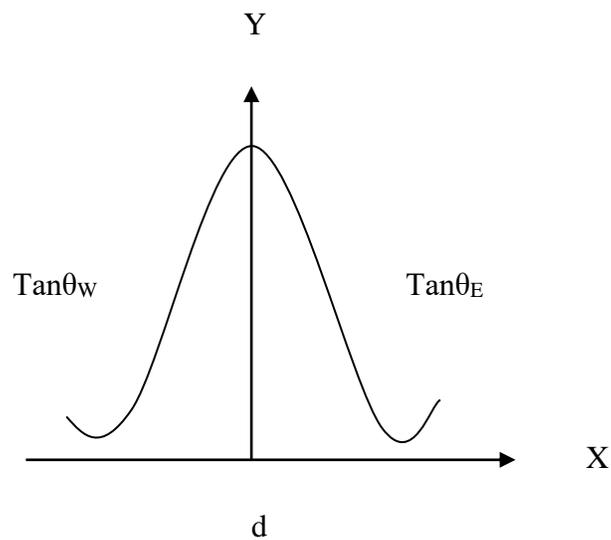


Fig.: Circuit diagram of Stewart & Gee's experiment

Graph : A graph is drawn between 'd' along x-axis and $\tan\theta$ along y-axis as shown in figure 2. It is symmetrical about the center of coil.



Procedure:

1. Orient the apparatus such that the coil is in the north-south plane as shown in the fig.
2. Adjust the leveling screws to make the base horizontal. Make sure that the compass is moving freely.
3. Connect the circuit as shown in the figure, selecting the number of turns (n) of the coil.
4. Keep the compass at the center of the coil and adjust the apparatus so that the pointers indicate 0-0 reading.
5. Close the plug keys (k) and commutator (C) (make sure that you are not shorting the power supply) and adjust the current with rheostat (R_h) so that the deflection is between 50 to 60 degrees. The current is noted by ammeter (A) and it will be kept fixed at this value for the rest of the experiment.
6. Note down the readings θ_1 and θ_2 . Reverse the current by changing the commutator keys and note down θ_3 and θ_4 .
7. Repeat the experiment at intervals of 2 cm along the axis towards East until the value of the field drops to 10 % of its value at the center of the coil.
8. Repeat the experiment on other sides of the coil towards West and note the deflections θ_5 , θ_6 , θ_7 and θ_8 .

Precautions:

1. The coil and the magnetic needle are adjusted to be in magnetic meridian.
2. All the magnetic materials and current carrying conductor should be kept away from the apparatus.
3. The apparatus should be kept without any disturbance throughout the experiment.
4. Readings should be taken without parallax error.

Table:

S.No	d (cm)	Deflection in degrees								Avg. θ	Tan θ	B=B _H Tan θ	$B = \frac{2\pi n i r^2}{10(d^2 + r^2)^{3/2}}$
		Left arm				Right arm							
		θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8				
1.	0												
2.	2												
3.	4												
4.	6												
5.	8												
6.	10												

Calculations:

1. **For d = 0**

2. **For $d = 2$**

3. **For $d = 4$**

4. **For $d = 6$**

5. **For $d = 8$**

6. **For d = 10**

Result:

1. The magnetic fields along the axis of a current carrying coil have been computed and compared.
2. The variation of magnetic field along the axis of a current carrying coil have been studied with the help of a graph.

MEASUREMENT OF THE SELF INDUCTANCE OF A GIVEN COIL BY ANDERSON'S BRIDGE

Aim: To measure the self inductance of a given coil by Anderson's bridge method.

Apparatus: Inductor, standard capacitor, resistors (fixed resistances and variable pots as given in the circuit), signal generator, head phones and connecting terminals.

Formula: Inductance of given coil $L = C [(R_1+ R_2) R_5 + R_2R_4]$ mH

Where $C =$ Capacity of the standard capacitor (μF)
 $R_2, R_3, R_4 =$ Known, fixed and non – inductive resistances ($K\Omega$) $R_1, R_5 =$ Variable resistances ($K\Omega$)

Circuit Diagram:

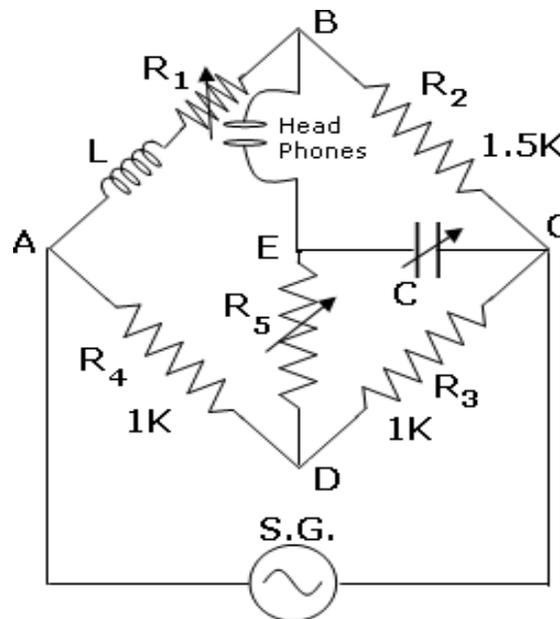


Figure: Circuit diagram of Anderson's bridge

Description:

Anderson’s bridge is the most accurate bridge used for the measurement of self – inductance over a wide range of values, from a few micro-Henries to several Henries. In this method the unknown self-inductance is measured in terms of known ca capacitance and resistances, by comparison. It is a modification of Maxwell’s L - C bridge. In this bridge, double balance is obtained by the variation of resistances only, the value of capacitance being fixed.

Procedure:

The circuit diagram of the bridge is as shown in the figure. The coil whose self-inductance is to be determined, is connected in the arm AB, in series with a variable non-inductive resistor R₁. Arms BC, CD and DA contain fixed and non – inductive resistors R₂, R₃ and R₄ respectively. Another non - inductive resistor R₅ is connected in series with a standard capacitor C and this combination is put in parallel with the arm CD. The head - phones are connected between B and E. The signal generator is connected between A and C junctions.

Select one capacitor and one inductor and connect them in appropriate places using patch chords. The signal generator frequency is adjusted to audible range. A perfect balance is obtained by adjusting R₁ and R₅ alternatively till the head – phones indicate a minimum sound. The values of R₁ and R₅ are measured with a multi-meter(While measuring the R₁ and R₅ values, they should be in open circuit).In the balance condition the self – inductance value of the coil is calculated by using the above formula. The experiment is repeated with different values of C.

Table:

S.No.	Capacity C (μF)	Resistance R ₁ (Ω)	Resistance R ₅ (Ω)	Calculated value $L=C[(R_1+R_2)R_5+R_2R_4]$ (mH)	Standard value of L (mH)
1.					
2.					
3.					
4.					
5.					
6.					

Calculations:

Precautions:

- 1) The product (CR_2R_4) must always be less than L.
- 2) R_1 and R_5 are adjusted until a minimum sound is heard in head phones.

Result: The self inductance of a given coil is given by $L =$

EXPT-9

DATE:

TRACING HYSTERESIS CURVE OF A TRANSFORMER CORE USING B-H CURVE

Aim: To trace hysteresis curve of a transformer core using a CRO and find the energy loss per unit volume per cycle, coercivity and retentivity of the material core.

Apparatus: B-H Curve unit, ferrite core, CRO, translucent paper etc.

Formula:

The energy loss can be calculated by

$$(E.L) = \frac{N_1}{N_2} \times \frac{R_2}{R_1} \times \frac{C}{AL} \times S_v \times S_H \times CH_1 \times CH_2 \times \text{area of the loop in j/cycle/volume}$$

Where N_1 = No. of turns of primary coil

N_2 = No. of turns of secondary coil

R_2 = Resistance used in the experiment

R_1 = Resistance between terminals

C = Capacitance used in the circuit

L = length of specimen

A = Area of cross section of transformer

S_v = vertical sensitivity

S_H = Horizontal sensitivity

CH_1 = First channel voltage in CRO

CH_2 = Second channel voltage in CRO

Circuit :

One Primary and one secondary

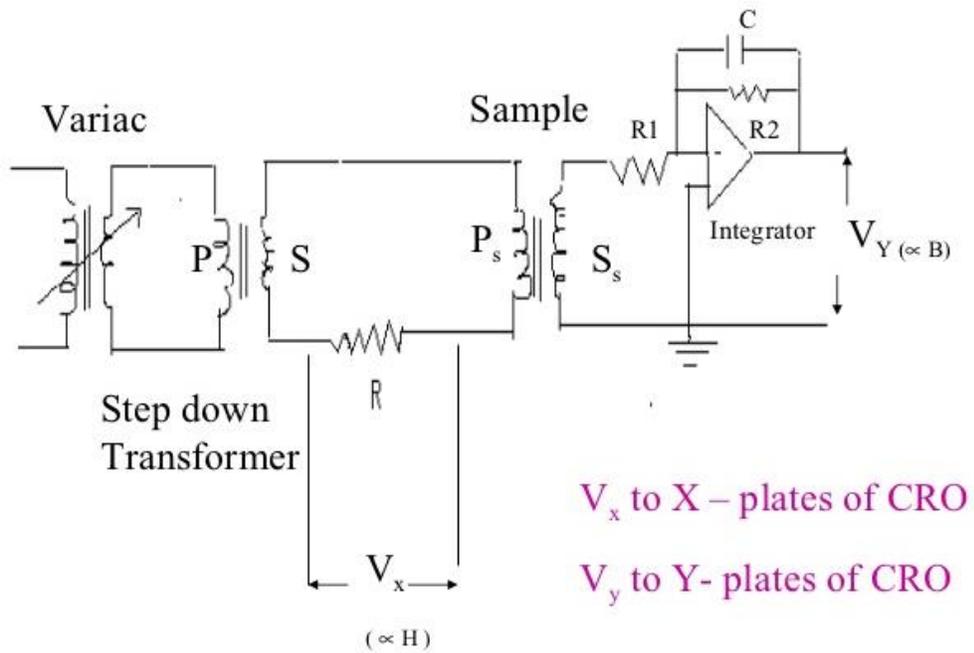


Fig 1: Circuit diagram of B-H curve

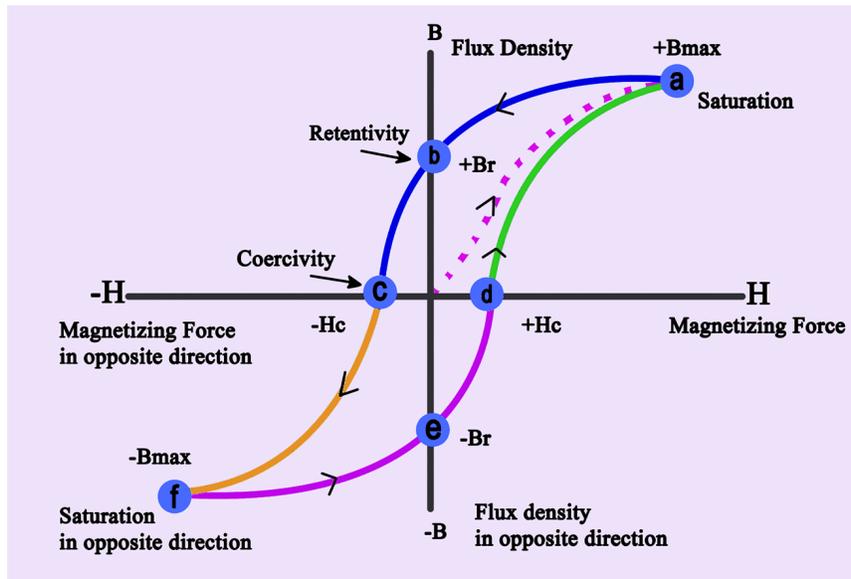


Fig 2: B-H curve

Procedure:

The phenomenon by which the magnetic induction (B) lags behind the magnetizing field (H) is called hysteresis.

1. The hysteresis curve graph with H on X- axis & corresponding B on Y- axis (of the material) will be as shown in fig 2.
2. The area under the B-H curve gives the hysteresis loss per cycle that is the work done per unit volume per cycle. Ob gives the value of retentivity (B_r) that is the remanent induction even when the field H is removed. Oc gives the value of coercivity (H_c) that is the negative field to be applied to demagnetize the specimen completely.
3. The circuit diagram required for experiment is as shown in fig. Connect the primary terminals of the specimen to the 'PRIMARY' and secondary to the 'SECONDARY' terminals. Adjust the CRO to work on external mode (the time base is switched off). Connect terminals "Vertical input" to CRO.
4. Connect terminal "Horizontal" CRO to the horizontal input of the CRO. Switch on the power supply of the unit. The hysteresis loop is formed. Adjust the horizontal and vertical gains such that the loop occupies maximum area on the screen of the CRO. Once this adjustment is made don't disturb the gain controls. The position of horizontal gain knob gives horizontal sensitivity S_H (Volts/m). Similarly the position of vertical gain knob gives vertical sensitivity S_V (Volt/m).
5. Trace the loop on a translucent sheet (butter paper) and reproduce the same on graph paper. Estimate area of loop in m^2 .
6. The energy loss is given by

$$(E.L) = \frac{N_1}{N_2} \times \frac{R_2}{R_1} \times \frac{C}{AL} \times S_V \times S_H \times CH_1 \times CH_2 \times \text{area of the loop in } j/\text{cycle}/\text{volume}$$

Tabular Form:

S. No.	Resistance	CH ₁	CH ₂	S _V (m)	S _H (m)	Area of the loop (m ²)	Energy Loss
1.							
2.							
3.							
4.							
5.							
6.							
7.							

Precautions:

1. The current in the primary of solenoid should be quite large so as to magnetize the specimen sufficiently.
2. Handle CRO carefully.
3. Trace of BH curve should be taken as tracing paper and it should of suitable size.

Result:

1. The energy loss of hysteresis loop =
2. The Retentivity of the core material =
3. The Coercivity of the core material =

DETERMINATION OF NUMERICAL APERTURE AND ACCEPTANCE ANGLE OF AN OPTICAL FIBER

Aim: To determine the acceptance angle and numerical aperture of an optical fiber.

Apparatus:

1. Fiber optical light source
2. Optical fiber cables
3. Numerical aperture
4. Optical bench

Formula:

The Numerical aperture of an optical fiber is given by,

$$NA = \sin \alpha = \frac{W}{\sqrt{4L^2 + W^2}}$$

Acceptance angle, $\alpha = \sin^{-1} (NA)$

Where W = Diameter of the light falling on the screen

L = distance between the fiber end to circular image (cm)

Diagram:

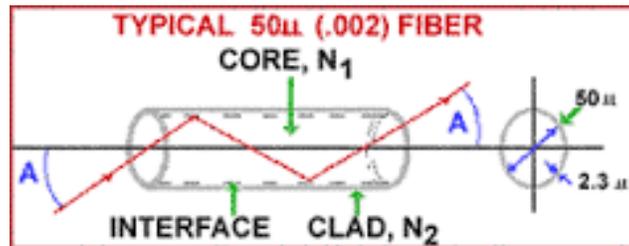


Fig.: Numerical aperture and acceptance angle of an optical fiber

Procedure:

1. One end of the optical fiber is connected to the power output of LED. And the other end of the fiber is connected to NA jig through the connector.

2. The A.C. mains is switched on. The light emitted by LED passes through the optical fiber cable to the other end. The set nob is adjusted such that, maximum intensity is observed on the screen and it should not be further disturbed.
3. A screen with concentric circles of known diameter is moved along the length of the NA jig to observe the circular spearing of light intensity on the screen.
4. The screen is adjusted such that, the first circle from the center of the screen is completely filled with the light. At this position, the distance (L) from the fiber end to the screen is noted on the NA jig.
5. The experiment is repeated for the subsequent circles by adjusting the length L along NA jig and the diameter of the rings (W) are noted in table.
6. By determining the values of 'L' and 'W', the NA and acceptance angle of the optical fiber can be calculated by using the above formulae.

Table:

S.No.	Diameter of the circular ring W (mm)	Distance from fiber end to screen L (cm)	$NA = \frac{W}{\sqrt{4L^2 + W^2}}$	$\alpha = \sin^{-1} (NA)$
1.	5			
2.	10			
3.	15			
4.	20			
5.	25			
6.	30			

Calculations:

Precautions:

1. Surroundings should be perfectly dark.
2. Fiber should be coupled smoothly to the connector.

Result:

Numerical aperture of the optical fiber NA = -----

Acceptance angle of the optical fiber α = -----

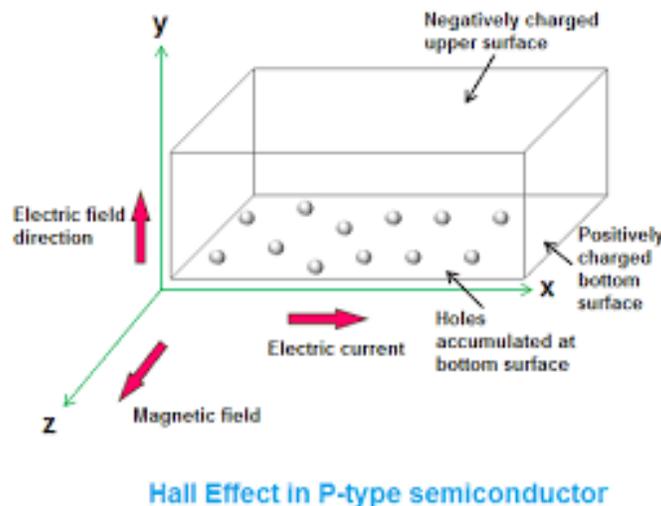
DETERMINATION OF THE HALL COEFFICIENT & THE CONCENTRATION OF THE MATERIAL USING HALL EFFECT

Aim: To determine the Hall coefficient, the concentration of the majority charge carriers and the mobility of charge carriers in the material.

Apparatus: Extrinsic semiconductor material, constant current source, electro-magnets, voltmeter having high input impedance.

Introduction: If a magnetic field is applied along X-direction and current is applied along Y- direction, then the voltage will be developed perpendicular to the both current and magnetic field i.e. in Z- direction. This effect is known as Hall effect and developed voltage is called Hall voltage.

The schematic demonstration of Hall effect is shown in fig.



Theory:

Take a p-type semiconductor wafer of thickness ‘t’ and area of cross section ‘A’. It carries a current I is acted up by a transverse magnetic field B. The magnetic field deflects charge carriers in a semiconductor wafer towards the one of the faces leading to an accumulation of charge carriers. This will produce an electric field E_H in a direction which opposes the Lorentz force due to magnetic field. The electric field which builds will be exactly balances the magnetic field. The potential difference V_H arising due to E_H is given by

$$V_H = \frac{BI}{\rho et} \text{ ----- (1)}$$

The ratio $\frac{I}{\rho e}$ is known as Hall coefficient R_H . Thus

$$R_H = \frac{I}{\rho e} \text{ ----- (2)}$$

$$R_H = \frac{V_H}{BI} \text{ ----- (3)}$$

If we know the thickness ‘t’ of the semiconductor wafer, the magnetic field B and by measuring the Hall voltage V_H produced in the wafer for given current I, the Hall coefficient R_H , can be determine with the help of equation (3).

If we know the Hall coefficient, the concentration of charge carriers in the material can be determine with the help of equation

$$\rho = \frac{1}{R_H e}$$

$$\sigma = \frac{1}{\rho}$$

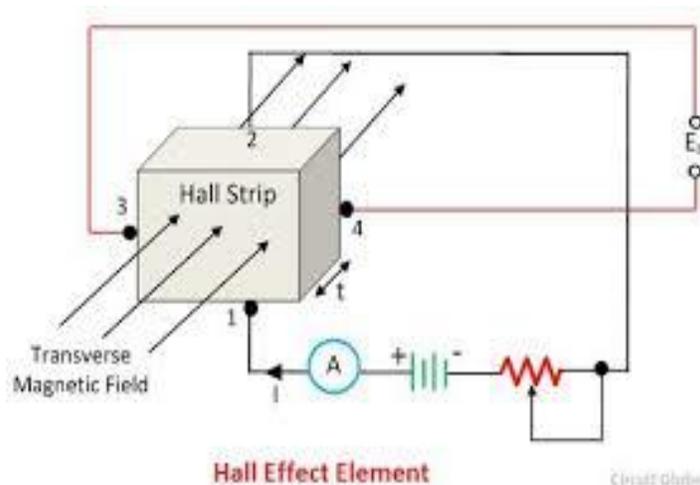
Knowing the conductivity σ of the semiconducting material, the mobility of charge carriers μ can be determine from following relation

$$\mu = \sigma R_H$$

Description of experimental set up:

The apparatus consist of a constant current source and digital panel meter. The current flowing through the semiconductor and voltage developed can be read with the help of current meter and volt meter. The semiconductor is taken in the form of a wafer and mounted on a strip. Four contacts were soldered on the wafer. An electro-magnet supplies uniform magnetic field. The magnetic field can be directly read from the panel meter located on the power supply unit. The strength of magnetic field can be varied with the help of potentiometer.

The circuit diagram for the measurement of Hall voltage is shown in figure.



Procedure:

1. The semiconductor is mounted on the probe strip and four electrical contacts are provided on the strip. The circuit is connected as shown in figure. The lengthwise contacts are connected to current meter and breadth wise contacts are connected to voltmeter.

2. The probe is placed in the gap of the electromagnets which provides magnetic field in direction perpendicular to the current direction and adjusts the magnetic field to a suitable value and keep constant.

3. The current through the semiconductor is adjusted to a suitable value with the help of constant current source and corresponding voltage and polarity can be noted.

4. For different current values, the corresponding Hall voltage developed can be noted down with the help of voltmeter and results tabulated in table1.

5. Now keep the current value constant at a constant value (say 3mA) and the magnetic field is varied in steps of 500 Gauss. At each set of magnetic field note down the corresponding Hall voltage. The observations are tabulated in table2.

6. Using the above observations plot the graphs. In one graph plot the current versus voltage at a constant magnetic field. In second graph magnetic field versus Hall voltage. In both cases graphs will be straight lines.

Table1:

At constant magnetic field

S.No.	Current(I) (mA)	Hall voltage V_H (mV)

Model graph 1:

Variation of Hall voltage with current

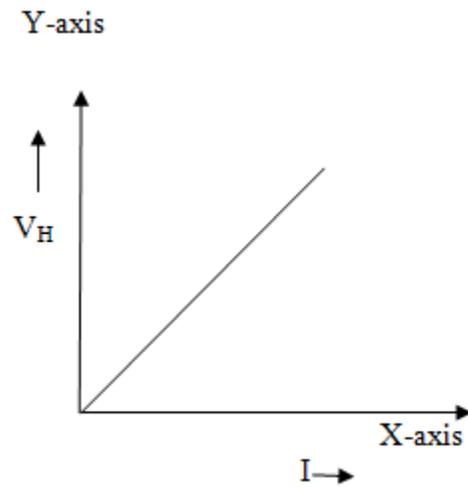


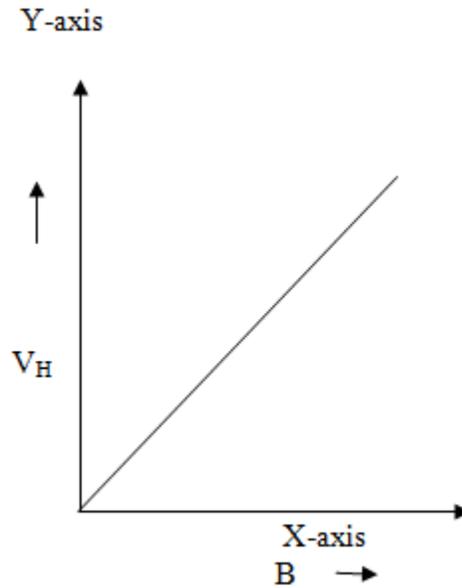
Table-2:

At constant current

S. No.	Magnetic field (Wb/m ²)	Hall voltage V _H (mV)
1.		
2.		
3.		
4.		
5.		
6.		
7.		

Model graph 2:

Variation of Hall voltage with Magnetic field



Precautions:

1. Care should be taken to limit the current through the probe to a value less than that of its capacity.
2. The probe should be properly centered and mounted in the magnetic field so that the maximum voltage is generated.
3. The potentiometer control of electro magnet is kept at a minimum value while switching on or off the power supply.
4. The potentiometer control of the current flow through probe is also brought to zero while on or off the current source.
5. Magnetic field should be varied gradually and slowly to avoid damage to the electromagnetic coil.

Calculations:

From the variation of current vs. voltage graph

$$(1) \text{ Slope} = \frac{V_H}{I}$$

From the variation of magnetic field vs. voltage graph

$$\text{Slope} = \frac{V_H}{B}$$

$$R_{H1} = [\text{slope} \frac{V_H}{I}] \times \frac{t}{B} = \text{_____} \text{ m}^3/\text{C}$$

$$R_{H2} = [\text{slope} \frac{V_H}{B}] \times \frac{t}{I} = \text{_____} \text{ m}^3/\text{C}$$

$$\text{Hall coefficient (Mean } R_H) = \frac{R_{H1} + R_{H2}}{2} = \text{_____} \text{ m}^3/\text{C}$$

(2) Majority carrier concentration

$$n \text{ (or) } p = \frac{1}{R_H e} = \text{_____} /\text{m}^3$$

(3) Mobility of charge carriers:

$$\mu = \sigma R_H = \text{_____} \text{ m}^2/\text{Vs}$$

Results:

1. The Hall voltage measured =

2. The mobility of charge carriers =

3. The carrier concentration of charge carriers =

DETERMINATION OF ENERGY GAP OF A SEMICONDUCTOR

Aim: To determine the energy band gap of a semiconductor.

Apparatus: p-n junction diode, thermostat, voltmeter, microammeter, thermometer and battery.

Formula:

$$\text{Band gap energy } E_g = \frac{2.303 \times 2k \times \text{slope}}{1.6 \times 10^{-19}} \text{ eV}$$

Where k = Boltzmann constant

The graph between $\log I_0$ vs $\frac{1}{T}$ gives the slope.

I_0 = Saturation current (mA)

T = Temperature (K^{-1})

Diagram:

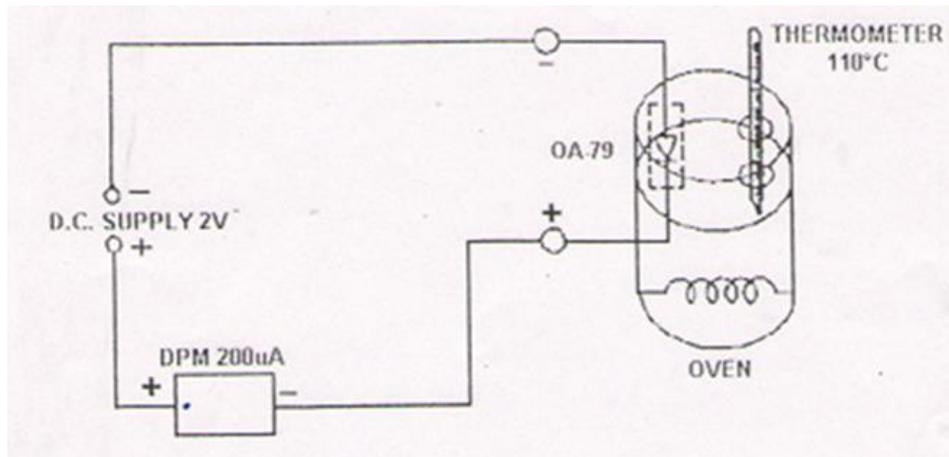


Figure: Energy gap of semi conductor

Procedure:

The circuit diagram of the experimental setup for the measurement of energy gap is shown in figure.

1. The point contact diode is connected in a reverse bias as shown in the diagram.
2. It is placed in an oil bath and heated uniformly.
3. Saturation current is noted for various temperatures.
4. The bias voltage is maintained at a constant value.
5. The readings in the microammeter are noted as a function of temperature in steps of 5°C .
6. A graph is drawn with $\log(1/T)$ in Kelvin on the X-axis and $\log I_0$ on the Y-axis.
7. The slope of the graph is calculated and substituted into the formula.

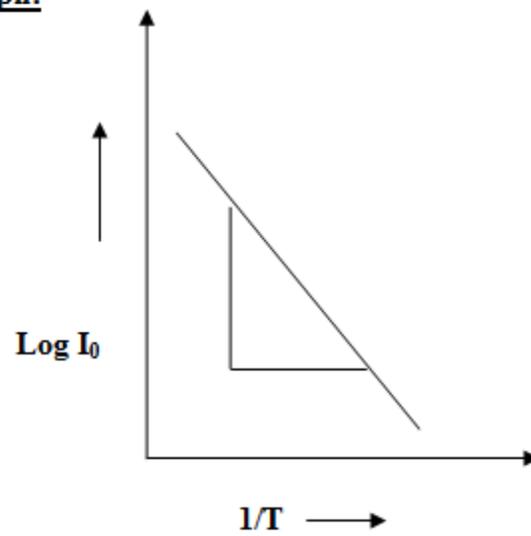
Precautions:

1. The current flow should not be too high; if the current is high, then the internal heating of the device will occur. This will cause the actual temperature of the junction to be higher than the measured value. This will produce non-linearity in the curve.
2. There may be contact potentials, thermoelectric emfs, and meter DC offsets which must be added and subtracted from the readings.
3. Poor contact results in huge variations in the results and must be carefully soldered.
4. It is better to repeat a few measurements at the end of each run to check the source of error.

Table:

S.NO.	Temperature (t) °C	Temperature T (K)	Saturation Current (I ₀)	$\frac{1}{T}$ (K ⁻¹)	Log I ₀

Model graph:



Calculations:

Result: The energy gap of the material = ----- eV.