Applied Physics Lab Manual

I/IV B.Tech (AI&DS, CSE, ECE, EEE & IT Branches)

R20 Regulation

SIR C R R COLLEGE OF ENGINEERING, ELURU
(Permanently affiliated to JNTUK, Kakinada)

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APPLIED PHYSICS LAB

BRACHES:AI&DS, CSE, ECE, EEE & IT

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List of Experiments

1. Determination of thickness of thin object by wedge method.
2. Determination of radius of curvature of a given plano convex lens by Newton’s rings.
3. Determination of wavelengths of different spectral lines in mercury spectrum using diffraction grating in normal incidence configuration.
4. Determination of dispersive power of the prism.
5. Determination of dielectric constant using charging and discharging method.
6. Determination of numerical aperture and acceptance angle of an optical fiber.
7. Determination of wavelength of Laser light using diffraction grating.
8. To determine the energy gap of a semiconductor using p-n junction diode
9. Magnetic field along the axis of a current carrying circular coil by Stewart & Gee’s Method
10. Measurement of resistance of a semiconductor with varying temperature.

AIR WEDGE

Aim of this experiments is to determine the thickness of the given paper piece using interference due to wedge shaped air film.

Introduction : **The apparatus mainly used here are travelling microscope, sodium vapour lamp (monochromatic source of light), a glass plate fixed to a stand, black paper or cloth and two optically plane glass plates of the same size. The experimental arrangement is shown in the figure.**

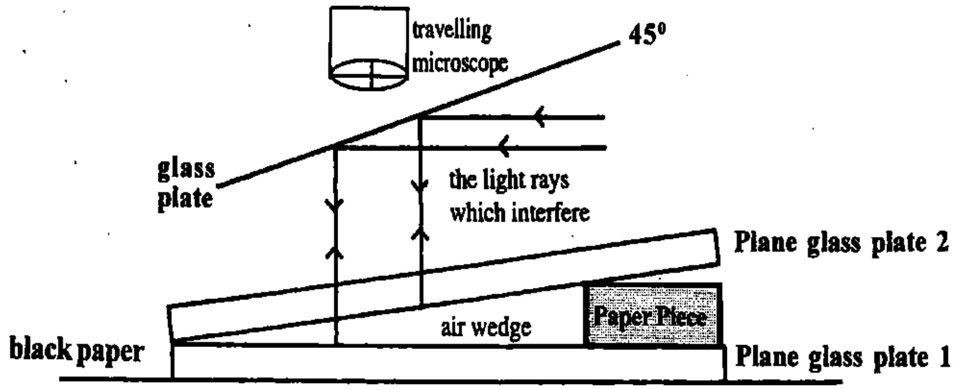


Fig. 1 Experimental Set up for air wedge

Theory : Two plane glass plates are kept at small angle forming a wedge by keeping the thin paper at one end. Let L be the length of wedge and T be its thickness of the paper piece. Let x_m and x_n be the distances from the edge corresponding to the m^{th} and nth dark fringes. Let y_m and y_n be the corresponding thickness of the air film.

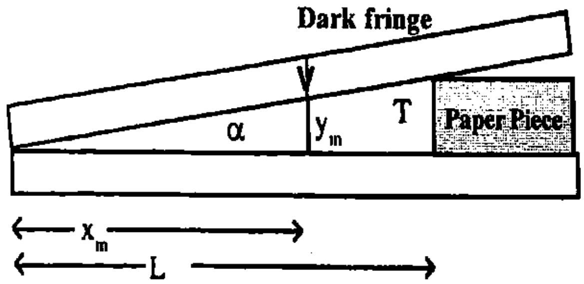


Fig.2 Length of air wedge

According to theory of interference, the condition for obtaining dark fringes is $2y_n=\left(n+\frac{1}{2}\right)\lambda$. Corresponding to the mth dark fringe, $2y_m=\left(m+\frac{1}{2}\right)\lambda$. Let α be the wedge angle.

$$\tan\alpha = \frac{y_m}{x_m}=\frac{y_n}{x_n}=\frac{y_m-y_n}{x_m-x_n}=\frac{T}{L}$$

$$2(y_m-y_n) = (m-n)\lambda$$

$$y_m-y_n = (m-n)\frac{\lambda}{2}$$

If β is the fringe width

$$x_m-x_n=(m-n)\beta$$

$$\frac{y_m-y_n}{x_m-x_n}=\frac{(m-n)\frac{\lambda}{2}}{(m-n)\beta}=\frac{\lambda}{2\beta}, \qquad \tan\alpha=\frac{T}{L}=\frac{\lambda}{2\beta}$$

The thickness of the paper T is given by

$$T=\frac{\lambda L}{2\beta}$$

λ =wavelength of the monochromatic light

L =distance of wedge from the edge of the glass plate

β = fringe width

Procedure :

1. The least count of the travelling microscope is to be determined. The two glass plates are cleaned well with a lens cleaning paper. One glass plate is placed over a blackpaper under the microscope and is focussed. This was done by taking a small piece of graph paper and it was placed on the glass plate. When microscope is focussed, the magnified image of the lines of graph paper should be clearly seen.
2. Form the air wedge by keeping the second glass plate over the first glass plate with the given paper piece at on one end between the two plates. A glass plate is fixed to a stand and is fixed to a stand and is placed at 45^0 to the horizontal so that the light from the sodium vapour lamp falls normally on the glass plate system. Parallel straight fringes are formed and are observed through the microscope placed above it.
3. Take any one of the fringes as the zeroth fringe and coincide the one of the cross-wire parallel to the fringes system. Measure the positions of 0^{th}, 5^{th}, 10^{th}, 15^{th} .... fringes etc., Tabulate the results as shown in the table. Also find the length of the air wedge using the travelling microscope.
4. Since the locus of all points having the same path difference happen to be a straight line, one gets parallel to the fringes. At times one gets fringes inclined to the edge. This is due to adhesion of dust particles the edge of the plates or irregularities at the edge gives rise to improper inclination.
5. Certain fringes expected to be straight lines appear curved. It is due to strains built up inside the glass plates. Any glass plate under strain can give rise to variation in refractive index which gives rise to change in the shape of the fringe. This can be used for studying the planeness and strainfree nature of glass plates.

Table-1 : Least Count = $\dfrac{\text{1 Main Scale Division Value}}{\text{No. of Vernier Scale Division}}$ = Cm.

S. No	Microscope readings								Width of the air wedge (P~Q)
	At the edge of two plates				At the edge of paper peice				
	MSR (cm)	VC	VC x LC (cm)	TR(P) (cm)	MSR (cm)	VC	VC x LC (cm)	TR(Q) (cm)	(cm)

Table-2 :

S. No	Fringe No.	Microscope readings				Width of 5 fringes (cm)	Single fringe width (cm)
		MSR (cm)	VC	VC x LC (cm)	TR (cm)		
1	0				A	A~B	
2	5				B	B~C	
3	10				C	C~D	
4	15				D	D~E	
5	20				E	E~F	
6	25				F	F~G	
7	30				G	G-H	
8	35				H	H-1	
9	40				I	I-J	
10	45				J	J-K	
11	50				K	K-L	

Average Fringe width β_{avg} = ________ Cm.

Observations :

Least Count of the travelling Microscope	=	cm.
Length of the airwedge (L)	=	cm.
Single fringe width (β)	=	cm.
Wavelength of monochromatic source of light(λ)	=	cm.

Thickness of the given paper (T) = $\frac{\lambda L}{2\beta}$ = cm.

Report :

Thickness of the given thin paper T = cm. (from observations)

NEWTON'S RINGS

Aim of this experiment is to determine the radius of curvature of given lens by forming Newton's rings.

Introduction : Apparatus mainly used here are travelling microscope, sodium vapour lamp (monochromatic source of light), a glass plate fixed to a stand, black paper or cloth, plane glass plate and the given lens. The experimental arrangement is shown in the following figure.

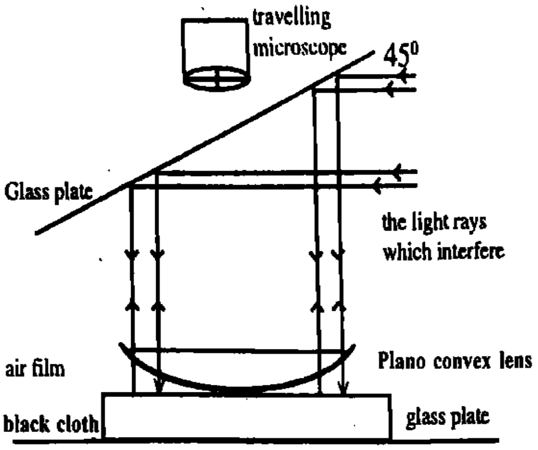


Fig. 1 Experiemental Setup Newton's Rings

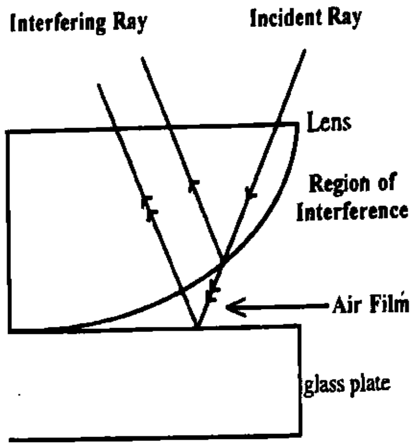


Fig. 2 Ray Diagram

Newtons rings with central dark.

Fig. 3

Theory : Newton's rings experiment is an example for interference of light by the division of amplitude in reflected light. According to theory of Newton's rings, the radius of mth dark ring is given by

$r_m = \sqrt{m\lambda R}$ where m=0,1,2,................(number of ring)

R=radius of curvature of the given lens

λ=wave length of the monochromic source of light.

The diameter of the mth dark ring is given by

$$D_m = 2\sqrt{m\lambda R} \Rightarrow D_m^2 = 4m\lambda R$$

The diameter of the nth dark ring is given by $D_n^2 = 4n\lambda R$

$$\therefore D_m^2 - D_n^2 = 4m\lambda R - 4n\lambda R$$

$$D_m^2 - D_n^2 = 4\lambda(m-n)R$$

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

Procedure :

1. The least count of the travelling microscope is found. The plane glass plate and the lens are cleaned well with a lens cleaning paper. The plane glass plate is placed over black paper under the microscope and is focussed. This is done by taking a small piece of graph paper and placed on the plane glass plate, When microscope is focussed, the magnified image of the lines of graph on the piece of graph paper should be clearly seen.
2. Then the given lens is placed over the plane glass plate so that air film is formed between the plane glass plate and the lens. A glass plate is fixed to a stand and is placed at 45^0 to the horizontal

so that the light from the sodium vapour lamp is falls normally on the lens. By adjusting the angle of the glass plate, Newton's rings are formed and are observed through the microscope placed above it. Newton's rings can observed very easily if microscope is focussed at the centre of the glass plate and lens system.

3. As a result of interference between the light reflected from the lower surface of the lens and the top surface of the plane glass plate (light reflected from the top of the air film and bottom of the air film), a concentric ring system with alternate dark and bright rings having a dark spot at the centre, will be seen through the microscope. Some times due to the presence of dust particals between the lens and the plane glass plate, the central spot may appear bright.

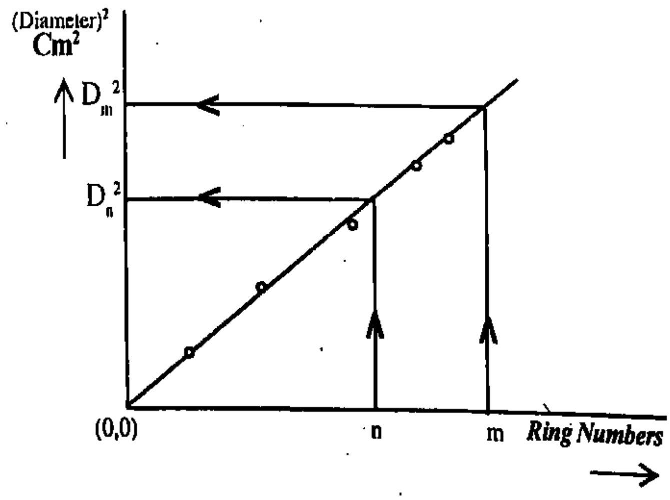
4. Bring the point of intersection of the cross wires to the centre of the ring system. Taking the center of the ring system as zero, move the travelling microscope with slow motion, say to the left across the field of view counting the number of rings. After passing beyond the 21^{st} dark ring, reverse the direction of motion of the microscope and set the vertical cross-wire at the middle of 21^{st} dark ring tangential to it.

5. Now, note the main scale reading on the horizontal scale and note the vernier coincidence using a reading lens. Similarly note the readings with the Vertical cross-wire set successively on the 18^{th}, 15^{th}, 12^{th}, 9^{th}, 6^{th}, 3^{rd} dark ring. Move on the microscope in the same direction and note the readings corresponding to 3^{rd}, 6^{th}, 9^{th}, 12^{th}, 15^{th}, 18^{th} and 21^{st} dark ring on the right side.

6. Readings should be taken with the microscope moving in one and the same direction to avoid errors in coinciding the vertical cross-wire respective dark rings. Record the observations in the table below with left side readings from top to bottom and rightside readings from bottom to top.

7. Concentric ring system is formed at the centre because the path difference between the two light rays, those are interfering with each other, is constant radially or the locus of all points having the same air gap happen to be a circle. Dark spot is formed at the centre because the reflecting system of glass plate and lens is used. At the centre, actually there is no path difference between the two reflected beams. first one from the upper surface of the glass plate and the other from the bottom surface of the lens. But, the former undergoing reflection in a rarer medium (air) against denser medium (glass), has an extra path of $\frac{\lambda}{2}$. Hence there is a net effective path difference between the two rays giving rise to dark fringe at the centre. Mathematically we have $D_n^2=4n\lambda R$ for the n^{th} dark rings so that for n=0, $D_n=0$. Hence from the relation, there is a dark ring at the centre.

Graph : Draw a graph between the ring number (on x-axis) and the square of the ring Diameter (on y-axis)



S. No	No. of ring	Microscope readings								Diameter (P~Q)	(Diameter)^2 Cm^2
		Left edge of ring				Right edge of the ring					
		MSR Cm	VC	VC x LC Cm	TR Cm P	MSR Cm	VC	VC x LC Cm	TR Cm Q	Cm	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Observations :

Least Count of the microscope = $\frac{\text{1 Main Scale Division Value}}{\text{No. of Vernier Scale Divisons}}$ = Cm.

m =

n =

D_m^2 = Cm^2 from graph only

D_n^2 = Cm^2 (from graph only)

λ = wavelength of the monochromatic source

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

Report :

The radius of curvature of the given lens (R) = cm.

DIFFRACTION GRATING -DETERMINATION OF WAVELENGTHS

Aim of this experiment is to determine the wavelengths of the spectral lines of mercury emission using plane diffraction grating at normal incidence.

Introduction : Plane diffraction grating consists of large number of parallel straight lines drawn on a transparent plate with the lines acting as opaque regions and the space between the lines acting as slits for the passage of light. Originally they are drawn on a glass plate which is called master grating. The impressions made by the master grating on a transparent resin is sealed between two glass plates and is commecially supplied as grating.

Theory : Let d be the width of each slit, approximately number of lines per cm. of the grating is given by $N=\frac{1}{d}$

When the light incident normally on the plane grating make an angle θ with the normal on diffraction, the path difference between the two rays passing through successive slits is given by d sinθ. For maximum of the diffracted beam, d sinθ = nλ where n gives the order of the spectrum and λ is the wavelength of the light used. Since,

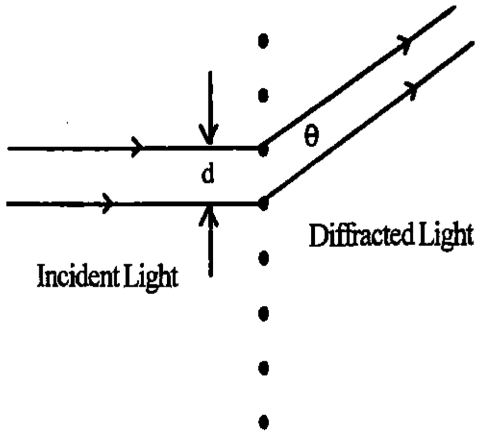


Fig 1. Diffraction of Light through grating

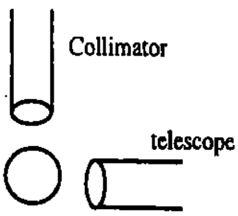
$$d=\frac{1}{N}$$

$$\sin\theta = nN\lambda$$

with the known angle of diffraction, order n of the spectrum and known N, the wavelength λ of the line is determined by using the relation, $\lambda=\frac{Sin\theta}{nN}$

Procedure :

1. Least count of the circular scale of the spectrometer is to be found. After preliminary adjustments of the spectrometer, the grating is to be kept at normal incidence. For this keep the telescope in line with collimator to observe the white slit and coincide the vertical cross-wire with the white slit. Adjust zero reading.
2. Keeping the grating table fixed, rotate the telescope to an angle 90^0



3. Mount the grating in the grating stand and rotate the grating table in such a way that the reflected image of the white slit is observed through the telescope. By rotating the grating table, make sure that the white slit coincides with the vertical cross-wire.

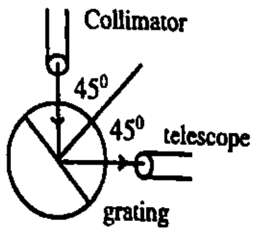


Fig 2. To keep grating at Normal incidence position

4. Tehn rotate grating table through an angle 45^0 towards colloimater Now the grating is kept at normal incidence. Light rays from the collimator will be incident on the grating perpendicularly at normal incidence.
5. The spectrum can be observed through the telescope as shown in the figure. Normally, one may not get violet in the second order due to its low intensity.
6. Conventionally, one goes to the extreme left of the spectral line and starts making measurements until he reaches the extreme right of the spectral line, coinciding each spectral line with the vertical cross-wire. The data is presented in the tables given below

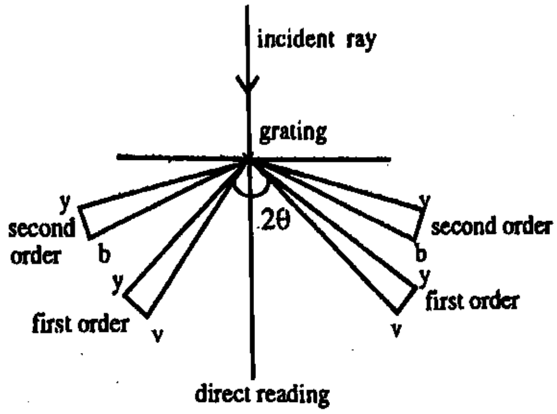


Fig 3. Angle of Diffraction

Table for the first order spectrum :

n= 1

N= Number of lines per cm of the grating =

$$\text{Least Count of spectrometer} = \frac{\text{1 main scale division value}}{\text{No. of vernier divisions}}$$

S. No	Clour	Readings on the circular scale								2θ	θ	$\lambda = \frac{Sin\theta}{nN}$ AU
		Left				Right						
		MSR	VC	VCxLC	TR	MSR	VC	VCxLC	TR			
1	Yellow-2											
2	Yellow-1											
3	Green											
4	Bluish Green-2											
5	Bluish Green-1											
6	Blue											
7	Voilet-2											
8	Voilet-1											

Report:

The wavelength of the spectral lines of mecury emission are in A.U.

Voilet-1 =

Violet-2 =

Blue =

Bluish green-1 =

Bluish green-2 =

Green =

Yellow-1 =

Yellow-2 =

DISPERSIVE POWER OF A PRISM

AIM : To determine the dispersive power of the material of the given prism.

APPARATUS: Spectrometer, prism, mercury source, reading lens and table lamp.

Theory :

The Refractive index of any transparent medium is given by,

$$\mu = \frac{\sin\left(\frac{A+D_m}{2}\right)}{sin\frac{A}{2}}$$

Where A= Angle of the prism

D_m = Angle of minimum deviation for the given colour of wave length λ .

Dispersive Power of a Prism is given by,

$$\omega = \frac{\mu_B + \mu_G}{\mu - 1} \qquad \text{Here } \mu = \frac{\mu_B + \mu_G}{2}$$

Where μ_B is refractive index of blue spectral line.

μ_G is refractive index of green spectral line.

Procedure :

1. After making the preliminary adjustments with the spectrometer, the prism is mounted on the prism table as shown in the figure with the refracting edge (edge opposite the rough surface) facing the collimator.

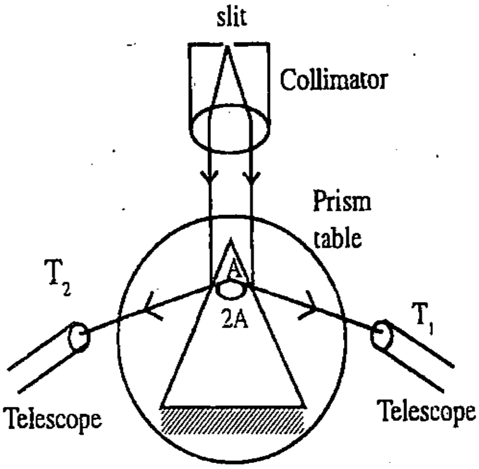


Fig. 1 Angle of the Prism (A)

2. The reflected image of the white slit on either side of the faces of the prism are observed with naked eye. Then, the reflected image from one face of the prism is observed through the telescope and the cross-wire of the telescope is made to coincide with the reflected image. The reading on the circular scale (T_1) is noted. Similarly, the reflected image from the other face of the prism is observed through the telescope and the cross-wire of the telescope is made to coincide with the reflected image. The reading on the circular scale (T_2) is noted.
3. The difference in the readings T_1 and T_2 gives the angle of the prism A as $2A=T_1 \sim T_2$. The results are tabulated in the table-1
4. To determine the angle of minimum deviation, set the prism approximately as shown in figure below, so that light from the collimator enters one face of the prism containing the refracting angle and emerges out of the other. Disperses spectrum can be seen through the telescope in this position.

The prism table is rotated such that the dispersed image of the slit (different coloured spectral lines) moves towards the direct reading position (white slit) of the telescope i.e., the deviation of the ray decreases. Looking through the telescope, the prism table is further rotated in the same direction. The image appears to move in the same direction but at a certain position, the image appears to remain stationary and suddenly retrace its path, the prism table is clamped. coincide each spectral line with the vertical cross-wire and note the reading on the circular scale for each colour.

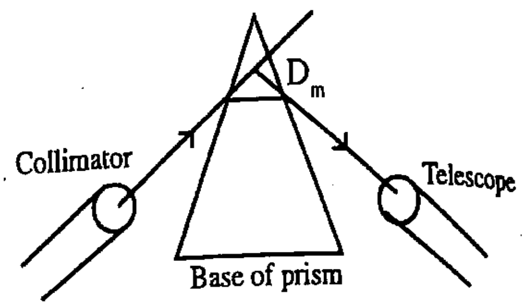


Fig. 2 Angle of Minimum Deviation

The prism is removed and the telescope is moved until the vertical cross-wire coincides with the image of the white slit. The direct reading is noted. Results are tabulated in the table-2.

Least count of spectrometer = $\frac{One\ main\ scale\ division\ value}{\text{Number of vernier scale divisions}}$ =

ANGLE OF THE PRISM

S.No	Telescope reading								2A=T_1 ~ T_2	A
	MSR	VC	VC X LC	TR (T_1)	MSR	VC	VC X LC	TR (T_2)		
1										

Direct reading : D=MSR + (VC x LC) =

S.No	**COLOUR**	**WAVE LENGTH λ (AU)**	**Telescope reading**				**Angle of Minimum Deviation D_m=T ~ D**	**μ = $\frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin\frac{A}{2}}$**
			MSR	VC	VC X LC	TR (T)		
1	Blue	4358						
2	Green	5461						

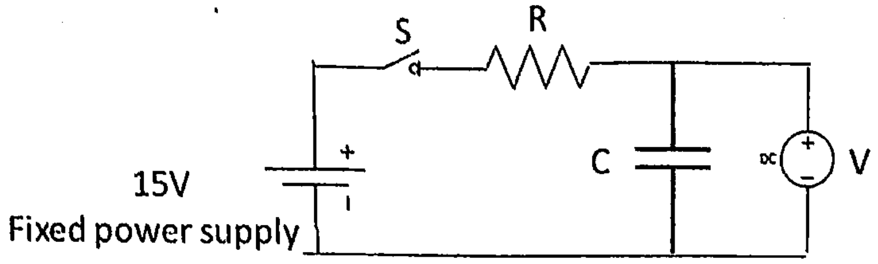
Report :

The Dispersive power of a given prism =

DIELECTRIC CONSTANT

AIM: To determine the dielectric constant of the dielectric medium present in a parallel plate capacitor.

APPARATUS: DC Regulated power supply, Electrolytic capacitor, Resistor, Digital voltmeter, Digital timer, Double plug key.



S= charging, discharging ; R= Resistance; C= Capacitance; V= Voltmeter

PRINCIPLE: Capacitors are devices which store electric energy by means of an electrostatic field and release this energy later. The voltage across the capacitor when it gets charged gradually at any instant of time t, is given by

Vc = V (1-e-t/RC),

where V is the voltage applied, R is the resistance and C the capacitance in the circuit. While discharging through the resistor R, the capacitor voltage at any instant t is given by,

Vc = V e-t/RC

Let T1/2 be the time required to charge or discharge a capacitor to 50%.

\When t= T1/2, Vc = V/2

V/2 = V e-t/RC

et/RC = 2

t/RC = loge 2 = 0.693

C = T1/2 /0.693 R

But C = Ke0A/d where A and d are the thickness and area of the dielectric material. e0 is the permittivity of free space and K the dielectric constant.

\K = d T1/2 /0.693e0AR

PROCEDURE: The circuit connections are made as shown in figure.

To begin with, the toggle key H is connected to point 1. Now the capacitor begins to get charged to higher voltage. The voltage across the capacitor is taken at every 10 seconds interval from the 0th second until capacitor voltage becomes practically constant. Now the capacitor is fully charged. Now the toggle key H is connected to point 2. The voltage across the capacitor is taken at every 10 seconds interval from the 0th second until capacitor voltage becomes practically zero.

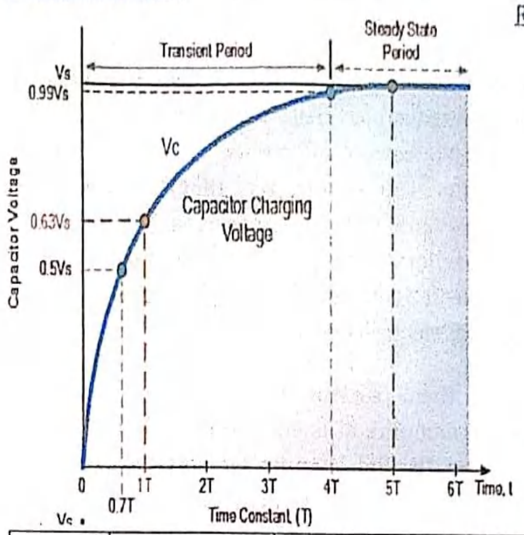
A graph is plotted with time T taken along X-axis and the capacitor voltage V along Y-axis. The charging mode curve and the discharging mode curve intersect at the point P. By referring the position 'P' to the time axis, the value of its abscissa T1/2 in seconds is found out. Now the dielectric constant K can be calculated.

- Connect the circuit as shown in the figure
- Turn on the power supply, Change the S(Switch) to Charging side & simultaneously start a stop clock
- Now the current flows & the capacitor gets charged. Note down the voltmeter reading, V at suitable regular interval of time (say 5 seconds) till the voltage reaches a maximum value
- Now change the switch S to Discharging mode & Similarly Note down the voltmeter readings V at suitable interval of time (say 5 seconds) till voltmeter reaches a minimum value.
- Note down the observations in Tabular form for Charging & Discharging.
- Plot the Graph Voltage Vs Time
- Repeat the experiment for different sets of R & C values.

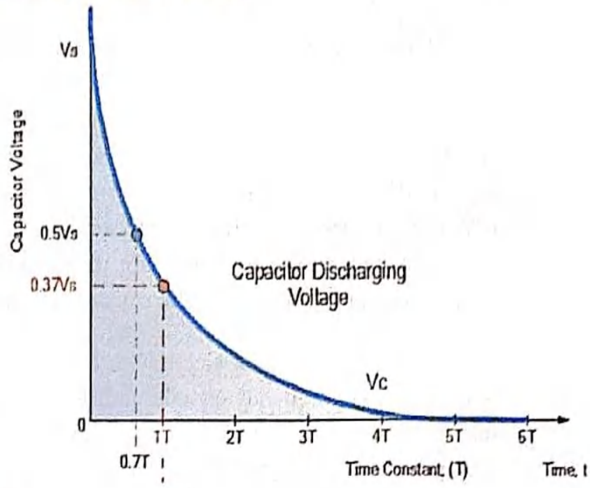
Graph: -

Observations:

RC Charging Circuit Curves



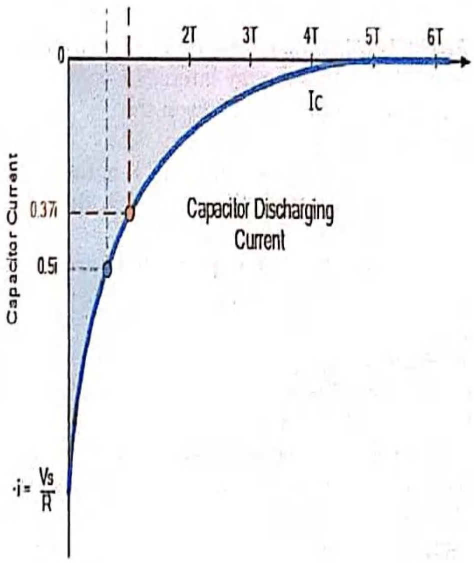
RC Discharging Circuit Curves



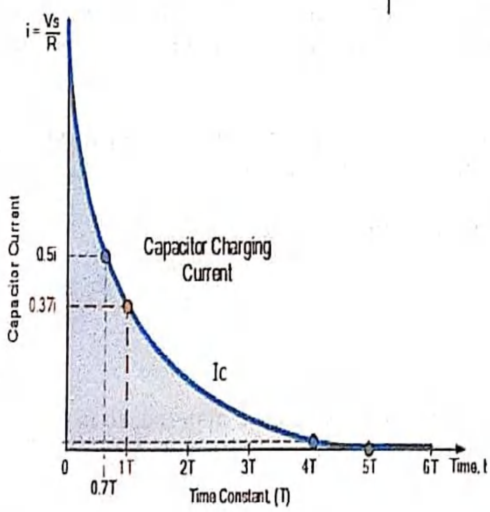
S.No	Time (t) Sec	Voltmeter Readings	
		Charging	Discharging
1	5		
2	10		
3	15		
4	20		

Connect Ammeter in series in between resistance & Capacitance

Current for Charging:



Current for Discharging:



The capacitor continues charging up and the voltage difference between Vs and Vc reduces, so to does the circuit current, i. Then at its final condition greater than five time constants (5T) when the capacitor is said to be fully charged, $t = \infty$, $i = 0$, $q = Q = CV$. Then at infinity the current diminishes to zero, the capacitor acts like an open circuit condition therefore, the voltage drop is entirely across the capacitor.

OBSERVATIONS:

R=

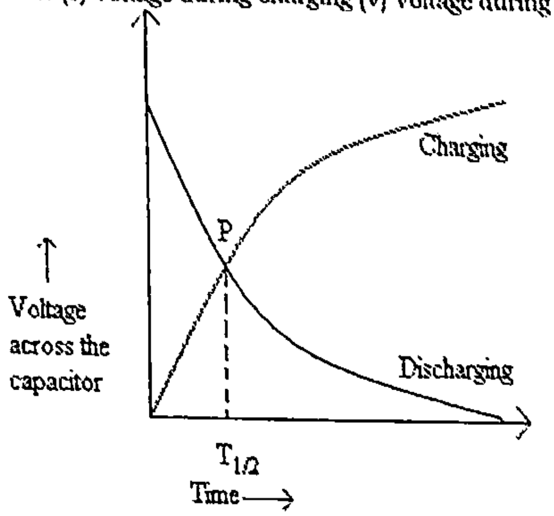
LengthL=

Breadthb=

Thichnessd=

AreaA=L×b=

Time (s) Voltage during charging (V) Voltage during discharging (V)



CALCULATIONS:

K=dT1/2/0.693e0AR=

RESULT: The dielectric constant of the material in the given capacitor =

NUMERIALAPERTURE OF AN OPTICAL FIBRE USING LASER

Aim:

To determine the numerical aperture (NA) of an optical fibre using a laser beam of wavelength λ = 630 nm.

Apparatus:

A meter long single mode optical fibre, a red diode laser, and a graph sheet.

Formula:

The numerical aperture (NA) is defined as the sine of the acceptance angle. Acceptance angle is defined as the maximum angle that a light rat can have relative to the axis of the fibre so that it propagates down the fibre suffering total internal reflections.

$$NA = Sin\theta_a = \frac{D/2}{\sqrt{(D/2)^2 + L^2}}, where D =$$

diameter of the circular patch of light in cm, L= the height of the fibre end from the graph sheet in cm, θ_a the acceptance angle.

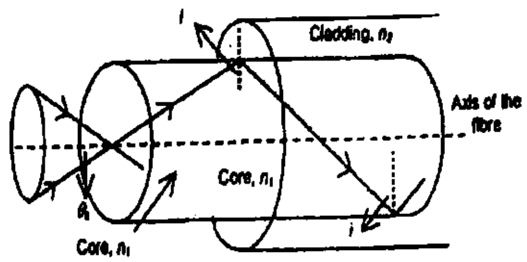


Fig.1

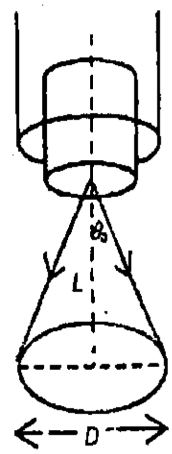


Fig.2

Theory and Procedure:

An optical fibre is a hair-Thin fibre consisting of, as shown in the figure, three coaxial cylindrical regions. The inner region is a cylindrical core made of glass of dimension about 50 μ m. This core is surrounded by a protective layer called sheath (not shown in the figure).

Laser rays are guided to propagate down the length of the fibre through successive total internal reflections. For this to take place, the refractive index n_1 of the core must exceed the refractive index n_2 of the cldding medium. And the angle of incidence i of the laser ray at the core-cladding interface must be greater than the critical angle. As shown in the figure, laser beam lauches into the fibre in the form of cone with an acceptance angle θ_a. The acceptance angle θ_a is the mzximum angle that a laser ray can have relative to the axis of the fibre in order to guide it down the fibre through total internal reflections. θ_a is a measure of the light gathering ability of the fibre.

The laser beam emerges from the other end of the fibre again in the form of a cone as shown in the figure and falls vertically on a graph sheet below to form a circular patch of light. The height (L) of the fibre end from the graphy sheet and the diameter (D) of the circular patch of light are measured.

The heights (L) are changed in steps of about 3 cm and the corresponding diameters (D) are tabulated.

The average value of NA is recorded

S.NO.	L	D	D/2	$NA = \sin \theta_{a} = \frac{D/2}{\sqrt{(D/2)^2 = L^2}}$
1				
2				
3				
4				
5				

Report:

Average Value of the Numerical Aperture =

Conclusion:

The transmission of laser light through a optical fibre is hence studied and the value of numerical aperture is presented.

DIFFRACTION GRATING - DETERMINATION OF WAVELENGTH OF A LASER

Aim : To determine the wave length of laser light by using plane diffraction grating at normal incidence.

Theory : When the laser light incident normally on the plane grating the diffracted ray makes an angle θ with the normal. The path difference between the two rays passing through successive light is given by d sin for maximum of the diffracted beam. Then we know that for a grating $d \sin\theta = n\lambda$ where n gives the order of the light and λ is the wave length of the light used.

$d=\frac{1}{N}$ Where N is number of lines of the grating per cm.

$\therefore \operatorname{Sin}\theta = n\,\lambda N$

Or

$$\lambda = \frac{Sin\theta}{Nn}$$

from the figure

$$\operatorname{Tan}\theta = \frac{d}{D}$$

θ - angle of diffraction

d - distance between Ist order maxima and central maxima

D- Distance between Screen from the grating

for θ is small

$\operatorname{Tan}\theta \simeq \operatorname{Sin}\theta$

$$\therefore \lambda = \frac{d}{DnN}$$

N= lines/cm

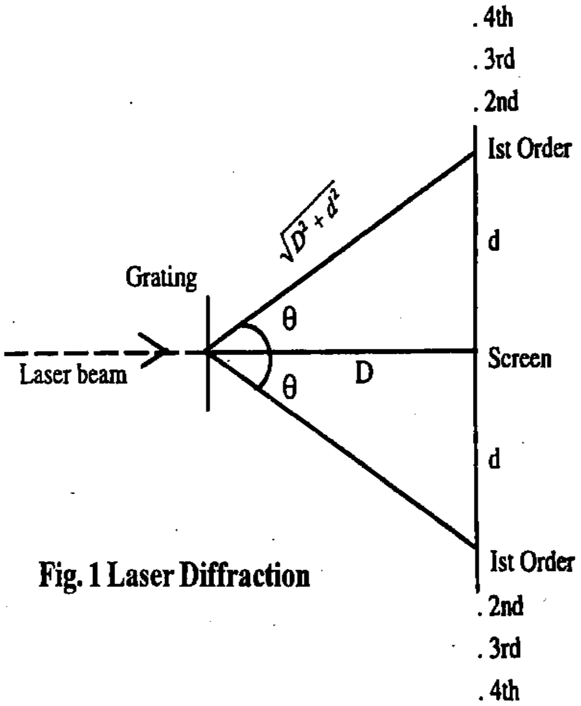


Fig. 1 Laser Diffraction

Procedure :

Coincide laser light to the vertical cross wire and fix the telescope. Release the vernier disc. Set the disc to a convenient reading (0 or 180) and fix the vernier screw. This is direct reading. Move the telescope by 90 from the direct ray reading position and clamp it . Now the telescope and collimator are at right angle to each other.

Mount the grating on the grating stand fix to the prism table rotate only the Prism table so that the reflected image is see on the vertical cross wire of telescope and clamp the prism table. In this position the angle of incidence will be 45^0 as shown in the figure. Release the vernier disc and turn it by 45^0 in proper direction such that the incident ray coming from the collimator is normal to the grating. Fix the vernier disc screw.

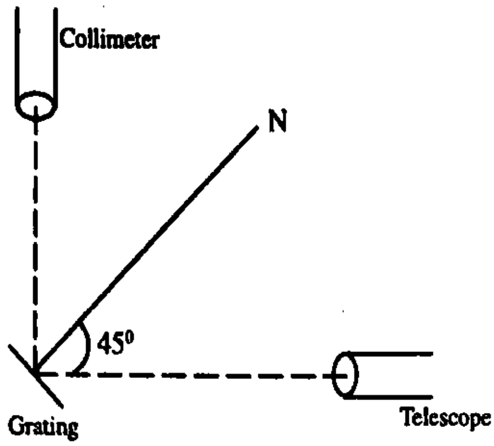


Fig. 2 Setting the Grating at normal incidence

Laser rays from the collimeter will be icident on the grating at normal incidence. Set the screen with scale an arangement at a distance (D) away from the grating and observe the Ist order diffraction light symmetrically on either side of the direct beam, note the distance between the Ist order line and the direct beam (d). Repeat the experiment by keeping the screen at different distance and table the observations. Note in no. of lines (N) of the grating/cm and take n=1.

By writing $\lambda = \frac{d}{DNn}$ the wave length of the laser beam is determined

Table :

S. No.	Order of the spectrum	Distance from the grating (D) cm.	Distance from the central maxima (d) cm.	$Sin\theta = \frac{d}{\sqrt{d^2+D^2}}$	$\lambda = \frac{Sin\theta}{Nn} A.U.$

Average Wage length= A.U.

Result : The wave lengths of the laser beam is .... A.U.

BAND GAP OF A SEMI CONDUCTOR

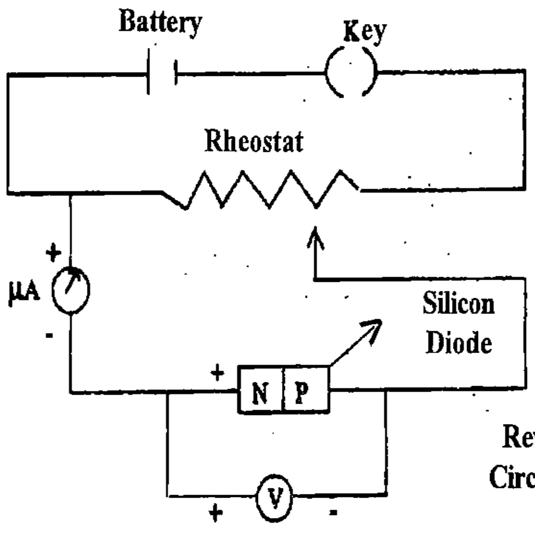
Aim of this experiment is to study the variation of resistance of a semiconducting diode with temperature and hence determine the band gap of a semiconductor.

Apparatus : A temperature controlled diode current voltage characteristic measurement kit is used for this experiment. The voltage can be varied from 0 to 10V. The temperature of the diode can be varied from 27°C to 100°C.

Theory : The conductivity of any semiconductor is found to vary with temperature T is, a $\sigma = \sigma_0 \exp\left(\frac{-Eg}{2KT}\right)$ where Eg is the band gap, K is the boltzmann constant and T is the absolute temperature. The diode is made of a semiconducting material, and hence the conductivity $\sigma = CExp\left(\frac{-Eg}{2KT}\right)$ of the diode, where C is constatnt

$$\log_{10}\sigma = \left[\frac{-Eg}{2X2.303K}\right]\frac{1}{T} + \log_{10} C$$

Diagram :



Reverse Bias
Circuit Diagram

Procedure : The diode is connected in reverse bias as shown in the circuit. At room temperature the reverse current is noted. The heater is on and temperature is raised by 10°C and the value of the reverse current is noted. The experiment is repeated at different temperature upto a maximum of 100°C. The results are tabulated and from I-V values the conductivity is measured.

Observations :

1. Specification of diode and apparatus
2. Room temperature = °C = °K
3. Reverse current I at room temperature = Amp
4. Constant voltage of the cell V= Volts

   K = boltzmen's constant = 1.38×10^{-23} J/K

Table :

S.No	Voltage (V)	Current x 10^{-6}	$\sigma = \frac{I}{V}$ mhos	$\log_{10}\sigma$	Temp T ^0C	Temp T ^0K	$\frac{1}{T}$ (K^{-1})

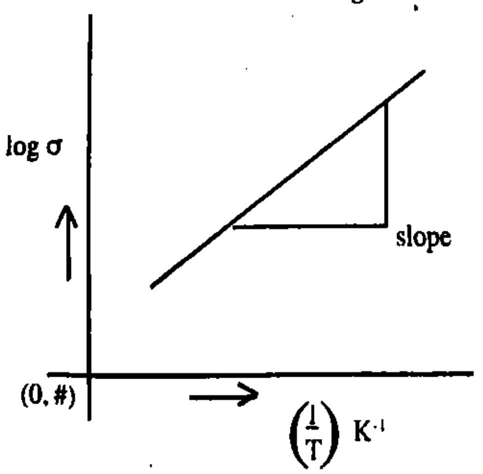
Graph :

A graph is ploted between $\frac{1}{T}$ and $\log_{10}\sigma$ and from the slope of the line Eg is calculated.

$$Slope = \frac{-Eg}{2(2.303)K}$$

$$Eg = -slope \times 2 \times 2.303 \times 1.38 \times 10^{-23} \text{ in Joules}$$

$$Eg = \frac{-\text{Slope} \times 2 \times 2.303 \times 1.38 \times 10^{-23}}{1.6 \times 10^{-19}} \text{ e.v.}$$



Result :

The band gap of given semiconductor diode is ___________ ev

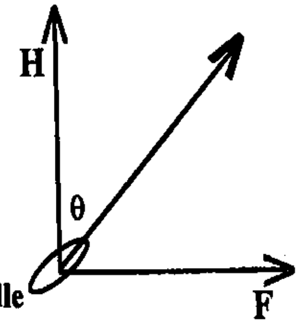
MAGNETIC FIELD ALONG THE AXIS OF THE CIRCULAR COIL

Aim : To study the variation of the magnetic field along the axis of a circular coil carrying current

Apparatus : **Stewart and Gees type apparatus, deflection magnetometer, electric power supply, rheostat, commutator, ammeter.**

Theory : The intensity of the magnetic field 'F' at any point on the axis of the circular coil is given by

$$F = \frac{2\pi n i a^2}{10\left(x^2 + a^2\right)^{3/2}} \text{ Oestred} \qquad \text{.........................} (1)$$



Where

x : the distance of the point from the center of the coil
n : number of turns in the coil
i : Current through the circular coil
a : radius of the circular coil

If the coil is placed in the magnetic meridian, the direction of the magnetic field will be perpendicular to the magnetic meridian i.e., perpendicular to the direction of the horizontal component of the earth's magnetic field (H). If the deflection magnetometer is placed at any point on the axis of the coil such that the centre of the magnetic needle in the magnetometer lies exactly on the axis of the coil, then the magnetic needle is acted upon by two fields F and H which are at right angle to each other. So the magnetic needle shows a deflection θ obeying the tangent Law.

$$F = H \tan\theta \text{ Oestred} \qquad \text{.............................}(2)$$

Assuming H and knowing θ the intensity of the magnetic field can be calculated using the equation (2)

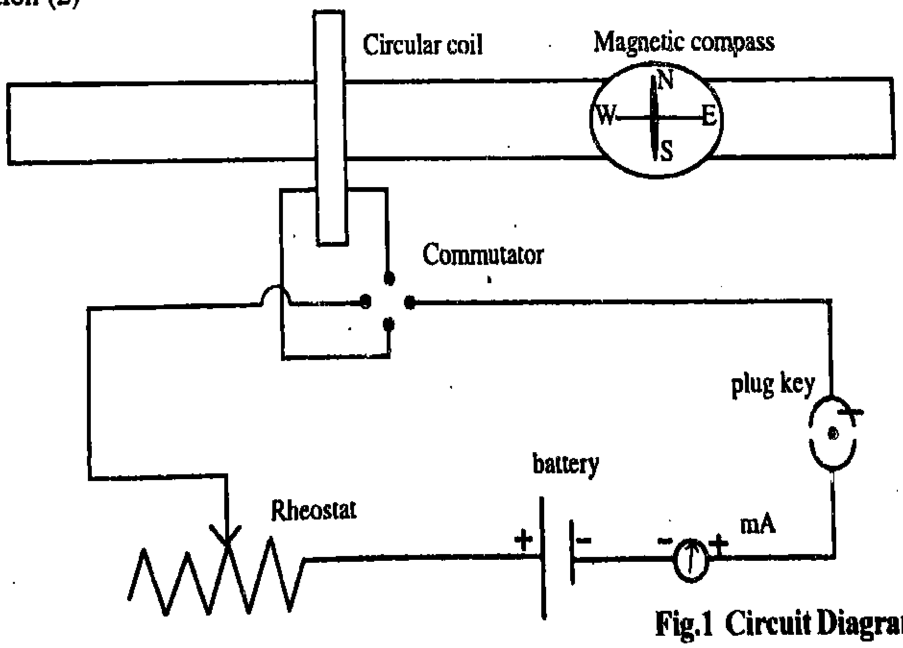


Fig.1 Circuit Diagram

Procedure : Generally there is a provision for different number of turns like 5,50,500. The circular frame is sufficiently large so that a deflection magnetometer can slide on graduated scale fixed centrally and perpendicular to the plane of the coil. The scale graduation stands from the centre of the circular frame. The distance are marked on either side of the scale starting from this zero, when the magnetometer is moved on the scale, the centre of the magnetic needle lies always on the axis of the circular coil.

The connection are made as shown in the circuit. The circular coil is set with its plane in the magnetic meridian i.e., the plane of the coil is parallel to the magnetic needle when no current passes through the coil. The scale is automatically tanA to the magnetic meridian. The magnetometer is adjusted such that the pointer read 0-0 on the circular scale with out disturbing the position of the coil.

The circuit is closed and the rheostat is adjusted until the magnetometer shows a deflection of about 60^0 when coil centre and the centre of the magnetic needle are coincide. The deflection θ_1 and θ_2 are noted. The current is reversed using the commutator and deflection θ_3 and θ_4 are noted. θ_1, θ_2 and θ_3, θ_4 values may differ but the difference should not be grater than 1 or 2. The mismatch between the values indicates the alignment of the coil with NS direction. When the values are matched, the mean of four values gives for x=0. Now the magnetometer of is moved through 2cm along the scale towards east. The values of θ_1, θ_2 θ_3 ,and θ_4 are noted same as in the case of x=o. The mean value 'θ' is calculated for x=2 and noted. The experiment is repeated by moving the magnetometer insteps of 1cm and in each case the four vales are noted and corresponding mean value is also calculated. The whole experiment is repeated by moving the magnetometer towards west.

The values of θ in west θ_5, θ_6 θ_7 ,and θ_8 are noted

Observations :

Number of turns of the coil (n) =

Current through the coil (i) = ampere

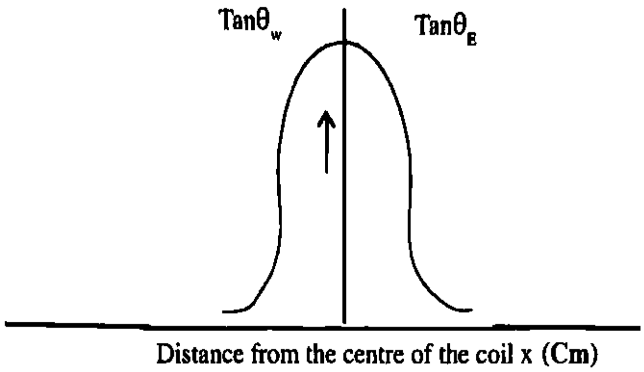
Radius of the coil (r) = cm

Horizontal component of the earth's magnetic field (H) = 0.39 Oersted

S. No.	Distance x cm.	Deflectioon in Magnetometer in East				mean	$Tan\theta_E$	Deflectioon in Magnetometer in West				mean	$Tan\theta_W$	$\theta = \frac{\theta_E + \theta_W}{2}$	F=H $Tan\theta$ Oersted	$F = \frac{2\pi n i a^2}{10(x^2+a^2)^{3/2}}$ Oersted
		θ_1	θ_2	θ_3	θ_4	θ_E		θ_1	θ_2	θ_3	θ_4	θ_W				
1	0 cm															
2																
3																
4																
5																
6																
7																
8																
9																
10																

The magnetic field values obtained from equation (1) and (2) are copared in the Table

A graph is drawn between the distance x along the x-axis and corresponding tand along the y-axis. The shape of the curve is shown in the figure.



Precautions :

1. Plane of the coil should be in the magnetic merdiun
2. The centre of the coil must lie of the axis of the coil
3. The deflection magnetometer should be ganely tapped be before taking the readings.

Result :

The variation of magnetic field along the axis of a circular coil carrying current is studied using Stewart – Gee's type apparatus.

TEMPERATURE COEFFICIENT OF A THERMISTER

Aim : 1. To study temperature – resistance characteristics of a given thermistor.

2. To determine the temperature coefficient of electric resistance of the given thermistor at any particular temperature.

Apparatus : Thermistor, Standard resistance, Variable resistance, Thermometer, Oil, Water, Electric heater, Digital multimeter, Connecting wires. (or Thermistor R-T characteristics kit.)

Theory : Thermistors are semiconductor sensor devices which are used to measure temperature. The resistance of a thermistor varies with temperature, so by measuring resistance, one can determine the temperature of the environment or object in thermal contact with the thermistor. The thermistor shows large change in its resistance even for a small change in its temperature; i.e. its temperature – resistance characteristics are nonlinear. A thermistor element is shown in Fig.1.

Thermistor has a negative temperature coefficient of resistance, since as the temperature increases, its resistance decreases. This feature of the thermistor can be used to counteract the increase in resistance of a circuit with a temperature increase. Thermistor has very high temperature sensitivity of the order of 0.01°C. Thermistors are preferably used to measure low temperatures but not high temperatures.

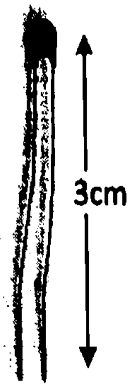


Figure 1: A Thermistor element

Principle:

The resistance R of a thermistor at temperature T is given by,

$$R = R_0 e^{-B\left(\frac{1}{T_0} - \frac{1}{T}\right)} \quad \text{.........................(1)}$$

where R_0 is the resistance of the thermistor material at temperature T_0 (a reference temperature which is generally taken at 298^0 K). The constant B depends on the material.

Suppose, $R_0 = A$ and let T_0 be considerably high so that Eq. (1) can be written as,

$$R = Ae^{\frac{B}{T}} \quad \text{..............(2)}$$

Fig. 2 shows the dependence of the resistance of a thermistor on temperature. The graph is drawn between T (K) on X-axis and R on Y-axis.

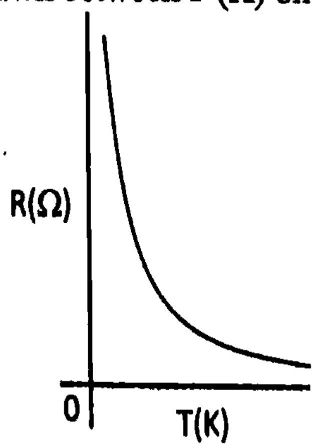


Figure 2: Resistance - Temperature characteristics of thermistor

We can obtain the physical characteristics of a thermistor (the constants A and B) by rearranging the Eq. (2) into a logarithmic form:

$$\ln(R) = \ln(A) + B\frac{1}{T} \quad \text{.................(3)}$$

From Eq. (3), we note that, ln *(R)* is linearly dependent on *1/T* as shown in Fig.3. The graph is drawn between *1/T* on X- axis and ln(*R*) on Y-axis. A straight line is obtained. From the slope of the straight line, *B* can be calculated and *A* value can be obtained.

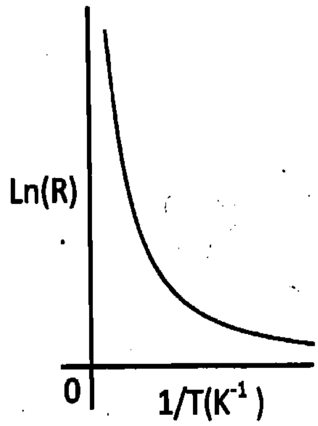


Figure 3: ln (R) - 1/T graph

It can be noted that, *B* is the slope of the straight line, and ln (*A*) represents the intercept of the straight line.

The temperature coefficient α of electric resistance of thermistor is defined as a drop in the resistance per a degree increase in temperature. The unit of α is K^{-1}. It is given by:

$$\alpha = \frac{1}{R}\frac{dR}{dT} \quad \text{..................(4)}$$

Differentiating Eq. (2) with respect to temperature, and substituting into the Eq. (4) one obtains:

$$\alpha = -\frac{B}{T^2} \quad \text{.......................(5)}$$

By determining the constants *A* and *B* from the graph, α can be determined at a given temperature.

Procedure:

The principle of Wheatstone bridge is used to determine the resistance of the thermistor. According to Wheatstone bridge principle, for the circuit in Fig. 4 at balancing condition, the ratio of resistances, P/Q = R/S. Since the resistances in P and Q arms are taken equal, the resistance of thermistor at balancing position, S = R. Hence the resistance of thermistor can be noted. Note the readings by the following procedure.

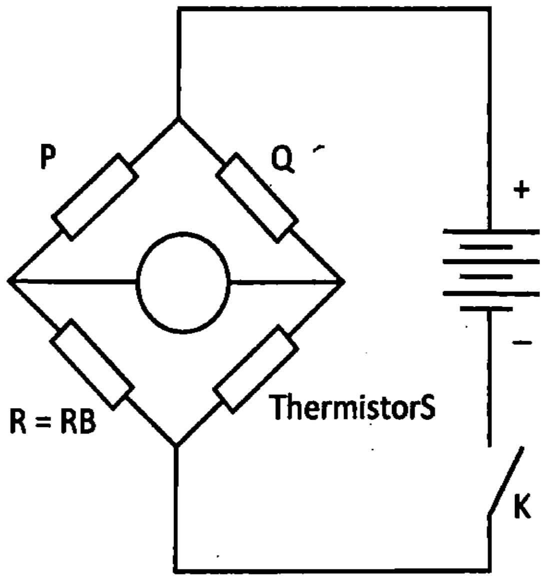


Figure 4: Circuit diagram of Wheatstone bridge

1. Connect the circuit according the diagram shown in Fig. 4. In the circuit two equal known resistors are connected in the arms **P** and **Q**. In the arm **R** a variable resistance **RB** (say, resistance box) is connected and in the arm **S** the thermistor is connected. The overall circuit represents a Wheatstone bridge.
2. Immerse the thermistor in an oil (or water) taken in a beaker. Place a thermometer and a stirrer in the beaker. Measure the temperature without heating the beaker.
3. Close the tap key K to close the circuit. By adjusting the resistance in variable resistance box **RB**, make the galvanometer reading zero. The bridge is balanced when the current through the galvanometer G is equal to zero. The value of the resistance in **RB** directly indicates the resistance of thermistor.

4. Now, gradually increase the temperature of oil bath till 95^0 C. Note the resistance at 95^0C and switch off heater.

5. Repeat the experiment to measure the resistance of the thermistor for every 5^0 C fall of temperature (i.e., 95^0C, 90^0C, 85^0C, 80^0C......). Ensure that in every case, the bridge is balanced. Enter the readings in Table – 1.

6. Draw a Resistance - Temperature graph to get the characteristic curve of thermistor as shown in Fig.2.
7. In order to obtain physical characteristics of the thermistor (A and B), calculate $1/T$ and ln (R). Enter the readings in Table – 1. Draw a graph between ln (R) and ($1/T$) to get a straight line as shown in Fig.3. The slope of the straight represents the value of B and the intercept corresponds to ln (A). Calculate A.
8. Calculate the resistance of the thermistor R and the temperature coefficient α at 25, 50, 75 and 95 ^{0}C using the Eq. (3) and the obtained values A and B. Enter the values in Table - 2.

Precautions:

1. Do not heat the thermistor beyond its specified range.
2. The oil bath temperature should be maintained uniformly throughout the liquid by stirring continuously.
3. Take the readings only after the bridge is exactly balanced.

Table - 1: To determine *R* - *T* Characteristics of thermistor:

S.No.	Temperature, t (^{0}C)	Absolute Temperature ($t + 273$) = T (K)	$1/T$ (K^{-1})	Resistance in RB, R (Ω)	ln (R)

Table-2: To determine Temperature coefficient of resistance (α) of Thermistor:

S.No.	Temparature, T (K)	Resistance of Thermistor, R (Ω)	α

Results:

The temperature coefficient of the given thermistor = ...