PHYSICS LAB MANUAL

DEPARTMENT OF PHYSICS
JRE GROUP INSTITUTIONS

List of Experiment

Subject: Physics Lab
Subject code: EAS 151/ EAS 251

1. To determine the wavelength of Sodium light by Newton's ring.

2. To determine the wavelength of Sodium light with the help of Fresnel's Biprism.

3. To determine the focal length of the combination of two thin convergent lenses separated by a distance with the help of a Nodal – Slide and verify to the formula.

4. To determine the specific rotation of cane sugar solution using Polarimeter.

5. To determine the wavelength of spectral lines using plane Transmission Grating.

6. To determine the specific resistance of a given wire using Carey Foster's Bridge.

7. To study the variation of magnetic field along the axis of current carrying - Circular coil and then to estimate the radius of the coil.

8. To verify Stefan's Law by Electrical Method.

9. To convert a Galvanometer into Ammeter and Voltmeter.

10. To determine the Energy Band Gap of a given semiconductor material.

11. To determine E.C.E. of copper using Tangent galvanometer.

12. To draw hysteresis curve of a given sample of ferromagnetic material and from - this to determine magnetic Susceptibility and permeability of the given specimen.

13. To determine the coefficient of viscosity of a Water.

14. To study the Hall Effect and determine Hall coefficient, carrier density and - mobility of a given semiconductor using Hall Effect set up.

15. Measurement of Wavelength of a laser (He- Ne) light using single slit diffraction.

JRE GROUP OF INSTITUTIONS

PHYSICS PRACTICAL

INDEX

S.No.	Description	
1.	List of experiments	-
2.	Index	-
3.	Instructions for Laboratory	-
4.	General Instructions	-
5.	Safety Rules	-
6.	Model Practical Record	-

Date:

OBJECTIVE: To determine the wavelength of sodium vapor light by measuring the diameter of Newton's ring.

APPARATUS:

A Traveling microscope, a sodium vapor lamp, Newton's rings apparatus consisting of an optically plane glass plate and a convex lens of large focal length placed in a box having an optically plane glass plate inclined at an angle 45^0, a convex lens of short focal length etc.

PRECAUTIONS:

1. The lens and glass plate should be clean.

2. A lens of a large radius of curvature should be used.

3. The point of intersection of the cross-wires should coincide with the center of the ring system.

4. The micrometer screw should always be moved in the same direction to avoid error due to back-lash.

5. The radius of curvature of surface of the lens in the contact with glass plate should be measured accurately.

6. The amount of light from the source should be adjusted for maximum visibility. To much light increase the general illumination and decreases the contrast between bright and dark rings.

THEORY:

Circular interference fringes produced by enclosing a very thin air film of varying thickness between the surface of convex lens of a large radius of curvature and a plane glass plate are known as Newton's ring.

In order to produce these fringes light from an extended monochromatic source S is rendered parallel by convex lens L. It falls on the glass plate G inclined at an angle of 45^0 to the vertical and is reflected normally on to the lens N. An air film of varying thickness is thus enclosed between the lower surface of this lens and the glass plate P. The light reflected from the upper and the lower surfaces of the air film produces interference fringes. At the center the lens is in contact with glass plate and thickness of the air film is zero. The centers will be dark as a phase change of is introduced due to reflection at the lower surface of the air film. As we proceed outward from the centre the thickness of the air film gradually increases being the same all along circle with centre at the point of contact. Hence the fringes produced are film. The fringes are viewed by means of a low power microscope M as show in fig1.

If R is the radius of curvature of the surface of the lens in contact with the glass plate P, D_n the diameter of the nth dark ring and λ the wavelength of light, then

$$D^2_n = 4nR\,\lambda$$

If the lens and the plate are not quite in contact at the centre of the ring system, as may occur if the surfaces are not clean, the centre may not be dark. To eliminate the error due to this the diameter of any two dark rings say n^{th} and m^{th} is determined, thus:

$$D^2_n = 4nR\,\lambda$$

And $\qquad D^2_m = 4mR\,\lambda \qquad\qquad m < n$

$$\lambda = \frac{D^2n - D^2m}{4(n-m)R}$$

This formula involves the difference of the square of the diameter of the two rings and is independent of the thickness of the air film at the so called point of contact.
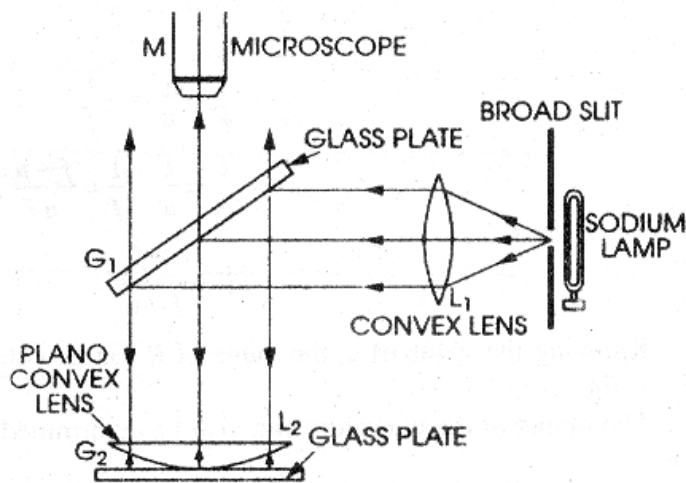

Fig. 1 Experimental arrangement for newton's ring

PROCEDURE:

1. Level the microscope table and set the microscope tube in the vertical position. Find the vernier constant of the horizontal scale.

2. Clean the surface of the glass plate P, the lens N and the plate G. Place all of them in position as show in the fig.1. Place the arrangement in front of a sodium lamp show that the height of the center of the glass plate G is the same as that of the center of the sodium lamp, placed in a wooden box having a hole of about one inch square in it at the same height. Place the convex lens in front of hole and adjust its position so that a parallel beam of light is made to fall on the glass plate inclined at an angle of 45^0.

3. Adjust the position of the microscope so that its lies vertically above the center of the lens N. Focus the microscope, so that alternate dark and bright rings are clearly visible.

4. Adjust the position of the microscope until the point of the inter-section of the cross-wire coincides with the center of the ring system and one of the cross-wire is perpendicular to the horizontal scale.

5. Slide the microscope to the left till the cross-wire lies tangentially at the 20th dark ring. The position of the cross-wire when the microscope is focused on 10th dark ring is shown in fig.2. Note the reading on the main scale and vernier scale of the microscope. Slide the microscope backward with the help of the slow motion screw and note the reading when the cross-wire lies tangentially at the 16th ,12th ,8th ,4th dark rings, respectively.

6. After reaching the 4th ring slide the microscope further and again note the reading corresponding to the same ring on the right and then on the left of the center of the ring system.
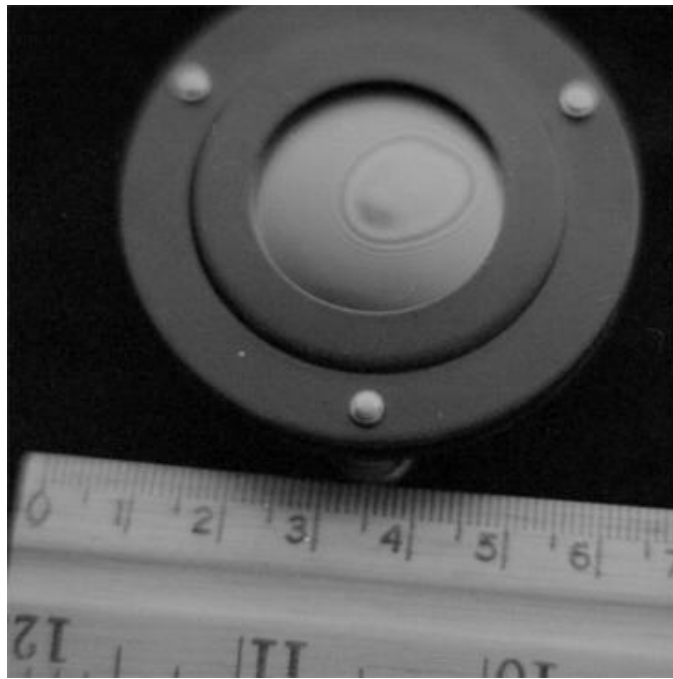
OBSERVATIONS:

Vernier constant =   .01 mm(variable)

Table1: To determine the diameter of Newton's Ring

S.No.	Ring No.	Microscope Reading						Diameter D = (a-b)	D^2
		Left side (a)			Right side (b)				
		M.S	V.S	Total	M.S	V.S	Total		
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									

Radius of curvature of convex surface R (Given) = …………… cm

Calculations:

Wavelength $\qquad \lambda = \dfrac{D^2n - D^2m}{4(n-m)R}$

Find the value of λ by taking the various combinations of n and m for example,

(2, 4), (4, 6), (6, 8), (8, 10)

λ = 1. $\qquad$ 2. $\qquad$ 3. $\qquad$ 4.

Mean wavelength of sodium light λ =------------ cm = ---------------Å

RESULT:

Standard value = ------------ Å(given)

Calculated Value = ----------- Å ----------------cm

$\qquad$ **% of error $\quad$ =**

OBJECT: - To determine the wavelength of sodium light by Fresnel's Biprism method.

APPARATUS:-

Optical bench with uprights, a sodium lamp, Fresnel's biprism, a convex lens and micrometer eyepiece.

FORMULA USED:-

In the case of biprism experiment the mean wavelength

$$\lambda = \beta \, \frac{2d}{D}$$

Where β = fringe width

$2d$ = distance between the two virtual sources

D = distance between the slit and the eyepiece

Where β is measured and distanced between the vertical source is given by

$$2d = \sqrt{(d_1.d_2)}$$

Where d_1 = distance between the two image formed by the convex lens in the first position.

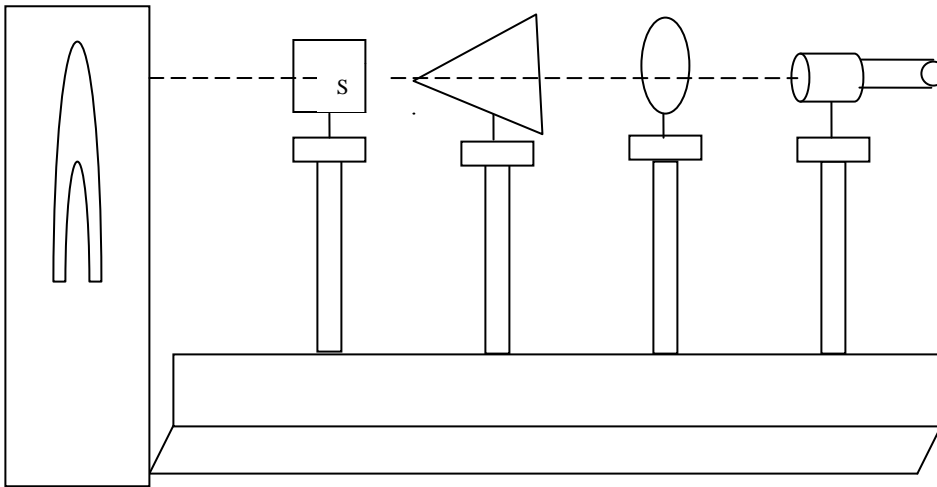d_2 = distance between the two image formed by the convex lens in the second position

Fig. 1 Experimental arrangement of Biprism

PROCEDURE:-

(1) Adjustment

(i)   The height of the slit biprism and eyepiece is adjusted at the same level.

(ii)   The biprism upright is placed near the slit. The slit is made narrow and vertical. It is illuminated with sodium light. Looking through the biprism two images of the source will be seen. The eye is moved side ways when one of the images will appear to cross the edge of the biprism from one side to the other. If the refracting edge of the biprism is parallel to the slit, the images as a whole will appear to cross the edge. Otherwise when adjustment is faulty, either the top or the bottom of the image will cross the edge first. The biprism is adjusted by rotating it in its own plane to effect the sudden transition of the full image.

(iii)   The eyepiece is placed near biprism and the biprism upright is moved perpendicular to the biprism till fringes or a patch of light is visible. If the fringes are not seen the biprism is rotated in its cross plane.

(iv)   If fringes are not clear reduce the slit width slightly.

(v)   The vertical cross wire is adjusted on one of the bright fringe at the center of the fringe system and the eyepiece is moved away from the biprism. In doing, if fringes give a lateral shift, it must be removed in the following way. From any position, the eyepiece is moved away from the biprism and at the same time a lateral shift is given to the biprism with its base screw so that the vertical cross-wire remains on the same fringe on which it was adjusted. The eyepiece is now moved towards the biprism and this procedure is repeated few times till the lateral shift is removed.
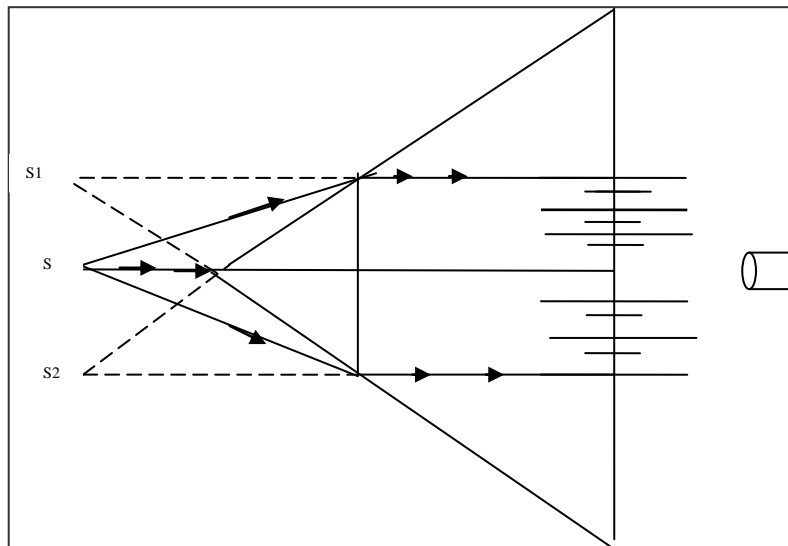

Fig. 2 Determination of fringe width

2. Measurement of β: (Fringe width)

1. The eyepiece is fixed about 100cm away from the slit.

2. The vertical crosswire is set on one of the bright fringes and the reading on the eyepiece scale is noted.

3. The crosswire is moved on the next bright fringe and the reading is noted. In this way observation are taken for about 20 fringes.

3. Measurement of D: (distance between source and screen)
        1. The distance between the slit and eyepiece gives D.

4. Measurement of 2d: (distance between the two sources on screen)
        1. For this part the distance between the eyepiece and slit should be kept slightly more than four times the focal length of lens. If necessary the position of the slit and the biprism should not be altered.

        2. The convex lens is introduced the biprism and eyepiece and is placed near to the eyepiece. The lens is moved towards the biprism till two sharp images of the slit are seen. The distance d_1 is measured by the micrometer eyepiece.

        3. The lens is moved towards the biprism till two images are again seen the distance between these two images give d_2.

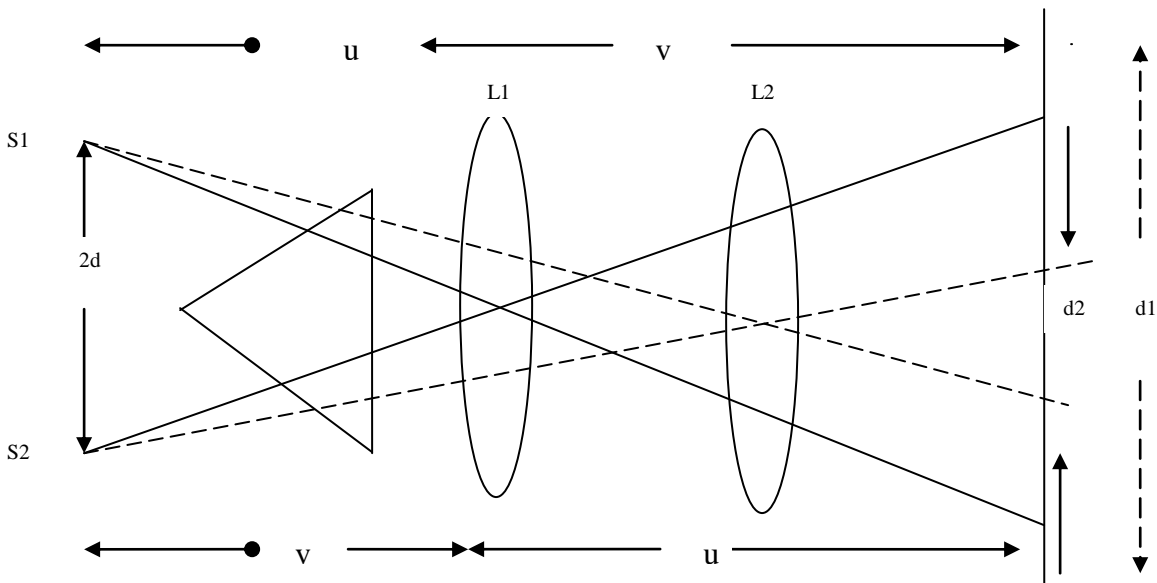   **4.** At least two sets of observation for d_1 and d_2 are taken.

Fig. 3 Determination of distance between two sources

Observation of β: (fringe width)

No of division on the vernier scale =
Least count of Vernier =

No of fringe	Micrometer reading(a)			No of fringe	Micrometer reading(b)			Difference for 10 fringe	Mean for 10 fringe	Fringe width (mm) $\beta =$ [Mean/10]
	MS	VS	Total (mm)		MS	VS	Total (mm)			
1 2 3 4 5 6 7 8 9 10				11 12 13 14 15 16 17 18 19 20						

Measurement of D:

Position of the slit   (a)   = -----------cm
Position of the eyepiece (b)   = -----------cm
Observation value of D (b-a) = -----------cm

Measurement of 2d:

Micrometer Reading												$2d = \sqrt{d_1\ d_2}$	Mean 2d
Observation for d_1						Observation for d_2							
Position of I Image			Position of II Image			Position of I Image			Position of II Image				
MS	VS	Total	MS	VS	Total	MS	VS	Total	MS	VS	Total		

Calculation:

$$\lambda = \beta\ \frac{2d}{D} \qquad = \qquad Å$$

Result:

Standard value = ------------ Å

Percentage Error=-------------.

Date:

OBJECT: -   To determine the focal length of the combination of two thin convergent lenses separated by a distance with the help of a Nodal – Slide and verify to the formula.

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$$

Where,   F   =   focal length of the combination

        f_1 =   focal length of the first lens

        f_2 =   Focal length of the second lens

    and   x   =   Distance between the two lenses.

APPARATUS: - Nodal – Slide assembly (consisting of an optical bench, plane mirror, cross slit and lamp) and the two given lenses.

PRECAUTIONS:

1.   False images formed by partial reflection from the faces of the lenses should not be confused with the true image of the cross-slit.

2.   While determining the focal length of a single lens, its optical centre must lie on the axis of rotation of the nodal slide. (for easy and quick setting)

3.   Bench-error should also be taken into account.

4.   The nodal slide should be rotated slightly about the axis of rotation.

5.   In order to get a bright image of the slit the plane mirror should be placed as close to the combination as possible.

(a)   (b)
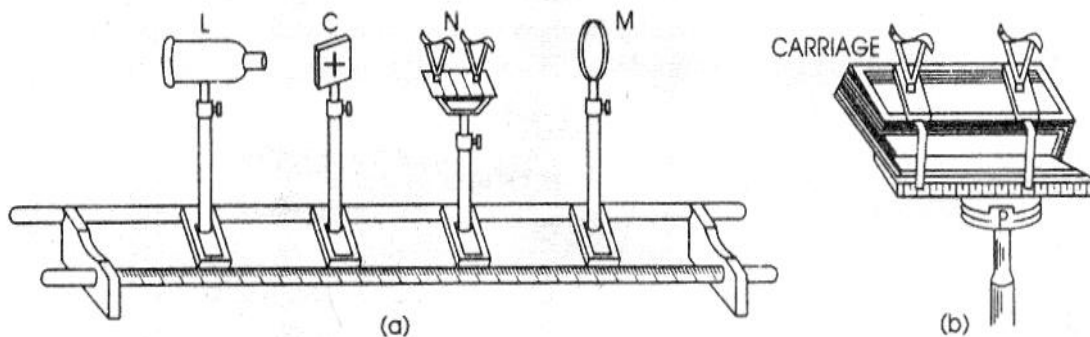
PRINCIPLE: The focal length of a lens system is the distance between its principal point and the corresponding focal point. The principal points coincide with the corresponding nodal points when the media are the same on both the sides of the system (here, air). Thus the focal length of the system can be determined by locating a nodal point and the corresponding focal point.

The second nodal point can be located by using the fact that in case of parallel beam of light incident on a convergent lens system, thus forming an image on a screen in its second focal plane, the image does not shift laterally when the system is rotated about a vertical axis passing through its second nodal point.

The distance between the uprights carrying the screen (or –cross- slit) and the nodal slide (which gives the position of the axis of rotation) will, therefore, give the focal length of the lens system.

PROCEDURE:

(1) First the focal length f_1 and f_2 of the two given lenses are determined. . For this one of the lenses is mounted on the nodal – slide such that its optical center lies on the axis of rotation of nodal slide. The source of light, screen having the cross slit and plane- mirror are mounted on the proper uprights and the heights of uprights are adjusted in such a manner that the line joining the center of each part is parallel to the bed of the bench.

(2) The cross- slit is illuminated and the plane of the mirror is adjusted till the image of the cross slit is formed close to the cross slit itself. If the image is blurred and not well defined then the upright carrying the nodal slides moved towards or away from the slit till the image becomes sharp and well defined. (In this position light diverging from the cross-slit emerges as a parallel beam of light after passing through the lens. This parallel beam of light is reflected as a parallel beam from the plane–mirror and brought to focus on the plane of the cross- slit by the lens. In other words, the screen having the cross -slit serves as the second focal plane for the parallel beam of light coming from the plane mirror.)

(3) The slide is rotated slightly about the vertical axis and lateral shift of the image is observed. If there is any shift, the position of the axis of rotation with respect to the lens is slightly changed by moving the nodal slide on the upright by means of the screw provided for this purpose. The sharpness of the image is disturbed. The image is refocused by moving the upright (carrying the nodal slide) on the optical bench. Lateral shift of the image is again observed. The same process is repeated till the image of the slit is in sharp focus and does not show any lateral shift when the nodal slide is slightly rotated about its vertical axis. The distance between the plane of the cross slit and the axis of rotation now gives the focal length of the lens.

(4) The lens is rotated through 180^0 and the whole process is repeated. The mean of the two distances, thus obtained, will give the exact focal length "f_1" of the lens.

(5) The first lens is removed and the second lens is mounted on the nodal- side. Its focal length "f_2" is determined in the same manner as described.

(6) To determine the focal length of the combination, the two lenses are mounted on the nodal slide at some distance apart (the lenses are being placed equidistance and on opposite sides of the axis of rotation). By adjusting the inclination of the plane mirror and the position of the nodal slide the image of the cross slit is made to lie on the side of the slit itself. The shift in the image due to a slight rotation of the nodal slide is observed. If there is any lateral shift, with the simultaneous focusing of image a suitable position of the nodal slide is determined for which no lateral shift of the image occurs due to a slight rotation of the nodal slide. The distance between the plane of the screen and the axis of the rotation of the nodal slide now gives the focal length of the combination.

(7) Different sets of reading are to be taken by turning the faces of the lens through 180^0 and inter–changing the position of the component lenses.

(8) The experiment is repeated for different values of x- the distance between the lenses (say 4,6,8 cms)

(9) The focal length of the combination is also obtained theoretically for each value of x by the formula

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$$

$$F = \frac{f_1 f_2}{f_1 + f_2 - x}$$

10 It will be found that the experimental and theoretically values of the focal length of the combination for given separation agree fairy well thus verifying the truth of the formula.

OBSERVATIONS: -

Table 1: Observation for the focal length of the first lens:

S.No.	Light Incident On	Position Of The Cross- Slit (a) (cm)	Position Of The lens (b) (cm)	Focal Length f_1 = (b-a) (cm)	Mean f_1 cm
1.	One face				
	Other face				
2.	One face				
	Other face				
3.	One face				
	Other face				

Mean f_1 = cm

Table 2: Observations for the focal length of the second lens:

S.No.	Light Incident On	Position Of The Cross- Slit (a) (cm)	Position Of The lens (b) (cm)	Focal Length $f_2=(b-a)$ (cm)	Mean f_2 cm
1.	One face				
	Other face				
2.	One face				
	Other face				
3.	One face				
	Other face				

Mean $f_2 =$ cm

Table 3: Observations for the focal length of the combination of two lenses:

S.No.	Distance Between lenses x Cms.	Light Incident On	Position Of Cross Slit (a) (cm)	Position Of The Nodal Slide (b) (cm)	Experimental Focal Length F (b-a) (cm)	Mean Focal length (F) (cm)	Calculated focal length	Mean Calculated focal length (F)
1.		One face						
		Other face						
2.		One face						
		Other face						
3.		One face						
		Other face						

Mean F =   Mean F =

CALCULATION:
$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$$

$$F = \frac{f_1 f_2}{f_1 + f_2 - x}$$

(a)   For x = ----------------------cm.   F = --------------------cm.

(b)   For x = ----------------------cm.   F = --------------------cm.

(c)   For x = ----------------------cm.   F = --------------------cm.

f_1 = ----------------------------cm

f_2 = ----------------------------cm.

Position of principal point:

$(L_1 H_1)_1 = + F x_1 / f_2$

$(L_1 H_1)_2 = + F x_2 / f_2$

$L_1 H_1)_3 = + F x_3 / f_2$

Mean L1 H$_1$ = (L$_1$ H$_1$)$_1$ + (L$_1$ H$_1$)$_2$ + (L$_1$ H$_1$)$_3$ / 3

RESULTS:

EXPERIMENT NO. 4 (Specific Rotation)

Date:

OBJECT:- To find the specific rotation of cane- sugar solution by a polarimeter at room temperature, using Half shade polarimeter.

APPARATUS:- Polarimeter, Polarimeter tube, cane-sugar, Physical Balance, Weight box, measuring cylinder, beaker and source of light.

FORMULA USED:- The specific rotation of cane- sugar solution is given by

$$S = \frac{\theta}{l.c} = \frac{\theta.v}{l.m}$$

where θ = rotation of the plane of polarization (in sugar)produced by the solution

v = volume of the sugar solution in cc

l = length of the polarimeter tube in decimeter

m = mass (in gms.) of sugar dissolved in water

Source of light — Polariser — Solution — Polarimeter tube — Analyser — Telescope
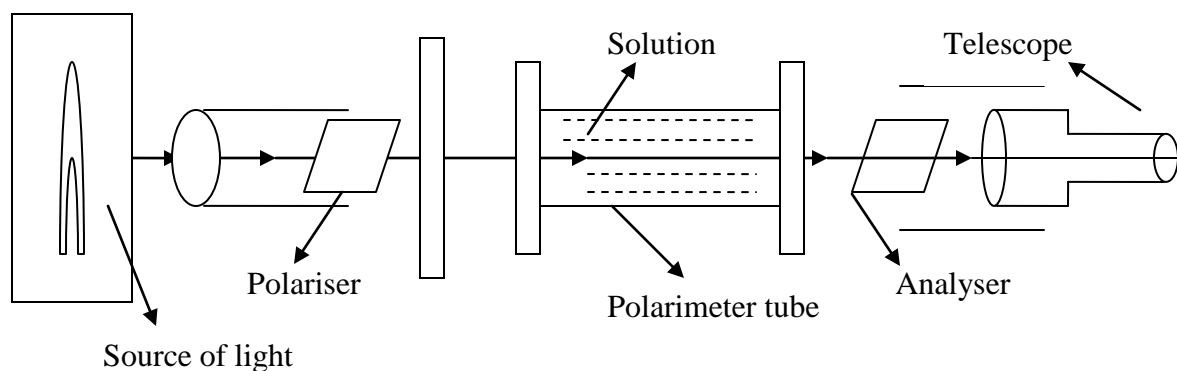
METHOD:-

1. The polarimeter tube is cleaned and filled with water such that no air is enclosed in it If there remains a small air bubble, then the bubble is brought in the bubble trap while placing the tube inside the polarimeter.

2. The tube is placed in its position inside the polarimeter and the polarimeter is illuminated with a white light source.

3. The analyser is rotated and adjusted in the position of tint of passage where yellow light is quenched and blue and red colures overlap and both halves of the field of view appear pink. The reading of the main scale and vernier scale is noted.

4. The Analyser is rotated by 180^0 where a similar situation appears and analyzer is again adjusted at the position of tint of passage. The reading on the main scale and vernier scale is noted.

5. About 10 gm of sugar is weighed and dissolved in water in the measuring cylinder to make 100cc of solution. Concentration of this solution is about 10%.

6. Water is removed and the solution is filled in the tube.

7. The tube is placed in polarimeter and observations are taken as in the case of water.

8. 50cc of the above solution is taken in measuring cylinder and water is added to make it 100cc. The Concentration of this solution is about 5%. Observations are repeated with this solution.

9. The above step is repeated and observations are taken for solution of about 2.5 % concentrates.

OBSERVATIONS:-

Length of the polarimeter tube	= --------dcm.
Mass of watch glass	= -------- gms
Mass of Watch glass and sugar	= ---------gms.
Mass of sugar	= ---------gms.
Volume of the sugar solution	= --------- cc
Temperature of the solution	= -----------^{0}c
Concentration of the solution ($\frac{M}{V}$)	= ----------gms/cc.

OBSERVATION FOR THE ANGLE OF ROTATION:-

Least count of instrument = ---------degree.

Analyser reading with pure water						Mean
Clockwise X			Anticlockwise Y			$a = \frac{X+Y}{2}$
MS	VS	Total	MS	VS	Total	

Concentration of solution in gm/cc	Analyser reading with sugar solution						Mean	
	Clockwise X$_1$			Anticlockwise Y$_2$			$b = \frac{X+Y}{2}$	$\theta = (b-a)$
	MS	VS	Total	MS	VS	Total		

Calculation:

$$S = \frac{\theta}{l.c} = \frac{\theta.v}{l.m}$$

S1 =

S2 =

S3 =

Mean (S) = S1+S2+S3+S4 / 4

Result: The specific rotation of sugar = ---------------degree/dm/gm/cc

Date:

OBJECT: To determine the wavelength of spectral lines of mercury light by a plane transmission grating.

APPARATUS: Mercury lamp, Spectrometer, a spirit level, grating with stand, table lamp and a reading lens.

FORMULA USED: The wavelength of any spectral line can be obtained from the formula.

$$(a+b) \sin\theta = n\lambda$$

$$\boxed{\lambda = \frac{(a+b)\sin\theta}{n}}$$

Where,

$(a+b)$ = grating element

θ = angle of diffraction

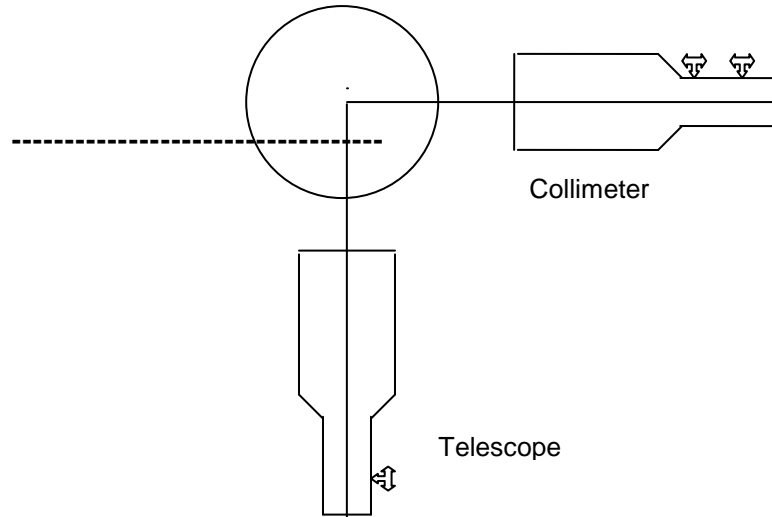n = the order of spectrum

Procedure:

1. Set the spectrometer by adjusting the position of the eyepiece of the telescope so that the crosswire are clearly visible. Focus the telescope on a distance object for parallel rays. Level the spectrometer and prism table with spirit level.

2. Set the grating stand on prism table with help of two screws P and Q provided on the table. Take out the grating from the box carefully, holding it from the edge and with out couching its surface towards the telescope.

3. The telescope is rotated by 90^0 towards the left side of direct image and the diffraction grating is placed on the grating table.

4. The grating should be adjusted by rotating the grating table without touching the telescope such that the slit gets appeared at the crosswire of the eyepiece.

5. When the slit is seen clearly we rotate the grating table 45^0 towards right. So the diffraction gratings become normal to the incident light and ruled surface focus the telescope.

6. Now, the telescope should be again brought in its original position by rotating it 90^0 towards right.

7. Focus the telescope for different colours violet, green, red, etc. (VIBGYOR) by moving telescope slowly on either side from normal position. It was the first order spectrum.

8. Now, the second order spectrum may be viewed by further rotating the telescope in the same direction.

9. After taking the measurement for first order spectrum on both sides, i.e; by nothing v1 and v2 (main scale and vernier scale), we turn the telescope for the other side (say, right or left). It is now focused on the same colours or spectral lines and the reading of the crosswire on the scale is recorded.

10. Finally, the same procedure is repeated for other colours (spectral lines) as well as for other order of the spectrum.
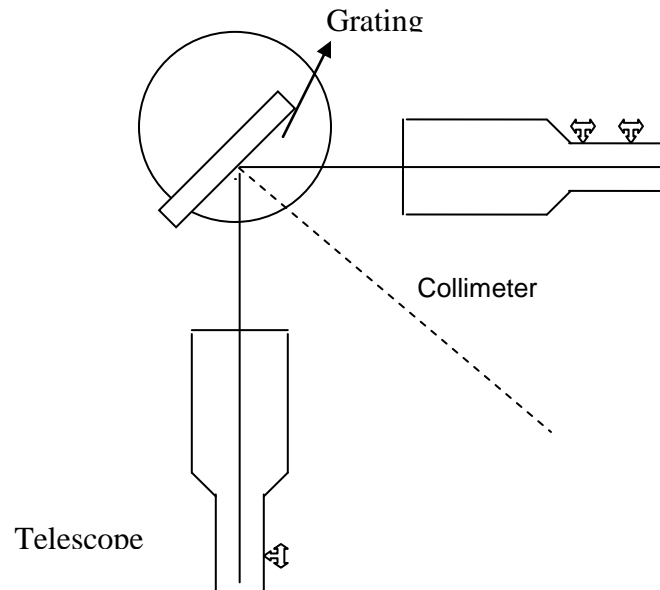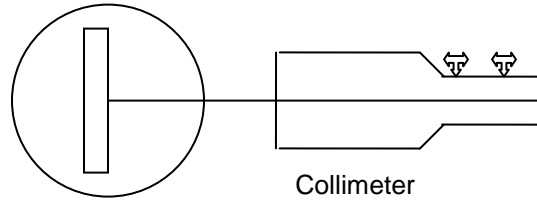
Step 1

Telescope
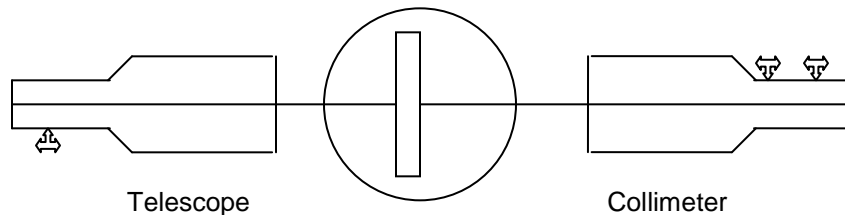
Prism table

Collimeter

Step 2

Collimeter

Telescope

Step 3

Grating

Collimeter

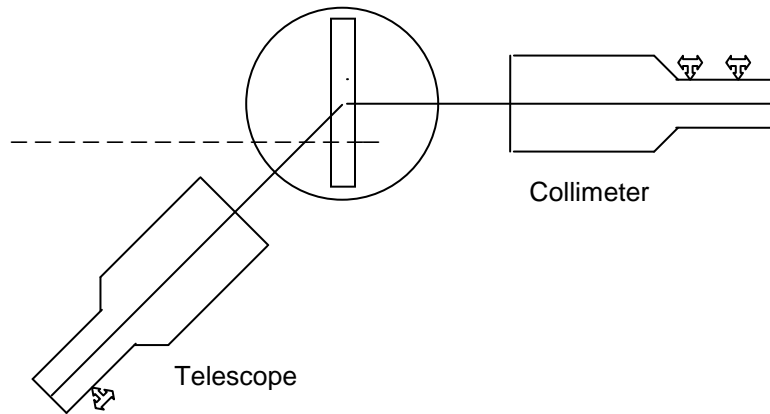Telescope
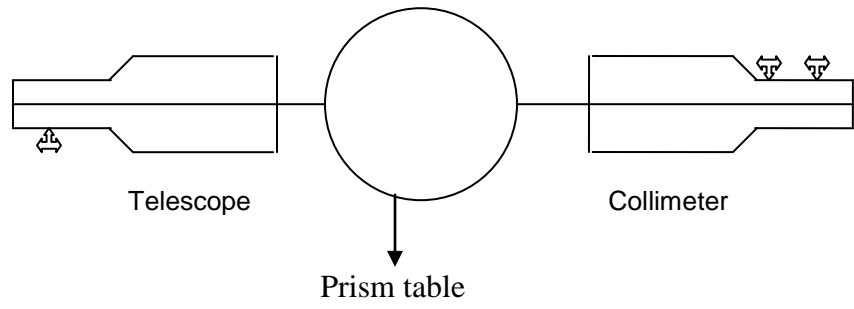
Adjustment of grating for normal incidence (step 1-3)

Step 4

Collimeter

Step 5

Telescope   Collimeter

Step 6

Collimeter

Telescope

Observation:

Table for determination of angle of diffraction:

Least count of spectrometer =

Number of lines per inch on the grating N =

Grating element (a+b) ------------------------$= \dfrac{2.54}{N}$

Reading of telescope for direct image $= 90^0$

Reading of telescope after image $= 180^0$

Order of spectrum	Colour of light	Kind of vernier	Spectrum on left side reading of telescope (a)			Spectrum on right side reading of telescope (b)			$2\theta=(a\text{-}b)$	Mean θ in degree
			MS	VS	Total	MS	VS	Total		
First	Violet	V_1								
		V_2								
	Green	V_1								
		V_2								
	Red	V_1								
		V_2								
Second	Violet	V_1								
		V_2								
	Green	V_1								
		V_2								
	Red	V_1								
		V_2								

Calculation:

Grating element (a+b) ------------------------$= \dfrac{2.54}{N}$

$N = 15000$

$\lambda = (a+b) \, \text{Sin} \, \theta$

First Order:

Violet ---------------Å

Green ---------------Å

Red ------------------Å

RESULT:

Violet ---------------Å

Green ---------------Å

Date:

OBJECT: To determine Specific resistance of the material of given wire using Carey foster's bridge.

APPARATUS: Carry foster's bridge, two equal resistances, copper strip, a fractional resistance box, a cell, connecting wire, a sensitive galvanometer, a jockey and one way key.

PRECAUTION:

1. The thick copper strip and the end of the wire should be cleaned.

2. The unknown low resistance, fractions resistance box and equal resistance P and Q should be connected to the bridge by thick equal and small copper leads.

3. The plugs of the resistance box should be tight.

4. The values of equal resistance P and Q should be very small i.e. between 1 to 5 ohms.

5. The jockey should be touched gently and should not be kept pressed on the wire when shifting it from one point to the other.

6. The difference between X and Y should not be more then the resistance of the bridge wire.

Theory: `The arrangement of Carey Foster's bridge is similar to Wheatstone bridge. As shown in figure P and Q are two ratio arms x along with the resistance of the wire and Y along with the resistance of the wire from the other two arms.
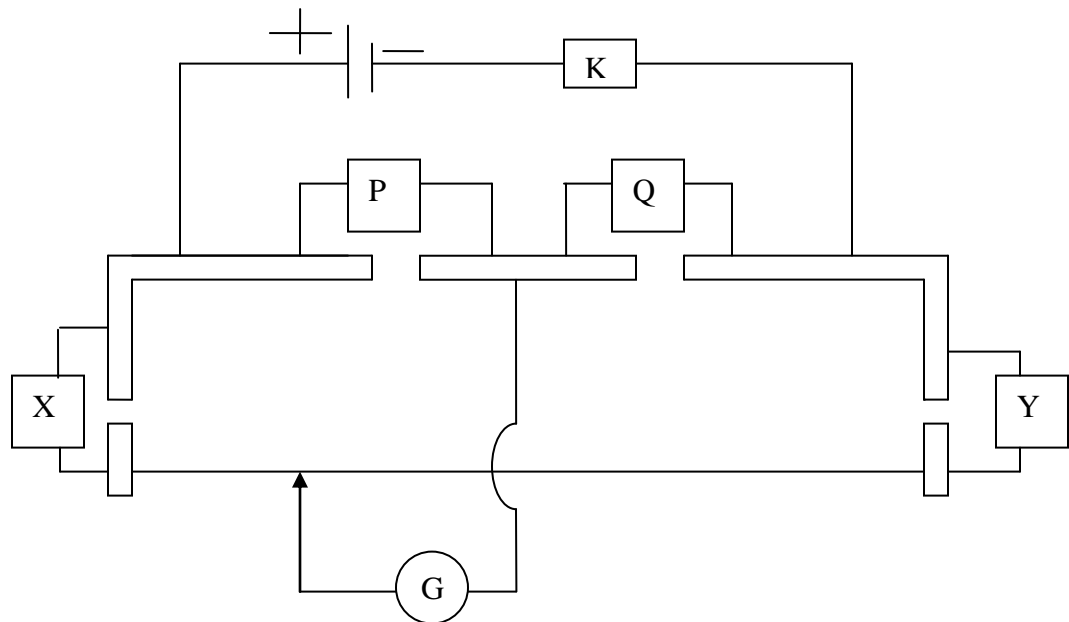
Method: **Low resistance by calibrating the bridge – wire:** Let x be the unknown resistance and d_1, d_2 shifts obtained with resistance Y_1 and Y_2 the know resistance box then

$$X - Y_1 = - d_1 \rho$$

$$X - Y_2 = - d_2 \rho$$

$$\frac{X - Y_1}{X - Y_2} = \frac{d_1}{d_2}$$

$$d_2 X - d_2 Y_1 = d_1 X - d_1 Y_2$$

$$X (d_2 - d_1) = d_2 Y_1 - d_1 Y_2$$

$$\boxed{X = \frac{d_2 Y_1 - d_1 Y_2}{d_2 - d_1}}$$

$$\boxed{\text{Specific resistance of the wire } \rho = \frac{X \pi r^2}{l}}$$

where, r is the radius and l is the length of wire

It is, therefore, not necessary to find out the value of ρ for the determination of an unknown low resistance. This method has the advantage that it does not require calibration of the bridge wire.

Procedure:

1. Draw the diagram showing the scheme of connections as in fig 1. Mark the gaps 1,2,3 and 4 on the bridge. Now clean the ends of the connecting wire and copper strip with sand paper. Connect the two equal resistance P and Q (say 1 ohm) in inner gaps2 and 3. Connect the copper strip in gap 1 and the fractional resistance box in gap 4. Connect one terminal of the galvanometer to the central terminal b and the other to a jockey. Connect the cell through a key K between the point A and C. Now test the connection by putting in the key K and touching the jockey at the end 'a' and then at 'b' end of the potentiometer wire, if the direction of deflection is in opposite direction in each case, then the connections are correct.

2. Now the keeping X and Y both equal to zero, find the balance point.Interchang X and Yand again find the balance point. The shift in the balance point gives the value of the corrections δl to be applied in all observations.

3. Replace the copper strip by X the unknown low resistance and find the shift in the balance point keeping Y equal to 0, 0.1, 0.2, 0.3, etc.

4. Calculate the radius of the given wire using screw gauge and length of the wire l. Measure only that length of the wire which is outside the binding terminals.

Observation:

Correction to applied δl = -----------cm

| S.No. | Y ohms | Position of balance point with unknown resistance | | Shift | Corrected shift |
		Left gap l_1	Right gap l_2	$d = (l_1-l_2)$	$(d - \delta l)$
1.	0.1				
2.	0.2				
3.	0.3				
4.	0.4				
5.	0.5				

Calculation: Value of X from observation

$$X = \frac{d_2 Y_1 - d_1 Y_2}{d_2 - d_1}$$

1and 2 ---------------------ohms

2and 3 ---------------------ohms

3 and 4 ---------------------ohms

4 and 5 ---------------------ohms

Mean value of X = ----------------ohms

Specific resistance of the wire $\rho = \dfrac{X\pi r^2}{l}$

Specific resistance ρ = -------------ohm cm

Result:

Date:

OBJECT: - To plot graph showing the variation of magnetic field with distance along the axis of a circular coil carrying current and evaluate from it the radius of the coil.

APPARATUS: - Stewart and Gee type galvanometer, Storage battery, rheostat, Millimeter, reversing key, one way key and connecting wires.

PRECAUTIONS: -

1.   There should be no magnetic material or current carrying conductor in the   neighborhood of the apparatus.

2.   The coil should be adjusted in the magnetic meridian carefully and this should be tested by passing the current through it in one direction and then in the reverse direction. The deflection in two cases should be very nearly the same and must not differ by more than 2°. Further, in this part of the experiment the current should be such that the deflection produced is nearly 45°. This is because the instrument is most sensitive at $\theta = 45^o$.

3.   After checking the setting of the coil in the magnetic meridian the current should be changed so that it may produce nearly 45° deflection in the needle. By so doing the deflection near the inflection point is nearly 45° and hence it can be located with greatest accuracy.

4.   Initial reading of the pointer must be set zero. If there is any error it must be taken into account while recording the deflection.

5.   **FORMULA USED: -**

$$\frac{2\pi n a^2 i}{10^7 (a^2 + x^2)^{3/2}} = H \tan\theta$$

Where,   n = used number of turns of the coil

a = radius of the coil

i = current (in amp.)flowing through the coil

x = distance of the axil point from the centre of the coil

H = horizontal component of earth's field in the lab.

and θ = deflection produced in the magnetic field of the galvanometer when the coil

has been placed in the magnetic meridian.

     On plotting the graph between x and Tan θ a curve m as shown in figure is obtained. The distance between the points of inflection A and B is measured. This gives the radius "a "of the coil

PROCEDURE: -

1.   The coil of the galvanometer is set into magnetic meridian. For this the arms are moved this way or that till the magnetic needle of the compass box lies nearly at the centre of the coil. The bench is then rotated in the horizontal plane till the coil is set roughly in the magnetic meridian. In this case, on looking vertically downwards from above coil; the coil, the magnetic needle and its image formed in mirror kept below it in the compass box, all lie in the same vertical plane. The compass box is rotated till the pointer read zero on the circular scale.

2.   Connections are made as shown in figure using say 50 turns of the coil and taking care that out of the four terminals provided on the commutator K any two diagonally opposite terminals are joined to the galvanometer and the other two to the battery through rheostat. The current is then passed by inserting the

plugs in one of the pairs of opposite gaps of the commutator.
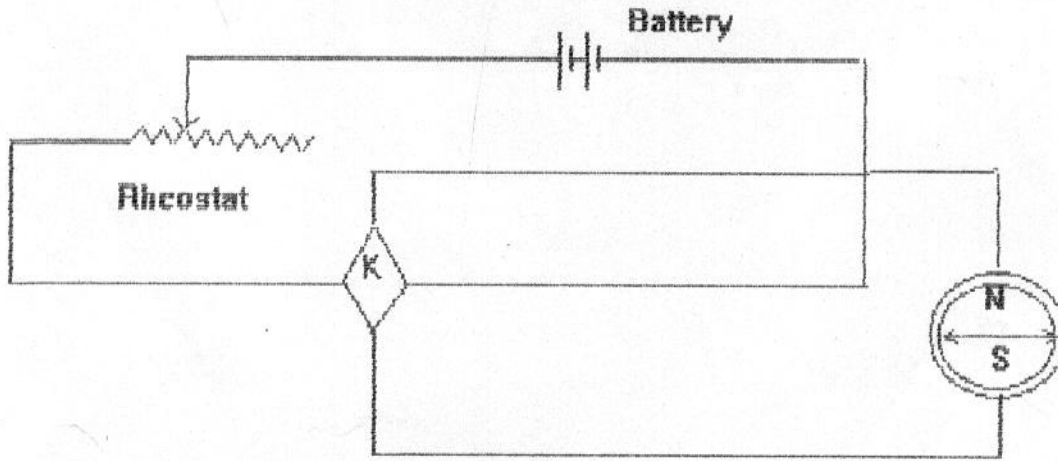
3. The value of the current is adjusted by means of the rheostat such that nearly $45°$ deflection is produced in the needle. This is because the instruments is most sensitive at $\theta = 45°$. The direction of the current in the galvanometer is then reversed by putting the plugs in the other pair of opposite gaps of the commutator and the deflection in the needle is again observed. If the difference between the deflections in the cases is less than $2°$ the adjustment is correct (i.e. the coil lies in the magnetic meridian). Otherwise the coil is further rotated along with the bench till the two deflections agree within this range.

4. The current is then changed to such a value that the deflection in the needle is about $75°$ (the number of turns used may be changed to 50, if this much deflection is not possible by using 5 turns). The readings of both the ends of the pointer (θ_1, θ_2) are noted. The direction of the current is revesered and again reading of both ends of pointers (θ_3, θ_4) is noted. The mean of the four reading will give the mean deflection.

5. The compass box is initially at the center of the coil and has maximum deflection $75°$. Now compass box is shifted in steps of 2 cm an east side and the corresponding readings are noted till the deflection falls to nearly $15°$.

6. Similarly the compass box is shifted in west side from center of coil, by sliding the wooden bench in steps of 2 cm and the corresponding reading is noted.

7. The graph between the position of the compass box and tan θ is plotted when a curve, as shown in figure is obtained.

8. The distance between the two points of inflection at A and B is found out from the graph. This should be equal to the radius of the coil.

9. The circumference of the coil can be measured by a thread and its radius can be calculated to verify the value obtained from the graph.
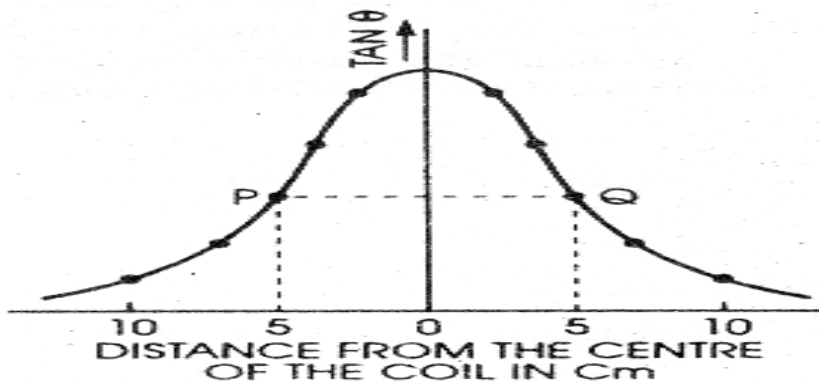
OBSERVATIONS: -

S.No	Position of the needle on one of the scale. (Distance of Compass box from center of coil) x (cm.)	Deflection in the needle when it is on the											
		East side of the coil						West side of the coil					
		Current one way		Current reversed		Mean $\theta\square\square\square\square$ $\square\square\square$ in deg.	tan θ	Current one way		Current reversed		Mean θ in deg.	tan θ
		θ_1	θ_2	θ_3	θ_4			θ_1	θ_2	θ_3	θ_4		
1.													
2.													
3.													
4.													
5.													
6.													
7.													
8.													

Graph

Circumference of the coil as obtained by a thread and meter scale = ----cm.

CALCULATION:-

Radius of the coil, as obtained from the graph = distance between the pointer A and B

=.. cm.

Radius of the coil, as obtained from measurement =

RESULT: - 1. The variation in the magnetic field with distance, along the axis of the given coil is as shown in the graph.

2. Radius of the coil = --------------- cm., as obtained from the graph and ----------------cm., as obtained from measurement.

Experiment No. 8 (Stefan's law)

Date:

OBJECT: To verify Stefan's Law by electrical method.

APPARATUS: 6V battery, D.C. Voltmeter (0-10 V), D.C. Ammeter (0-1 amp.), Electric bulb having tungsten filament of 6W, 6V, Rheostat (100 ohm).

Precaution: **1**. All connections should be tight.

2. Use the bulb having tungsten filament.

3. Increase the current in steps.

4. Note down the voltage reading carefully after every change in current.

5. Choose the rheostat of appropriate range.

6. Reading should be taken only when the system is stable.

FORMULA USED: - Stefan's law states that the total radiant energy emitted per second from the unit surface area of a perfectly black body is proportional to the fourth power of its absolute temperature.

or $$E = \sigma T^4$$

Where σ is called Stefan's constant.

In black body radiation, Stefan's law is

$$E = \sigma (T^4 - T_o^4)$$

Where E is the net amount of radiation emitted per second per unit area by a body at temperature T and surrounded by another body at temperature T_o. For other body (other than black).

$$P = A (T^a - T_o^a)$$

Where P is the total power emitted by a body at temp. T surrounded by another at temp. T_o. $a = 4$ and A is constant depending on the material and area of such a body.

$$P = A T^a [1 - T_o^a / T^a]$$

when $T > T_o$ $[T_0 / T]$

$$P = A T^a$$

Taking log both sides

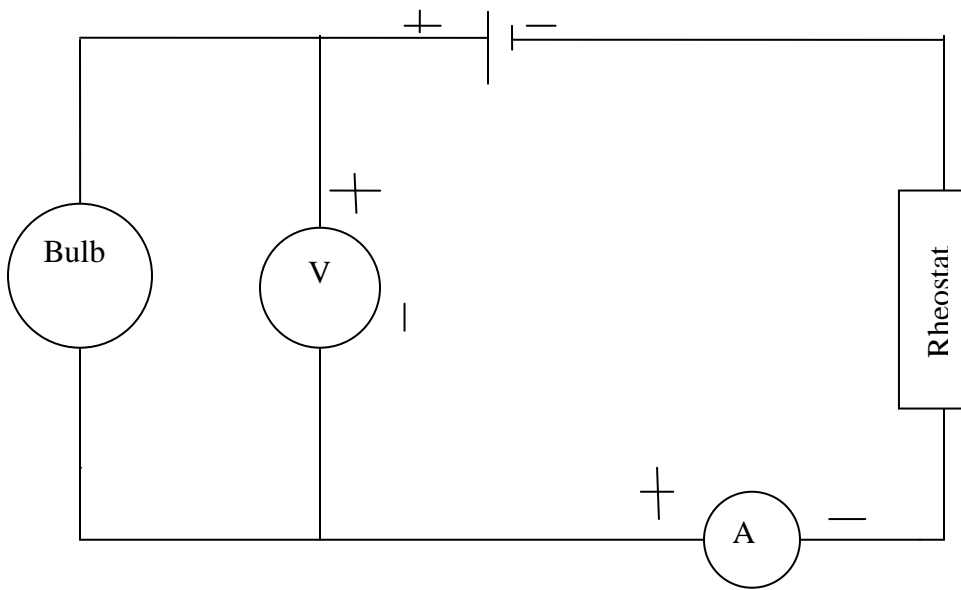$$\boxed{Log_{10} P = a\, Log_{10} T + Log_{10} A}$$

Fig.1

PROCEDURE:

1. Make the electrical connection as shown in fig 1.

2. Increase the value of current by using rheostat step and adjust such that the bulb glows each time and note down corresponding value of voltmeter in volts. Calculate the value of resistance $Rg = V / I$ in ohms.

3. Now repeat the same procedure by decreasing the current and calculate Rg in ohms.

4. Rg is the filament resistance at 800K [because when the filament first starts glowing and temperature is approximately 800K].

   For tungsten filament $\dfrac{R_{800}}{R_{273}} = 4.0$

   $$\dfrac{R_{800}}{4.0} = R_{273}$$

   Or $\qquad \dfrac{R_g}{4.0} = R_0\,^0c$

5. Increase the filament current I from a value below glow stage to values high enough to get very bright light, note down the voltage V across bulb every time. This will give resistance at that is instant of temperature Rt on ohms. This gives the value of power P. Using R_t / R_0 ratio, we deduce the temperature T of the filament.

6. **Draw the graph of** $\log_{10} p$ **versus** $\log_{10} T$ **which will be a straight line.**

OBSERVATIONS:-

Table 1: Determination of R_g: filament temperature = 800 K

S.No.	Current increasing			Current decreasing		
	Voltage V Volt	Current I Amp	$R_g = \frac{V}{I}$ Ohms	Voltage V Volt	Current I Amp	$R_g = \frac{V}{I}$ ohms
1.						
2.						
3.						
4.						
5.						

Mean value of R_g = ------------ohms, $R_0\,^0c = \frac{R_g}{4.0}$

Table: 2 Determination of power dissipated, P, for different temperatures T.

S.No.	Pot.diff. V volts	Current I Amps	$R_t = \frac{V}{I}$ Ohms	$\frac{R_t}{R_0}$	Temp. from table 3 or from graph K	$Log_{10}\ T$	Power P =VI Watts	$Log_{10}\ p$
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10								

Table:3

Temp. in 0^0c	$\dfrac{R_t}{R_0}$	Temp. in 0^0c	$\dfrac{R_t}{R_0}$
0	1.00	800	5.64
100	1.53	900	6.37
200	2.07	1000	6.94
300	2.13	1100	7.60
400	3.22	1200	8.26
500	3.80	1300	8.90
600	4.40	1400	9.70
700	5.00	1500	10.43

Graph

Ln (P) vs. Ln(T)

y = 4.5785x - 32.885
R² = 0.9998
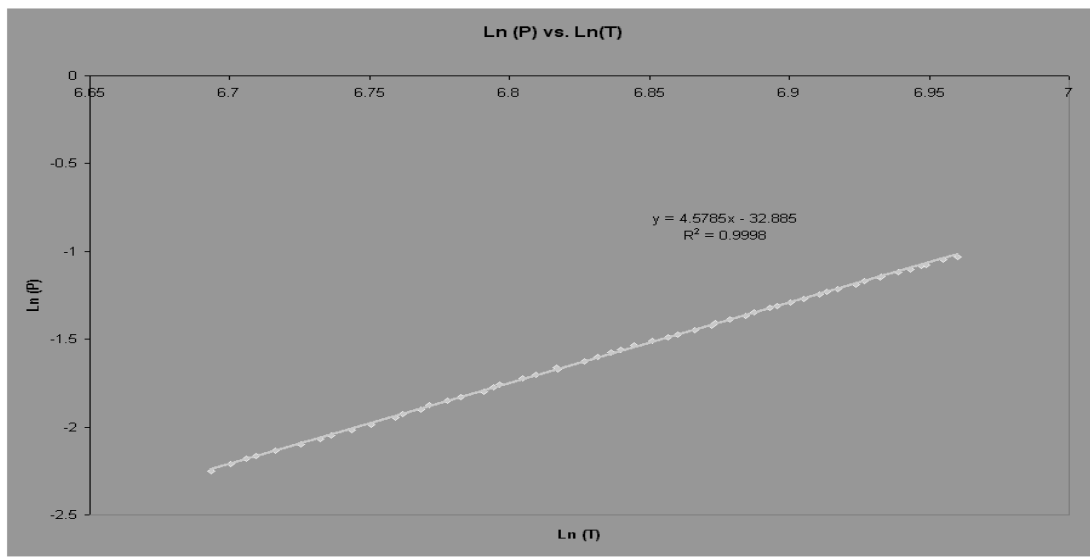
RESULT: - The graph of $\log_{10} p$ Vs $\log_{10}$ T is a straight line {fig}

Hence $P = AT^a$ law is verified. Because slop comes out to be 4.

Hence it is a fourth power law.

OBJECTIVE: Calibration of a Voltmeter with a potentiometer.

APPARATUS: Potentiometer, Given voltmeter, two storage batteries, two rheostats (50,110ohm), a standard cell, galvanometer, two one-way key, one two-way key and connection wires.

PRECAUTIONS:
        1. The e.m.f. of the cell used in the primary circuit should be greater than the e.m.f of standard cell.
        2. All the positive terminals should be connected to the same point of the potentiometer.
        3. The calibration should be checked after few readings.
        4. Jockey should not be moved on the potentiometer wire
        5. Voltmeter should be connected in parallel.

FORMULA USED:
        The error in voltmeter reading is given by

$$V'\text{-}\ V = \frac{El2}{l1} - V$$

$$V' = \frac{El2}{l1} = kl_2$$

Where V= potentiometer difference between two points read by voltmeter
    V'= potentiometer difference between the same two points read by potentiometer
    E= E.M.F. of the standard cell.
    l_1 = length of the potentiometer wire corresponding to E.M.F. of standard cell.
    l_2 = length of the potentiometer wire corresponding to the potential difference (V') measured by potentiometer.
    k = potential gradient of the potentiometer wire

PROCEDURE:
        1. Make the electrical connections are show in fig (1).
        2. Close K_1 and insert the plug key between 'a' and 'b' terminal of key K_2.Place the jockey on the last end 'B' of the potentiometer wire. If the deflection is observed in the galvanometer, then the rheostat h (1) is adjusted to get zero deflection (null point). The adjustment of the rheostat is not changed throughout the experiment..
        3. Record the total balancing length (l_1) of the potentiometer wire. This is 1000cm for ten wire potentiometer. The EM.F. of the standard cell (E) is recorded.
        4. Now remove the plug key from the terminal between 'a' and 'b' points of key K_2 and insert it in between 'b' and 'c' terminals. Close the key K_3. Again adjust the rheostat Rh(2) [Variable point(P)] of the potential divider circuit such that the voltmeter shows a constant reading. Adjust the jockey on the potentiometer wire such that Null point in the galvanometer is obtained..
        5. Note down the total length of potentiometer wire in this case (l_2).
        6. Now repeat the above procedure again and again and record atleast 6 -8 different values of voltmeter reading V and corresponding values of l_2.
        7. Now, plot a graph between the voltmeter reading (V) along the X-axis and the corresponding error in the reading (V'- V) along Y-axis. This is the required calibration curve for the given voltmeter.

Fig

OBSERVATIONS:

Table1: Table for the calibration of potentiometer wire:

e.m.f. of the standard cell (E) = 1.0286

Length of the potentiometer wire corresponding to E.M.f. of standard cell l_1 cm.	Remark
1000	**E.M.F. of standard cell E = -------------Volt** **Potential gradient , k = E/ l_1**

Table2: Table for calibration of voltmeter:

| S.No. | Voltmeter reading V volt | Balancing length of the potentiometer wire l_2 | | | $V' = (\frac{El_2}{l_1})$ $= kl_2$ | (V'-V) |
		No. of complete Wire	Length on sliding wire	Total l_2 in cm		
1						
2						
3						
4						
5						
6						

Calculation:

Potential gradient , $k = E/ l_1$ = -------------volt/cm

Now $V' = (\frac{El_2}{l_1})$

or $= kl_2$ = ---------- volt

Make similar calculations for other reading

Draw a graph between the error (V'-V) and the voltmeter reading (V) .

RESULT: The graph so obtained by plotting the error against the voltmeter reading is the calibration curve of the given voltmeter.

Standard value = ------------

% Error =

<div align="center">**Experiment No.**</div>

OBJECTIVE: Calibration of a Ammeter with a potentiometer.

APPARATUS: Potentiometer, Given Ammeter, two storage batteries, one ohm standard resistance, two rheostats (50,110ohm), a standard cell, galvanometer, two one-way key, one two-way key and connection wires.

PRECAUTIONS:
  1. The e.m.f. of the cell used in the primary circuit should be greater than the e.m.f of standard cell.
  2. All the positive terminals should be connected to the same point of the potentiometer.
  3. The calibration should be checked after few readings.
  4. Jockey should not be moved on the potentiometer wire
  5. Voltmeter should be connected in parallel.

FORMULA USED:
  The error in voltmeter reading is given by

$$I' - I = \frac{El2}{l1} - I$$

$$I' = \frac{El2}{l1} = kl_2$$

Where I' = current reading by potentiometer
  I= current reading by given ammeter
  E= E.M.F. of the standard cell.
  l_1 = length of the potentiometer wire corresponding to E.M.F. of standard cell.
  l_2 = length of the potentiometer wire corresponding to the potential difference (I') measured by potentiometer.
  k = potential gradient of the potentiometer wire

PROCEDURE:
  1. Make the electrical connections are show in fig (1).
  2. Close K_1 and insert the plug key between 'a' and 'b' terminal of key K_2.Place the jockey on the last end 'B' of the potentiometer wire. If the deflection is observed in the galvanometer, then the rheostat h (1) is adjusted to get zero deflection (null point). The adjustment of the rheostat is not changed throughout the experiment..
  3. Record the total balancing length (l_1) of the potentiometer wire. This is 1000cm for ten wire potentiometer. The EM.F. of the standard cell (E) is recorded.
  4. Now remove the plug key from the terminal between 'a' and 'b' points of key K_2 and insert it in between 'b' and 'c' terminals. Close the key K_3. Again adjust the rheostat Rh(2) [Variable point(P)] of the potential divider circuit such that the voltmeter shows a constant reading. Adjust the jockey on the potentiometer wire such that Null point in the galvanometer is obtained..
  5. Note down the total length of potentiometer wire in this case (l_2).
  6. Now repeat the above procedure again and again and record atleast 6 -8 different values of voltmeter reading I and corresponding values of l_2.
  7. Now, plot a graph between the voltmeter reading (I) along the X-axis and the corresponding error in the reading (I'- I) along Y-axis. This is the required calibration curve for the given voltmeter.

Fig

OBSERVATIONS:

Table1: Table for the calibration of potentiometer wire:

e.m.f. of the standard cell (E) = 1.0286

Length of the potentiometer wire corresponding to E.M.f. of standard cell l_1 cm.	Remark
1000	E.M.F. of standard cell E = -------------Volt Potential gradient , k = E/ l_1

Table2: Table for calibration of voltmeter:

S.No.	Ammeter reading I (amp)	Balancing length of the potentiometer wire l_2			$I' = (\frac{El2}{l1})$ $= kl_2$	(I'-I)
		No. of complete Wire	Length on sliding wire	Total l_2 in cm		
1						
2						
3						
4						
5						
6						

Calculation:

Potential gradient , k = E/ l_1 = -------------volt/cm

Now $\qquad\qquad I' = (\frac{El2}{l1})$

or $\qquad\qquad = kl_2 = $ ---------- **volt**

Make similar calculations for other reading

Draw a graph between the error (I'-I) and the Ammeter reading (I) .

RESULT: The graph so obtained by plotting the error against the Ammeter reading is the calibration curve of the given Ammeter.

Standard value = ------------

% Error =

Date:

Object: To convert a galvanometer into an ammeter of 0-3 range.

Apparatus: A galvanometer (30 -0 -30), Ammeter (0-3amp), a battery of different cell, two resistances boxes, a rheostat, two one way key. Screw gauge, wire and sand paper.

Precautions: 1.The cell used should have a constant e.m.f.
2. The length of the wire used as shunt should not be too small.
3. The ammeter should always be connected in series of the cell.

Theory: Let I_g be the current for maximum deflection in a galvanometer of resistance G. If this galvanometer is to be converted into an ammeter to measure a current I, than a shunt S is appalled across its terminal such that a current Ig flows through the galvanometer and $(I - I_g)$

$$I_g = SI / S + G$$
$$I_g (S + G) = SI$$
$$IS - I_g S = I_g.G$$
$$S (I - I_g) = I_g.G$$
$$S = I_g.g / I - I_g$$

Where I_g = nk (n is number of division in galvanometer, K is figure of merit I is the range of conversion.)

Procedure: 1. Determination of resistance of the galvanometer G half deflection method.
   (i) Draw the diagram showing the scheme the connections as shown in fig I and make the connection accordingly.
   (ii) Take out a high resistance R say 5000 ohms from the resistance box R. Close the key K_1 and adjust the value of R till the deflection is within scale and maximum in even number.
   (iii) Close the key K_2 and adjust the value of the shunt resistance S so that the deflection is reduced to half the first value. Not this deflection and the value of S.
   (iv) Repeat the experiment five times for different value of deflection.

To find the figure of merit:
   (i) Find the e.m.f of a battery by a galvanometer. Now connect the battery, the galvanometer, the resistance box and key series as shown in fig II. Take out 5000 ohms from the resistance box and than put in the key K and adjust the value of R till you get a deflection θ = 30 divisions in the galvanometer. Note the deflection θ and R.
   (ii) Take five reading by changing the deflection in galvanometer.

Observation:
Resistance of galvanometer G:

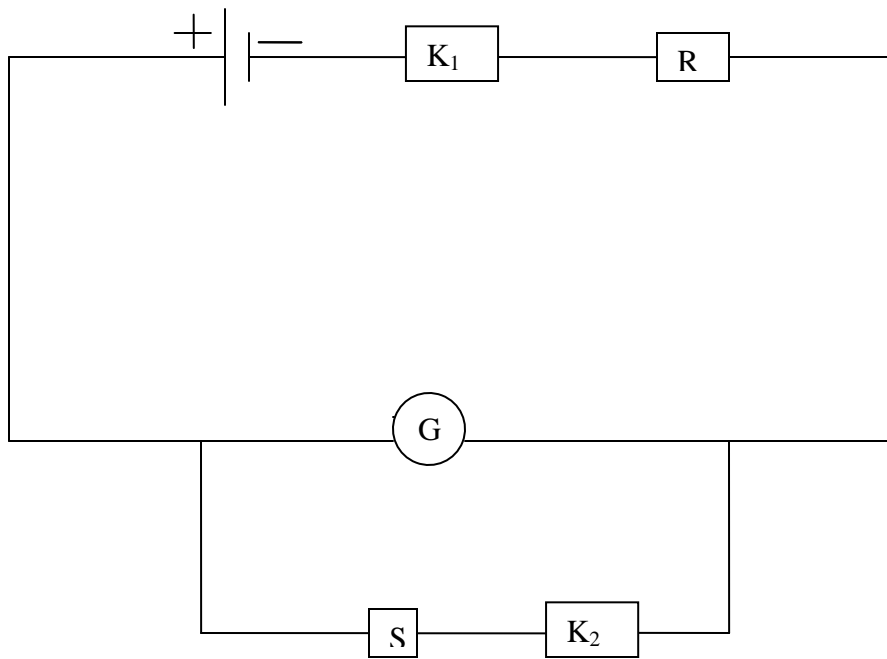| S.No.	Resistance {R} Ω	Deflection {θ}	Shunt resistance {S} Ω	Deflection $\{\frac{\theta}{2}\}$	$G = \frac{RS}{R-S}$ Ω
1.					
2.					
3.					
4.					
5.					

Fig I

Figure of merit:

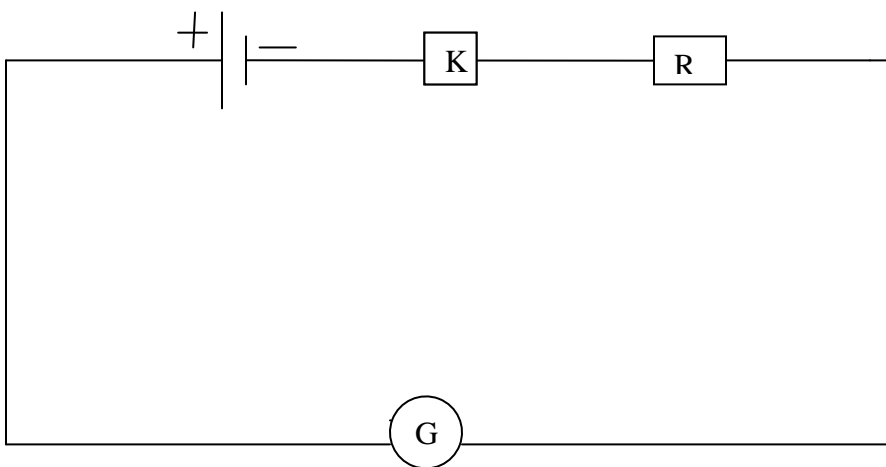| S.No.	e.m.f (V)	Resistance {R} Ω	Deflection {θ}	$K = \dfrac{E}{(R+G).\theta}$ Amp. / div.
1.				
2.				
3.				
4.				
5.				

Fig II

Calculation:

Number of division on galvanometer scale n = 30
Current for full scale deflection I_g = nk --------ampere
Range of conversion I = 3 amp

$$\text{Shunt resistance } S = \frac{G\, I_g}{I - I_g}$$

The value of S is usually very small and a resistance box of that range is not generally available in the laboratory. This low resistance is obtained by selecting wire of copper constantan eureka etc of a suitable diameter and length.

To find the length of wire: Find the diameter of the wire (if not given) of a copper wire and calculate the length of the wire which gives the required resistance. If
$\rho = 1.78 \times 10^{-6}$ ohms /cm is the specific resistance of copper and L is the length of the wire then:

$$S = \frac{\rho\, l}{A}$$

$$S = \frac{\rho\, l}{\pi r^2}$$

$$L = \frac{S \pi r^2}{\rho}$$

Verification:

(i) Cut a length of the wire 2 cms more than the calculated value. Connect the wire parallel to the converted galvanometer and battery, an ammeter, a key and a rheostat in series to the galvanometer as shown in fig III.

(ii) Put key K in and adjust the resistance from the resistance box so the galvanometer shows maximum deflection. Note the reading on the galvanometer scale and corresponding reading on the ammeter. Take 4 to 5 reading by changing deflection in the galvanometer.

(iii) Plot a graph between deflection and ammeter reading.
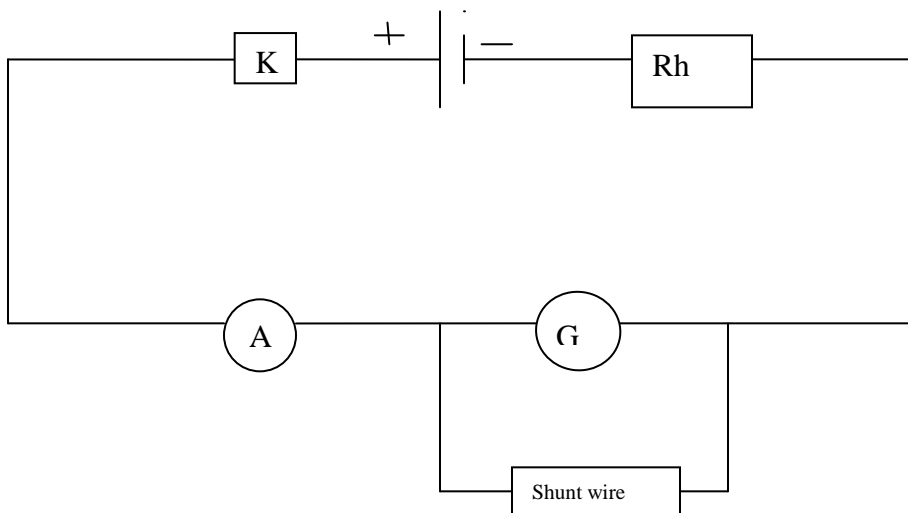
Observations: One scale division after Conversion $= \dfrac{3}{30}$ amp

S.No.	Galvanometer Reading		Ammeter reading	Difference
	Deflection	Current in amp		
1.				
2.				
3.				
4.				
5.				

Result:

Experiment No. 9B (Calibration of Voltmeter)

Date:

Object: To convert a galvanometer into a Voltmeter of 0-3 range.

Apparatus: A galvanometer (30 -0 -30), voltmeter (0-3v), a battery of different cell, two resistances boxes, a rheostat, two one way key. Screw gauge, wire and sand paper.

Precautions: **1.**The cell used should have a constant e.m.f.
2. The Resistance should be connected in series to the galvanometer.
3. The positive of the voltmeter and battery should be connected to one terminal of the rheostat.
4. The plugs of the resistance box should be tight

Theory: Let Ig be the current for maximum deflection in a galvanometer of resistance G.   If this galvanometer is to be converted into a voltmeter to measure a potential difference E, than a resistance R is placed in series with it such that the current through the galvanometer is Ig in that case:

$$I_g = \frac{E}{R+G}$$

$$R = \frac{E}{I_g - G}$$

.
Procedure: **1**. Resistance of the galvanometer G by half deflection method.
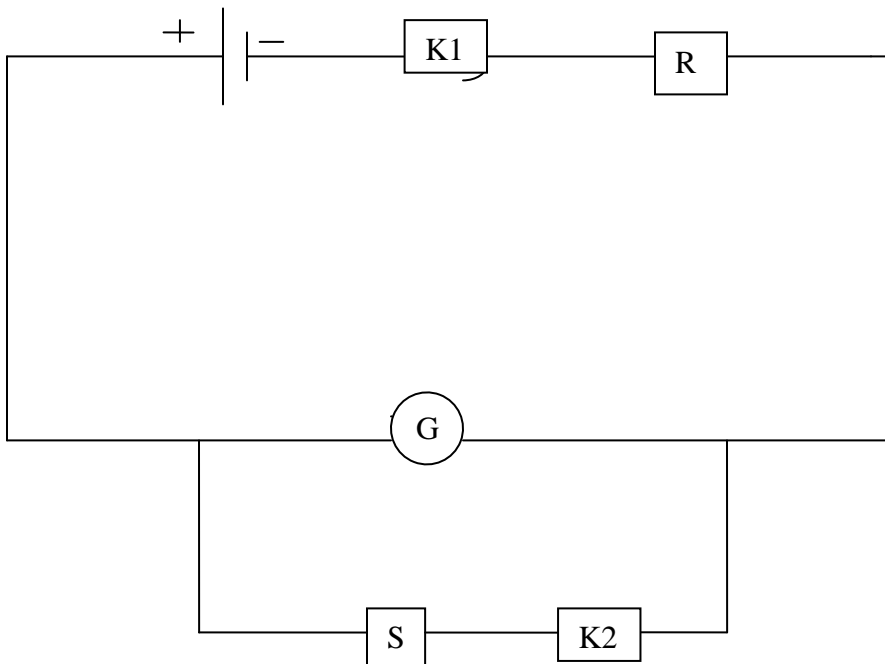

Fig I
Draw the diagram showing the scheme the connections as shown in fig I and make the connection accordingly.
        (i)   Take out a high resistance R say 5000 ohms from the resistance box R. Close the key K_1 and adjust the value of R till the deflection is within scale and maximum in even number.
        (ii)   Close the key K_2 and adjust the value of the shunt resistance S so that the deflection is reduced to half the first value. Not this deflection and the value of S.
        (iii)   Repeat the experiment five times for different value of deflection**.**

Observation:

Resistance of galvanometer G:

S.No.	Resistance {R} Ω	Deflection {θ}	Shunt resistance {S} Ω	Deflection $\{\frac{\theta}{2}\}$	$G = \dfrac{R.S}{R-S}$ Ω
1. 2. 3. 4. 5.					

To find the figure of merit:

    (i)   Find the e.m.f of a battery by a voltmeter. Now connect the battery, the galvanometer, the resistance box and key series as shown in fig II. Take out 5000 ohms from the resistance box and than put in the key K and adjust the value of R till you get a deflection θ = 30 divisions in the galvanometer. Note the deflection θ and R.

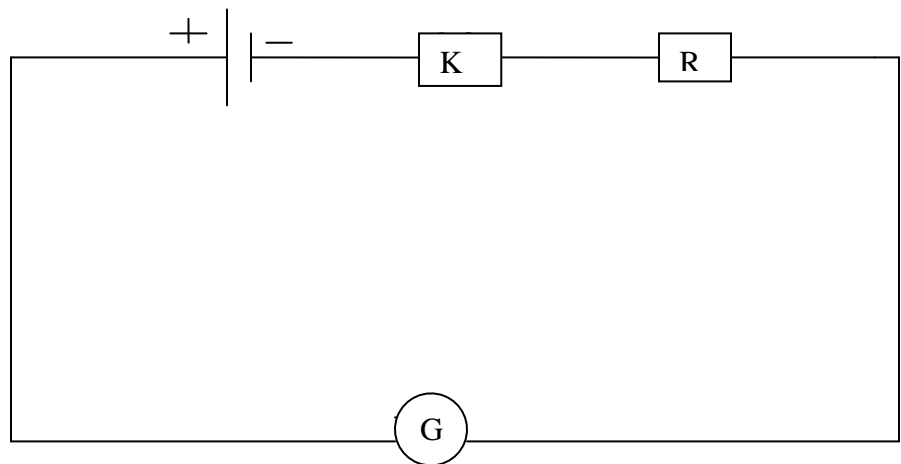   **(ii)**   Take five reading by changing the deflection in galvanometer.

Fig II

Figure of merit:

S.No.	e.m.f (V)	Resistance {R} Ω	Deflection {θ}	$K = \dfrac{E}{(R+G).\theta}$ Amp. / div.
1. 2. 3. 4. 5.				

Calculation:

        Resistance of the galvanometer = ---------ohms

        Number of division on galvanometer scale n = 30

        Current for full scale deflection I_g = nk --------ampere

        Range of conversion E = 3 volt

        Resistance to place in series with the galvanometer

$$R = \frac{E}{I_g - G}$$

Verification:

(i) Draw a diagram showing the scheme of the connection as in fig III. Connect the battery of 6 volt through a key to the fixed terminal A and B of the rheostat. Connect the galvanometer through a resistance box R between the terminal A and C of the rheostat. Also connect the positive terminal of the voltmeter to a terminal and negative to C terminal of the rheostat.

(ii) Take out a resistance equal to calculated value of R of the resistance box and keeping the moveable contact near A put in the key k. Note the reading of the galvanometer and voltmeter move the variable contact and take about 4 to5 observation by changing deflection in the galvanometer**.**

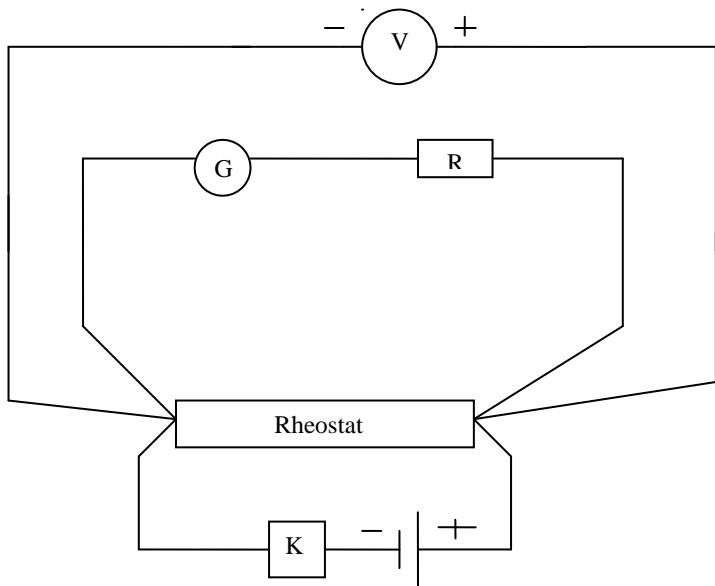**(iii)** Plot a graph between deflection and Voltmeter reading

Fig III

Observations: One scale division after Conversion $= \frac{3}{30} =$ volt

S.No.	Galvanometer Reading		Voltmeter reading	Difference
	Deflection	in volt		
1.				
2.				
3.				
4.				
5.				

Result:

<h1 align="center">Experiment 10</h1>

Object: To determine the energy band gap of semiconductor material by four probe method.

Apparatus: Probes arrangement, Sample (Ge crystal), Oven, Four probe set up, Thermometer.

Precautions:

1. The surface on which the probe rest should be uniform.
2. Do not exceed the temperature of the oven above 180^0 for safe side.
3. Semiconductor crystal with four probes is installed in the oven very carefully otherwise the crystal may damage because it is brittle.
4. Current should remain constant throughout the experiment.
5. Minimum pressure is exerted for obtaining proper electrical contacts to the chip.

Formula used: The resistivity of the semiconductor crystal given by

$$\rho = \frac{\rho_0}{G\,(W/s)}$$

Where $\rho_0 = \frac{V}{I} \times 2\pi s$

G (W/S) is the correction factor and this obtained from table for the appropriate value of (W/S) W is the thickness of the crystal S is the distance between probe V and I are the voltage and current across and through the crystal chip. The energy band gap Eg of semiconductor crystal is given by

$$Eg\ 2k\ 2.3026 \log \frac{10_\rho}{\frac{1}{T}}\ eV$$

Where K is Boltzmann constant $= 8.6 \times 10^{-5}$ eV / deg and T is temperature in Kelvin

Theory: The Four Probe Method is one of the standard and most widely used methods for the measurement of resistivity of semiconductors. The experimental arrangement is illustrated. In its useful form, the four probes are collinear. The error due to contact resistance, which is especially serious in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistances are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter),the measured value will remain unaffected. Because of pressure contacts, the arrangement is also especially useful for quick measurement on different samples or sampling different parts of the same sample.

Description of the experimental setup

1.ProbesArrangement

It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The whole –arrangement is mounted on a suitable stand and leads are provided for the voltage measurement.

2.Sample

Germanium crystal in the form of a chip

3.Oven

It is a small oven for the variation of temperature of the crystal from the room temperature to about 200°C (max.)

4.FourProbeSet-up,

The set-up consists of three units in the same cabinet.

Procedure:

1. Connect the outer pair of probes to current source through current terminal and the inner pairs to the probe voltage terminal.

2. Place the four probe arrangement in the oven and fix the thermometer in the oven through the hole.

3. Switch on the four probe set up and adjust the current to a desired value (say 8 mA) .Change the knob on the voltage side.

4. Connect the oven power supply. Rate of heating may be selected with the help of a switch low or high.

5. Switch on the power to the oven and heating will start.

6. Measure the voltage by putting the digital panel meter in voltage measuring mode and temperature (^{0}c)in thermometer.

Observations Table:

Distance between probes (S) = 0.200 cm

Thickness of the crystal (W) = 0.050 cm

Constant current (I) = 8.00mA

S.No	Temperature (0^0)	Voltage (volts)	Temperature (T in K)	ρ (ohm cm)	$\frac{1}{T} \times 10^3$	$\log_{10}\rho$
1.	20					
2.	30					
3.	40					
4.	50					
5.	60					
6.	70					
7.	80					
8.	90					
9.	100					
10.	110					
11.	120					
12.	130					
13.	140					
14.	150					
15.	160					
16.	170					
17.	180					

Table: G (W/S) function corresponding to (W/S) geometry of the crystal

S.No	W/S	G (W/S)
1.	0.100	13.863
2.	0.141	9.704
3.	0.200	6.931
4.	0.33	4.159
5.	0.500	2.780
6.	1.000	1.504
7.	1.414	1.223
8.	2.000	1.094
9.	3.333	1.0228
10.	5.000	1.0070
11.	10.000	1.00045

Calculation:

Find ρ corresponding to temperature in K using

$$\rho = \frac{\rho_0}{G\ (W/s)}$$

Where $\rho_0 = \frac{V}{I} \times 2\pi s =$ ---------ohm cm

For different 'V' calculate ρ_0 and hence ρ in ohm cm
Find {W/S} and then corresponding to this value choose the value of function
G (W/S) from the following table:

Graph

Now plot a graph for logρ versus $\frac{1}{T} \times 10^{-3}$ as shown in
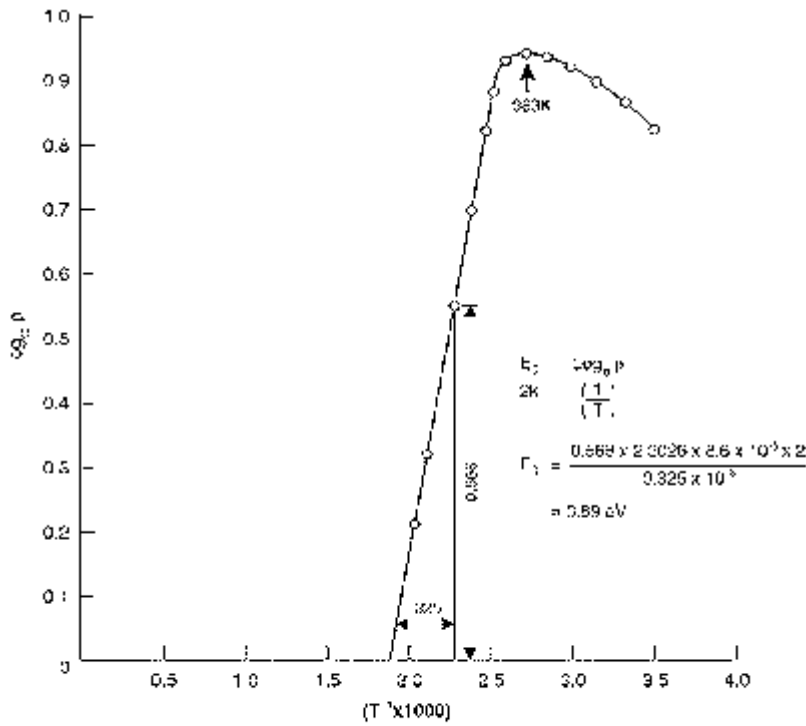
Fig. The resistivity of a Germanium crystal as a function of inverse temperature. For this sample T≈363K, conduction is due mainly to the impurity carriers (Extrinsic Region). For T>363K, conduction is due to electrons promoted to the conduction band (and the corresponding holes created in the valence band). This is the intrinsic region.

fig

Slop of the curve is $\frac{AB}{BC}$

Energy band gap Eg = 2K $\times \dfrac{2.3026 \times \log 10\, \rho}{\frac{1}{T}}$

$\quad = 2K \times 2.303 \times \dfrac{AB}{BC} \times \dfrac{1}{1000}$

$\quad = 4.606 \times 8.6 \times 10^{-5} \times \dfrac{AB}{BC} \times \dfrac{1}{1000}$

$\quad = 0.396 \times \dfrac{AB}{BC} ev$

Result: 1. Resistivity of semiconductor crystal at different temperature are shown in the graph of log 10ρ versus $\frac{1}{T} \times 10^{-3}$

2. Energy band gap o semiconductor crystal Eg = --------eV

Standard Eg : Ge = 0.72 eV
$\qquad\qquad$ Si = 1.1 eV

**Percentage error:**

<center>**Experiment No. 11**</center>

Object: To determine the Electro – Chemical Equivalent (ECE) of copper using a Tangent galvanometer.

Apparatus used: Copper voltmeter, Tangent galvanometer, Rheostat, one way key, Battery, Commutater, Stop watch, Sand paper and connecting wire.

Precautions: **1.** The maganometer box should be carefully leveled so that the magnetic needle moves freely in horizontal plane.
2. The coil should set in magnetic meridian.
3. All the magnetic materials and current carrying conductors should be at considerable distance from the apparatus.
4. The copper plate on which the deposit has to be made should be crapulously clean.
5. The deflection of the galvanometer should be kept constant with help of rheostat.
6. As far as possible the deflection should be kept as nearly equal to 45^0 as possible since under this circumstance the accuracy in measurement is at a

maximum.
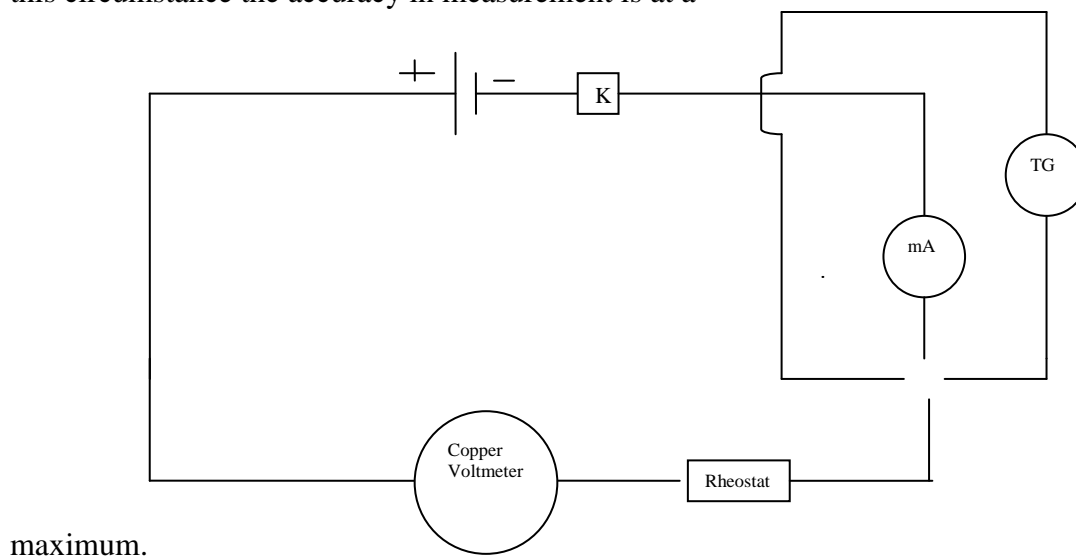
<center>Fig</center>

Formula used: Copper voltmeter it consists of a glass vessel containing 16 to 22% solution $CuSO_4$ with a few drops of sulphuric acid. The anode consists of pair of copper plates.

Faraday's Law of Electrolysis

(i)   According to first law mass deposited

$$M = Zit$$

Where Z is constant and is called the Electro – Chemical Equivalent of the substance.

$$Z = \frac{m}{It}$$

For tangent galvanometer $I = \dfrac{10rH\ \tan\theta}{2\pi n}$

$$\boxed{Z = \frac{2\pi n \cdot m}{10rH\ \tan\theta \times t}}$$

Procedure:

1. Draw a neat diagram indicating the scheme of the connections as shown in fig.
2. Clean the cathode plate with a piece of sand paper and weigh it accurately.
3. Place the coil of T.G in magnetic meridian. Rotate the compass box to make the pointer read zero-zero.
4. Suspend an extra copper plate in the copper voltmeter for the cathode and complete the circuit containing an accumulator, rheostat and an ammeter.
5. Using copper test plate as cathode, allow a current to flow in circuit and read the deflection. Now reverse the current with help of commutator and again read the deflection if the two deflections are the same then the coil are in the magnetic

meridian otherwise rotate slightly the coil till the two deflection are same. The pointer should read zero when no current is passed.

6. Using rheostat adjust the deflection (in the range 40-50).
7. Switch of the current and remove the test plate and place weighed plate as cathode.
8. Now switch on the current and immediately start stop watch. Take the deflection reading after every 5 minutes and keep it constant using rheostat. After about 20 minutes reverse the current and note the deflection .At the end of other half of time switch off the current and note down the reading of stop watch.
9. Remove the copper plate and immerse it in water and dry it and weigh it with chemical balance.
10. Measure the diameter of the coil and calculate radius by equating to $2\pi r$. Both external and internal circumference should be measured and then mean of the radius.

Observation:

Value of the field H = ----- 0.345 Oersteds
Radius of the coil (r) =-------------cm
Numbers of turns in each coil (n) =
Mass of the copper plate before deposition of copper =----------------gm
Mass of the copper plate after deposition of copper =------------------gm
Mass of copper deposited = --gm
Initial reading of stop watch =--sec
Final reading of stop watch =--sec
Total time taken =--sec

Table for the determination of θ:

S.No.	Time	Deflection of pointer for direct current		Deflection of pointer for direct current		Mean	$\tan\theta$
		Left pointer θ_1	Right pointer θ_2	Left pointer θ_1	Right pointer θ_2		
1.	5						
2.	10						
3.	15						
4.	20						
5.	25						
6.	30						

Calculation:

$$Z = \frac{2\pi n.m}{10rH \tan\theta \times t} = \text{--------------------------gms / columb}$$

Result: The E.C.E of copper = ---------------------------------------gms / columb

Standard value of E.C.E of copper = 0.000329g / columb

%error= -------------.

Object: To draw hysteresis curve (B-H curve) of a given sample of ferromagnetic material on a C.R.O. using a solenoid from this to determine the magnetic susceptibility and permeability of the given specimen.

Apparatus: C.R.O, ferromagnetic specimen, Solenoid, Hysteresis loop tracer

Formula used:

(a) Coercivity: $e_x = \frac{1}{2} \times$ Loop width = ------------------mm

$$H = \frac{G_0 \times e_x}{\{\frac{A_s}{A_c} - N\}}$$

(b) Saturation magnetization: $(e_y)_{s=\frac{1}{2}} \times$ tip to tip height =-------- -mV

$$\mu_s = \frac{J_s}{4\pi} = \frac{G_0 \, \mu_0 \, gx \, (e_y)_s}{gy\{\frac{A_s}{A_c} - N\} \times 4\pi}$$

(c) Retentivity: $(e_y)_{r=\frac{1}{2}} \times (2 \times \text{Intercept})$

$$\mu_r = \frac{J_r}{4\pi} = \frac{G_0 \, \mu_0 \, gx(e_y)_r}{\{gy\{\frac{A_s}{A_c} - N\} \times 4\pi}$$

(d) Magnetic Permeability: $\mu = B / H =$ Slop of B – H curve

Procedure: 1. Calibration: When an empty pickup coil is placed in the solenoid field, the signal e_2 will only be due to the flux linking with coil area. In this case M = 0 Area ratio $A_s/A_c = 0$, N = 0 so that H = H_a.
Hence $e_y = 0$ and $e_x = H_a / G_0$
i.e; on C.R.O it will be only a horizontally straight line representing the magnetic field H_a. From know values of H_a and corresponding magnitude of e_x we can determine G_0 and hence calibrate the instrument. The dimensions of a given sample define the values of demagnetisation factor N and the area ratio A_s / A_c pertaining the pickup coil. N can be obtained from manufacturers manual.
Now without sample adjust the oscilloscope at D.C. Time base EXT. Adjust the line in the center. Put the knob of Demagnetisation at zero and area ratio 0.40 and magnetic field 200gauss (rms).

$e_x =$ 64mm, or
= 7.0 V (if read by applying on Y input of C.R.O)

For Area ratio 1 $e_x =$ 160mm, or
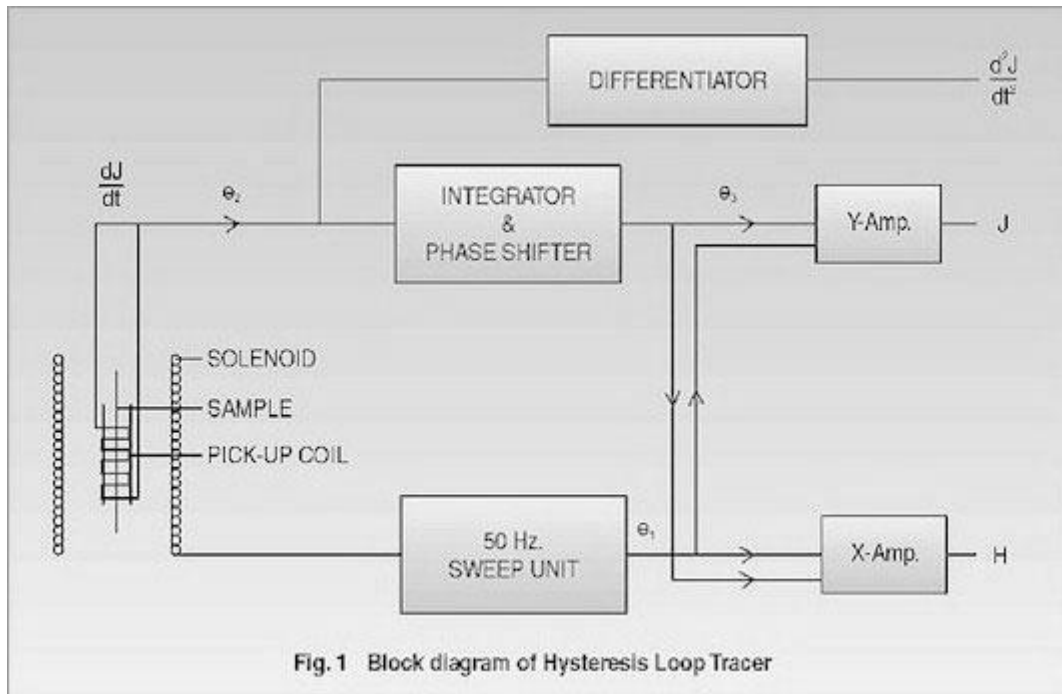= 17.5V
G_0 (rms) 200 / 160 = 1.25 gauss / mm
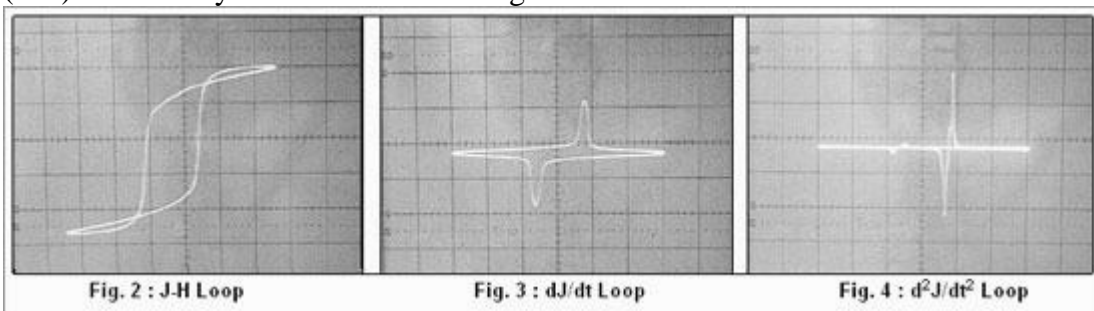G_0 (peak to peak) = 1.25 ×2.82
= 3.53 gauss / mm
also G_0 (rms) = 200 / 17.5 = 11.43 gauss / volt

$$G_0 \text{ (peak to peak)} = 11.43 \times 2.82$$
$$= 32.23 \text{ gauss / volt}$$

Fig. 1   Block diagram of Hysteresis Loop Tracer

2. Now adjust the knob of magnetic field in the hysteresis loop tracer to minimum value say 30Gauss. Note down the loop width in mm, Tip to tip height (mV) as shown in fig.
3. Increase the magnetic field and note down the corresponding loop width, Tip to tip height (mV). In this way take about 7-8 readings.

Fig. 2 : J-H Loop   Fig. 3 : dJ/dt Loop   Fig. 4 : d^2J/dt^2 Loop

B Flux Density

Saturation

Retentivity

Coercivity

−H
Magnetizing Force
In Opposite Direction

H
Magnetizing Force

Saturation
In Opposite Direction
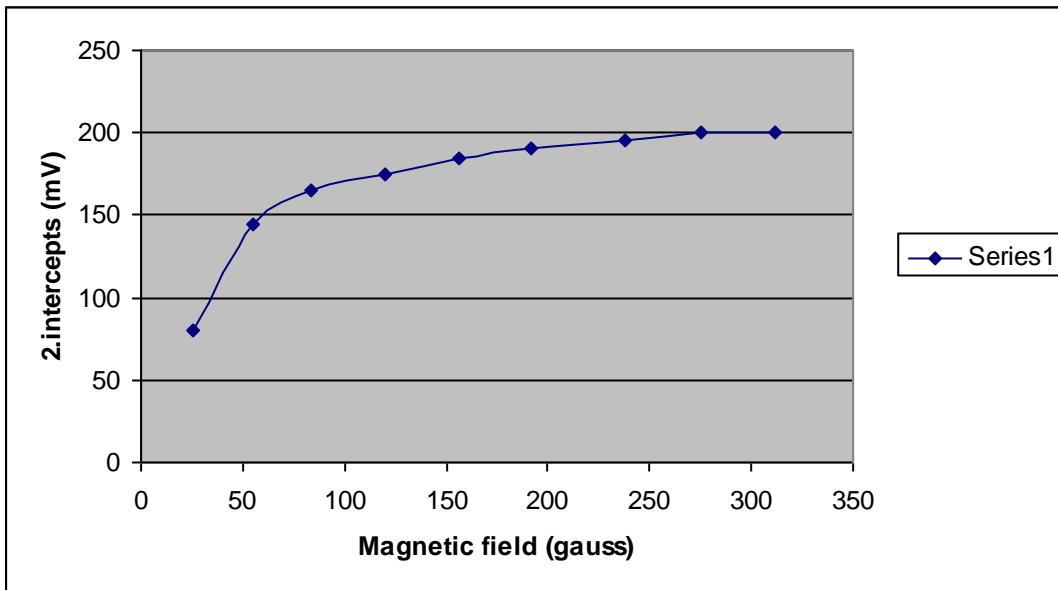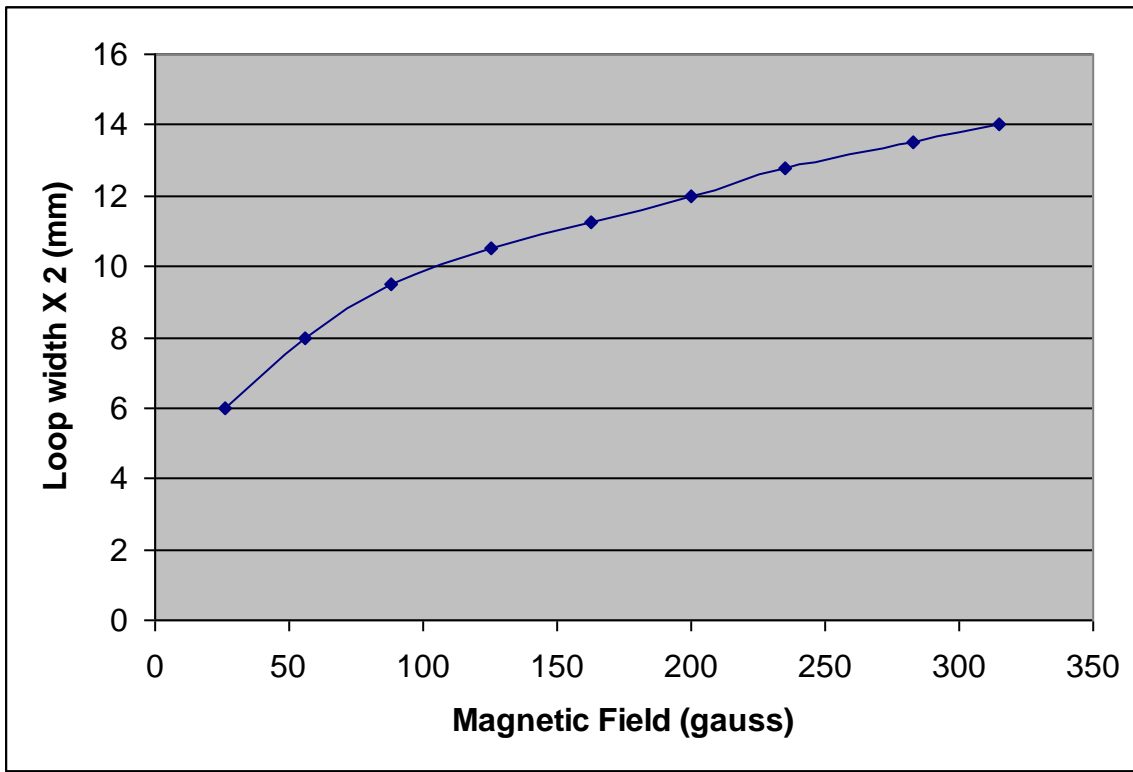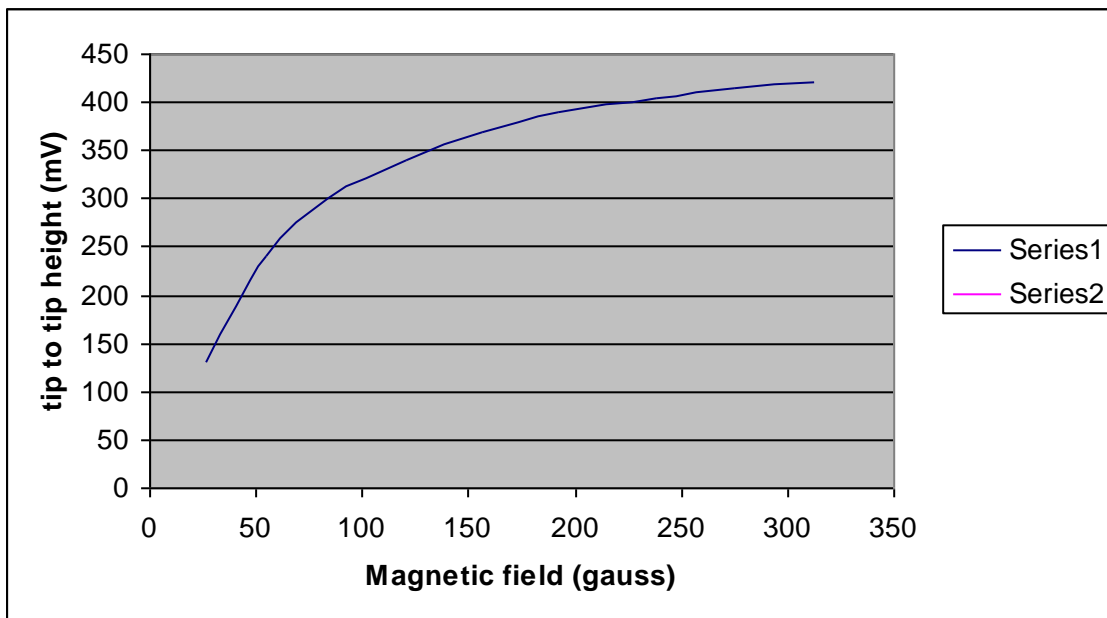
Flux Density
−B In Opposite Direction
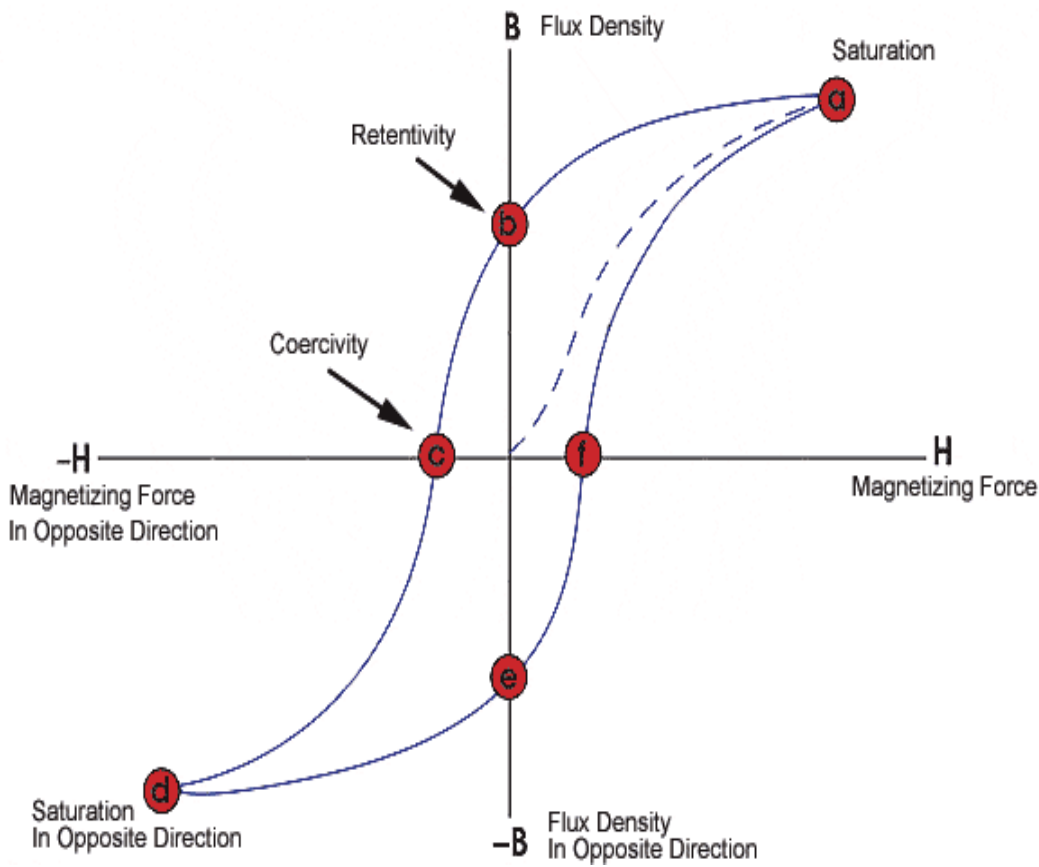
4. Plot the graph for loop width, intercept and saturation position against magnetic field.
5. From these values coercivity, retentivity, saturation magnetization magnetic permeability, can be calculated.

Observation: **1.** Diameter of pickup coil (Given by manufacturer) = 3.21mm
2. Total gain of X and Y amplifier g_x = 100
3. Gain of Y amplifier g_y = 1
4. Length of sample = 39mm
5. Diameter of sample = 1.17mm
6. Area ratio = $\dfrac{A_s}{A_c}$ = 0.133 × 30 = 3.99
7. Demagnetisation factor N = 0.0029 × 30 = 0.087

Observation table:

S.No	Magnetic field (Gauss)	Loop width (mm)	Tip to tip height (mV)	2 × Intercept (mV)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

fig

Calculation:

  From the graph

        Loop width = ---------------mm
        Tip to tip height = ---------mV
        2× intercept = --------------mV

(a) Coercivity: $e_x = \frac{1}{2} \times$ Loop width = ---------------------mm

$$H = \frac{G_0 \times e_x}{\left[\frac{A_s}{A_c} - N\right]}$$

(b) Saturation magnetization: $(e_y)_{s=\frac{1}{2}} \times$ tip to tip height =---------mV

$$\mu_s = \frac{J_s}{4\pi} = \frac{G_0 \, \mu_0 \, g_x \, (e_y)_s}{g_y \left\{\frac{A_s}{A_c} - N\right\} \times 4\pi}$$

(c) Retentivity: $(e_y)_{r=\frac{1}{2}} \times (2 \times \text{Intercept})$

$$\mu_r = \frac{J_r}{4\pi} = \frac{G_0 \, \mu_0 \, gx\left(e_y\right)_r}{\{gy\{\frac{A_s}{A_c} - N\} \times 4\pi}$$

(d) Magnetic Permeability: $\mu = \frac{B}{H} = \text{Slop of B} - \text{H curve}$

Result:

Experiment No. 14

OBJECT :   To determine the coefficient of viscosity of water, by poiseuille's method.

APPARATUS: A Capillary tube of uniform bore and a constant level reservoir fitted on a board, a manometer, stop watch and graduated jar.

PRECAUTIONS:

1.   The tube should be placed horizontally to avoid the effect of gravity.
2.   The value of h should not be made large and should be so adjusted that the water comes out as a streamline flow.
3.   The radius should be measured very accurately as it occurs in fourth power in the formula.
4.   The Pressure difference should be kept small to obtain streamline motion

**FORMULA USED:** The coefficient of Viscosity of a liquid is given by the formula

$$\eta = \frac{\pi\, \mathrm{P} r^4}{8Vl} = \frac{\pi h \rho g r^4}{8Vl}\ Poise\ or\ Kg\,/(m-\sec)$$

Where r   =   radius of capillary tube

V   =   volume of water collected per second

l   =   length of the capillary tube

ρ =   density of liquid ($\rho = 1.00 \times 10^3$ kg / m^3 for water)

h   =   difference of levels in manometer
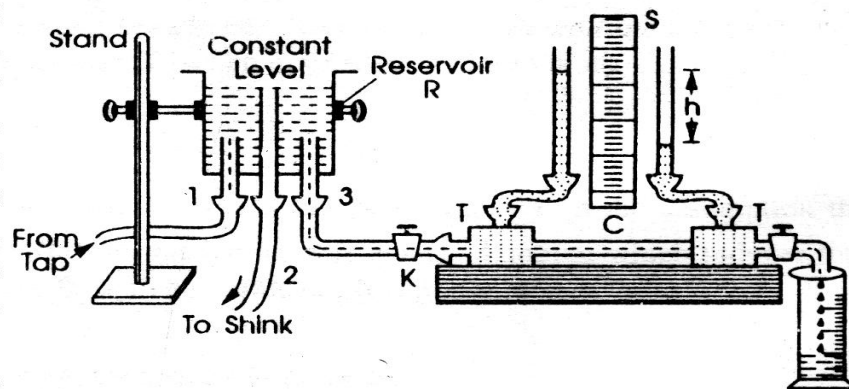
PROCEDURE:

1.   Allow the water to enter the constant level reservoir through tube (1) and leave through tube (2) in such a way that water comes drop by drop from the capillary tube. This is adjusted with the help of pinch cock K. It should be remembered that all the bubbles should be removed from the capillary.

2.   When every thing is steady collect the 10ml water in a graduated jar and note down the time taken and thus calculate the volume V of the water flowing per second.

3.   Note the difference of the level of water in manometer. This gives h.

4.   Vary h by raising or lowering the reservoir. For each value of h, find the value of V.

5.   Measure the length and diameter of the tube.

6.   Plot graph h vs v & find its slop.
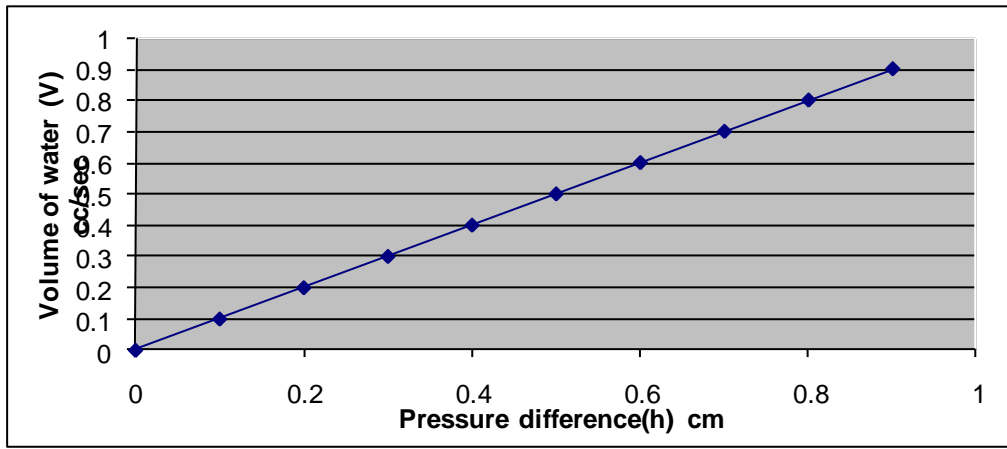
OBSERVATIONS:

Room Temperature= --------- °C

Sl.	Manometer Reading		Pressure Difference h (meter)	Measurement of V		$V= \dfrac{meter^3}{Sec.}$
	One end (meter)	Other end (meter)		Total volume of water Collected meter ^{3}	Time t Sec.	

Mean (h/v)=

Temperature of water   = ------------°c
Length of capillary tube   = -----------cm. = ----------------meter.
Radius of capillary tube(r) = -----------cm. = ----------------meter.

CALCULATIONS:

The coefficient of viscosity η for water is given by;

$$\eta = \frac{\pi \rho g r^4}{8l}(h/v)$$

**RESULT:** The coefficient of viscosity of water at --------------------°c = ----------------Poise

Experiment No. 15

Object: To study the Hall coefficient and to determine. Hall coefficient (R_H) Carrier Density (n) and carrier Mobility (μ) of a given semiconductor material Hall Effect set up.

Apparatus: Hall probe, Hall Effect set up (Digital milivoltmeter), Electromagnet, Constant current power supply, Digital gauss meter.

Precaution: 1. The Hall probe is placed between the pole pieces (in magnetic field) such that maximum Hall voltage is generated.

2. Current through the Hall probe should be strictly within the limit as mentioned by the manufacturer.

3. Hall voltage developed must be measured very accurately.

4. Magnetic field is varied gradually in steps to avoid damage to the electromagnetic coils.
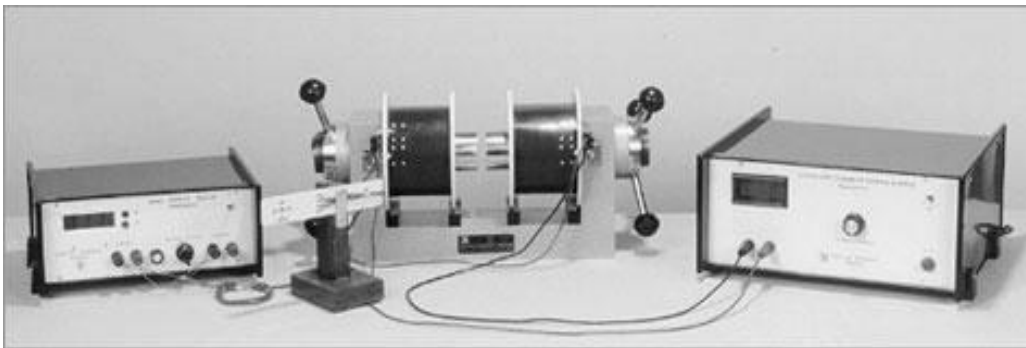
Formula used:

(i) Hall coefficient $R_H = \dfrac{V_H.Z}{I.H_Z} \, volt \, cmA^{-1}G^{-1} = \dfrac{V_H.Z}{I.H_Z} \times 10^8 cm^3$ / Coulomb

        Where V_H is in volt, I in amperes, Z in cm and H_Z in gauss

(ii)Carrier density $n = \dfrac{1}{R_H.q} cm^{-3}$ (where q = electronic charge = 1.6×10^{-19} C)

(iii)Carrier mobility $\mu = R_H \, \sigma \, cm^2$/ volt-sec ($\sigma$ for Ge = 0.1 coul/ volt sec cm)

Procedure: **1.** Connect the widthwise contacts of the Hall probe (with Ge crystal) to the voltage terminal lengthwise contacts terminal of the Hall Effect set-up.

2. Now switch 'ON' the Hall Effect set-up and adjust the current to a few mA.

3. Check the 'Zero field potential' by changing the knob to the voltage side. This voltage is error voltage and should be subtracted from the Hall voltage reading. (when Hall probe is outside the magnetic field).

4. Now place the Hall probe in the magnetic field as shown in fig. This Hall probe must be fitted in the magnetic field so that Hall probe becomes perpendicular to magnetic field.

5. Switch on the electromagnet power supply by connecting the pole pieces to the power supply.

6. Now place the Hall probe (In As) attached with Gauss meter between the pole pieces to measure the magnetic field.

7. Measure the Hall voltage as a function of current keeping the magnetic field constant.

8. Measure the Hall voltage as a function of current of magnetic field keeping a suitable value of current as constant (this is done by placing two probes between the pole pieces and decrease the spacing between the pole pieces and measure the magnetic field and Hall voltage).

9. Plot the graph between V_H and I (H_Z = constant) V_H and H (I = constant)

10. Calculate the slopes V_H / I and V_H / H_Z from the two graphs and calculate Hall coefficient in two ways and determine the mean value.

Observations:

Thickness of the semiconductor crystal Z = 0.50 mm

Conductivity σ = 0.1 cm/ohm for p-type ; 0.2 cm / ohm for n type

Table 1:

Magnetic field Hz = -------------------------Gauss

S.No.	Current I (mA)	Hall voltage V_H (mV)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Table 2:

Current I = -------------------------mA

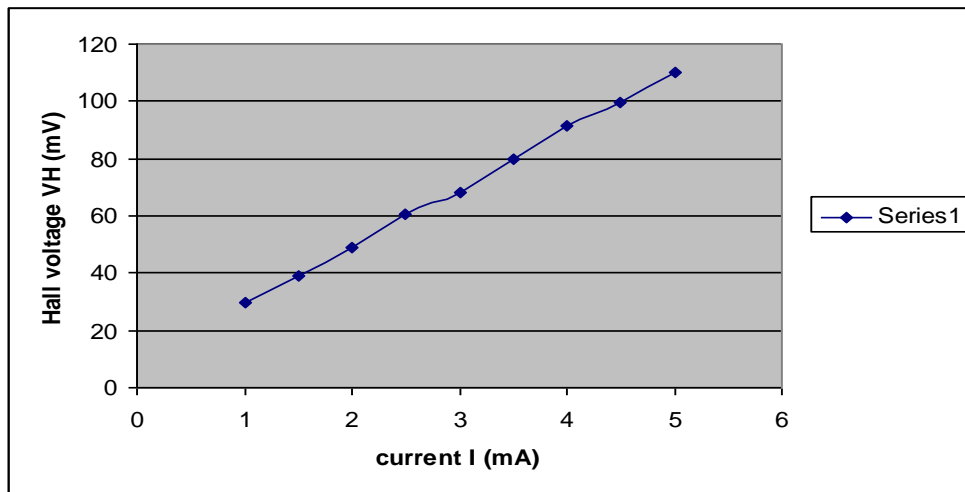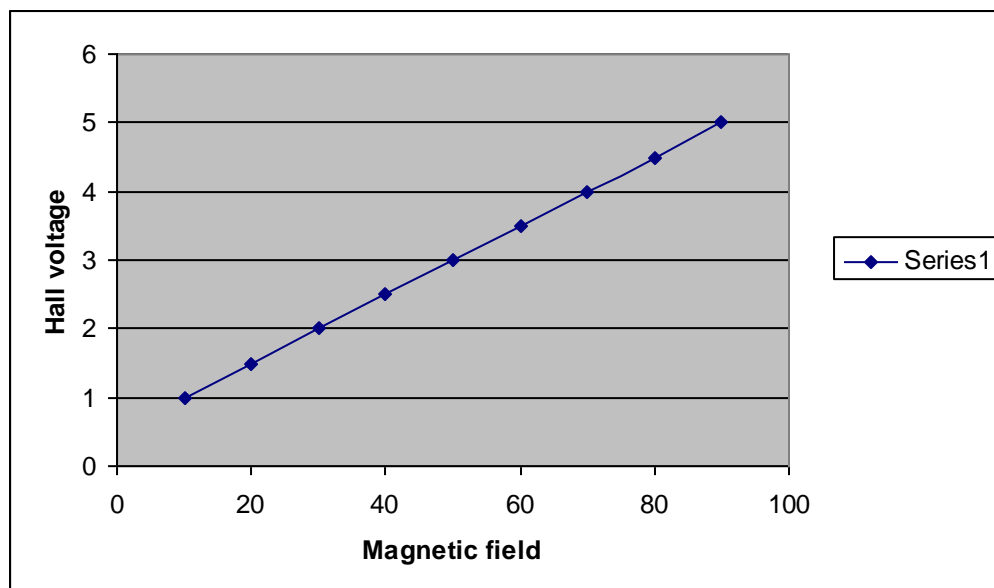| S.No.	Magnetic field Hz (Gauss)	Hall voltage V_H (mV)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Fig 1

Fig 2

Calculation:

$$\text{Slope } \frac{V_H}{I} = \frac{AB}{BC} \quad\quad \textbf{(Fig 1)}$$

$$\text{Slope } \frac{V_H}{H_Z} = \frac{AB}{BC} \quad\quad \textbf{(Fig 2)}$$

(i) $R_{H1} = \{\textbf{Slope } \frac{V_H}{I}\} \times \frac{Z}{H_Z} = \quad\quad$ volt cmA^{-1}G^{-1} $_=\quad \times 10^8$ cm^3/coulomb

$R_{H2} = \{\textbf{Slope } \frac{V_H}{H_Z}\} \times \frac{Z}{I} = \quad\quad$ volt cmA^{-1}G^{-1} $_=\quad \times 10^8$ cm^3/coulomb

Mean $R_H = \frac{R_{H1}+R_{H2}}{2} = \quad\quad$ cm^3/coulomb

(ii) Carrier density $= \frac{1}{R_{H}.q}$ cm^{-3}

(iii) Carrier mobility $= R_H \, \sigma$ cm^2/ volt-sec

Result: The value of Hall Coefficient R_H is $\quad\quad$ cm^3/coulomb. The carrier density $\quad$ /cm^3 and carrier mobility of charge carriers is found to be $\quad$ cm^2/volt sec

Hall Probe (Ge Crystal) # 3825

Specification of the material

Crystal : p type lightly doped

Hall coefficient : 15.1×10^3 cm^3 coulomb^{-1}

Carrier Mobility : 25.2×10^2 cm^2.volt^{-1}.sec^{-1}

Carrier density : 4.1×10^{14} cm^{-3}

Resistivity : ≈ 6 ohm.cm

Hall Probe (Ge Crystal) # 3903

Specification of the material

Crystal : n- type lightly doped

Hall coefficient : 19.8×10^3 cm^3 coulomb^{-1}

Carrier Mobility : 33.0×10^2 cm^2.volt^{-1}.sec^{-1}

Carrier density : 3.1×10^{14} cm^{-3}

Resistivity : ≈ 6 ohm.cm

Date:

<div align="center">

EXPERIMENT No.
</div>

OBJECT: To study the transient nature of a RC circuit and hence to measure the changing current over time**.**

APPRATUS: Charging and discharging circuit board with resistance and capacitances, digital stop clock, connecting wire, power supply (voltage source) .

THEORY: A capacitor is changed by a resistor. The current is measured as a function of time and the effects of capacitances, resistance and voltage applied are determined.
The variation of current with time, I (t) when a capacitor 'C' is changed is determined by the equation

$$I(t) = I_0\, e^{-t/RC} \text{ ----------------------------- (1)}$$

Where I_0 denotes the

PROCEDURE:
1. Make the circuit for charging a capacitor as shown in fig 1.
2. For different values of capacitances keeping constant measure the value of current variation with time (table 1).
3. Plot I vs t and log I vs t as shown in figure 2&3 for all the values of capacitances.
4. From the above two plots it is clear that I_0 does not depend on C as all the curves begin at the same current values. The function takes the general form

$$I(t) = I_0(U, R)\, e^{-\alpha(U, R, C).t}$$

5. In order to investigate the dependence of the exponent on the capacitance, slop of all the straight capacitance on a log - log sidle. (fig 4).
6. From fig 4, the slop of straight line is calculated which is ≈ -1

$$I(t) = I_0(U, R)\, e^{-\alpha(U, R)/C.t}$$

7. Now for a constant value of U &C, for different values of R, again the capacitor is observation (table 2).
8. Plot I vs t; log I vs t as plotted above for different values of 'R' [fig 5& fig 6].
9. In order to investigate the dependence of the exponent on the resistance, slop of all straight lines in fig 6 are plotted against 'R' on a log – log scale.[fig 7]
10. From fig 7, the slope of straight line is calculated ≈ -1

$$I(t) = I_0(U, R)\, e^{-\alpha''(U)/RC.t}$$

11. Plot I_0 vs R, for different values of R. The slop of the graph. [fig 8]

$$\approx -1$$
$$I_0 = \beta(U)/R$$

12. In order to investigate the dependence of exponent & I_0 on 'U', measure I with time for constant 'R' & 'C' but different values of 'U' plot log I vs t .(fig 9)
13. All straight lines in fig 9 have same slop. Thus exponent is independent of voltage U. Slope of straight line can be calculated

$$\text{Slop } m = 1/RC \quad RC = \text{-----------s.}$$

14. The starting current values I_0 for measured values in fig 9 are plotted against voltage 'V' (fig 10)

$$\text{Slope} = 1/R \qquad R = \text{-----------} \ \Omega$$

!5. From above the equation

$$I(t) = I_0\, e^{-t/RC}$$

Can be (verified**)**

OBSERVATION TABLE:

Table: 1 Draw this table for different 'C' values

Time	C₁		C₂		C₃	
	I (t) (μA)	Log I	I (t) (μA)	Log I	I (t) (μA)	Log I

Table: 2 For different 'R' values

Time	R₁		R₂		R₃		R₄	
	I	Log I	I	Log I	I	Log I	I	Log I

Table: 3 For Different values of 'V' (voltage)

Time	V₁		V₂		V₃		RV₄	
	I (t)	Log I(t)	I (t)	Log I(t)	I (t)	Log I (t)	I (t)	Log I (t)

RESULT: The current variation with time for the given RC circuit is
   I (t) = ----------------

Date:

<p align="center">**EXPERIMENT No.**</p>

OBJECT:

To determine the wavelength of a given laser source using diffraction grating.

APPARATUS:

Laser source (He-Ne laser or red diode laser) with its holder diffraction grating with its mount microscope objective (MO) with its hoder (mount), millimeter graph sheet to be used as screen, optical bench.

FORMULA USED:

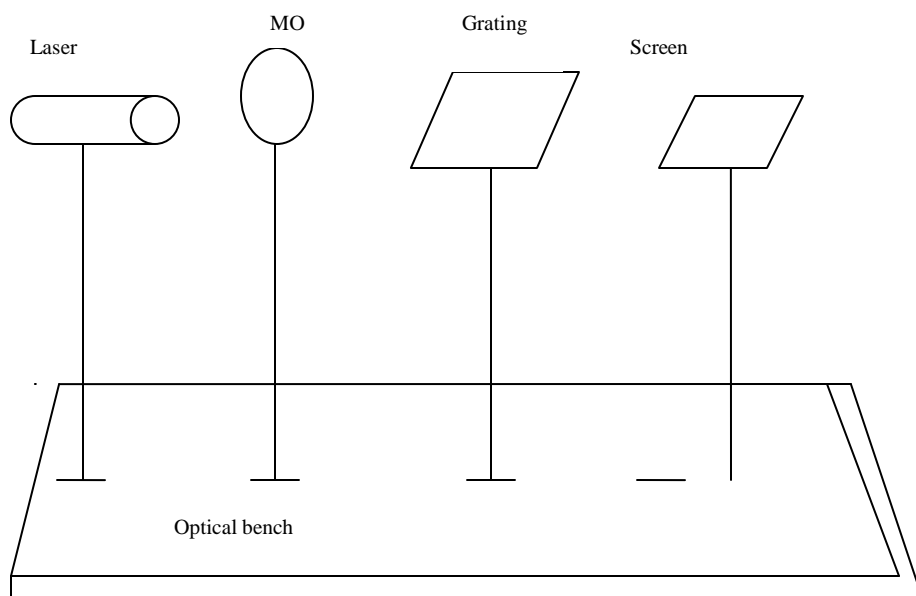The wavelength λ of the given laser source is

$$\lambda = \sin\theta / n\,N$$

θ = angle of diffraction
n = order of diffraction
N = the number of line per inch on the grating

PROCEDURE:

Experiment set up is show in fig

1. Laser source, MO grating and screen are mounted so as to be in a line.
2. Diffraction pattern as spots will be visible on the screen.
3. The brightest spot is the central maxima, on both side of which are other spots of diminishing intensity corresponding to different orders of diffraction.

Number of lines per inch on the grating. N = ------------ If y be the distance between n^{th} order maxima and the central maxima then

$$\sin\theta = \theta = y/x \text{ red} = 180/\pi \times y/x \text{ deg}$$

Where ,x is the distance between screen and grating. Coppy diffraction spots on a trace paper from the screen. From this measure y. The other way to use millimeter graph on screen which will directly give the value of y in mm.

OBSERVATION TABLE:

S.No.	Order of maxima n	y in mm	x in mm	Sinθ =180/π ×y/x
1				
2				
3				

CALCULATION:

$$\lambda = \sin\theta / n \, N \text{ ------------------Å}$$

for different sets and take mean

RESULT:

The wavelength of given laser source λ = ---------- Å

Date:

Experiment No.

OBJECTIVE:
To study polarization of light using the He-Ne laser.

APPARATUS:
He-Ne laser, polarization, analyzer, detector, power meters, optical bench, etc.

PRECAUTIONS:
1. Beam should be along the axis of Polaroid.
2. Good quality laser beam should be used.
3. Power supply should be continuous.
4. There should be dark room for this experiment.
5. No obstacle should lie in the path of beam.

FORMULA USED:
The Malus law is used, to determine the optic polarization intensity (I).
$$I = I_0 \cos^2 \theta$$
Where I_0 is the maximum intensity. θ is the position of the axis of analyzer.

THEORY:

When an electromagnetic wave is propagating in direction then its electric and magnetic field vectors will be x-y plane, this unpolarised wave. If it is passed through a polarizer then its electric vector will be confined along a direction, e.g. for a polarized beam in y-direction polarizer is to be placed with its polarization axis along y-axis. The beam thus emerged from the polarizer can be analysed by placing another polarizer in its path, this is called analyzer. It is noted that if the analyzer is rotated in x-y plane then:
(i) The intensity will be maximum (I_0) when the polarization axis of the analyzer coincides with that of the polarizer and minimum (or zero) when the two axes are crossed.
(ii) For any other position of the axis of the analyzer (θ) with respect to the axis of polarizer, the optic polarization intensity (I) will follow the relation, called Malus law.

$$I = I_0 \cos^2 \theta$$
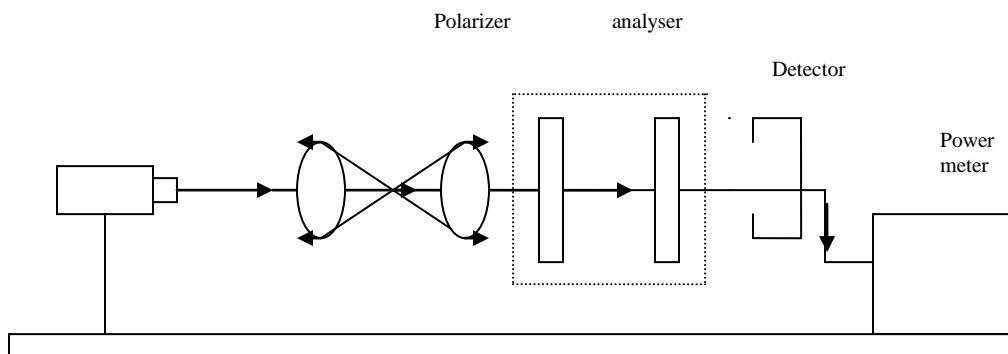
Fig

PROCEDURE:
1. Light from laser source is focused on to a pin hole by lens − 1 and the pin hole is placed at the focus of lens -2. Thus, a parallel extended beam falls on the polarizer.
2. Polariser and analyzer are suitably placed in this expanded beam.
3. The power meter and detector are fitted to the light energy emerging from the second polarizer (called analyzer). Analyser is rotated in steps of 10^0 from the position of transmission direction and optic polarization of power meter is read for all orientations between 0^0 and 180^0.
4. Now rotate the analyzer to get the maximum intensity I_0.

OBSERVATIONS TABLE:

Maximum intensity I_0

S.No.	Analyser Rotation- θ (degree)	Power Meter Reading	$I_0 \cos^2 \theta$

CALCULATIONS:

The validity of Malus law can be verified by plotting a graph between θ and I

RESULT: The Malus law is verified

MAHARAJA AGARSAIN INSTITUTE OF TECHNOLOGY

Safety Rules

- Obey all the instruction given by Laboratory Asstt./Faculty member /any other authority of institute.

- Do not play / touch live wire.

- Do not break any glass material.

- Do not touch sharp edged materials.

- Do not see Laser source directly.

- Do not plays with such items i.e meter scale, wires, lenses, etc

- Do not put your bags on experimental table which can be kept at proper place.