GENERAL PHYSICS AND OPTICS

M.Sc. PHYSICS

SEMESTER-I, PAPER-V

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FOREWORD

Since its establishment in 1976, Acharya Nagarjuna University has been forging ahead in the path of progress and dynamism, offering a variety of courses and research contributions. I am extremely happy that by gaining 'A+' grade from the NAAC in the year 2024, Acharya Nagarjuna University is offering educational opportunities at the UG, PG levels apart from research degrees to students from over 221 affiliated colleges spread over the two districts of Guntur and Prakasam.

The University has also started the Centre for Distance Education in 2003-04 with the aim of taking higher education to the door step of all the sectors of the society. The centre will be a great help to those who cannot join in colleges, those who cannot afford the exorbitant fees as regular students, and even to housewives desirous of pursuing higher studies. Acharya Nagarjuna University has started offering B.Sc., B.A., B.B.A., and B.Com courses at the Degree level and M.A., M.Com., M.Sc., M.B.A., and L.L.M., courses at the PG level from the academic year 2003-2004 onwards.

To facilitate easier understanding by students studying through the distance mode, these self-instruction materials have been prepared by eminent and experienced teachers. The lessons have been drafted with great care and expertise in the stipulated time by these teachers. Constructive ideas and scholarly suggestions are welcome from students and teachers involved respectively. Such ideas will be incorporated for the greater efficacy of this distance mode of education. For clarification of doubts and feedback, weekly classes and contact classes will be arranged at the UG and PG levels respectively.

It is my aim that students getting higher education through the Centre for Distance Education should improve their qualification, have better employment opportunities and in turn be part of country's progress. It is my fond desire that in the years to come, the Centre for Distance Education will go from strength to strength in the form of new courses and by catering to larger number of people. My congratulations to all the Directors, Academic Coordinators, Editors and Lesson-writers of the Centre who have helped in these endeavors.

Prof. K. Gangadhara Rao
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M.SC. PHYSICS

SYLLABUS

SEMESTER-I, PAPER-V

105PH24- GENERAL PHYSICS AND OPTICS

PRACTICAL-I

- Plank’s Constant
- Twin - T Filter
- Newton’s Rings
- Diffraction Grating - Normal Incidence
- Thermistor
- Mesh Method Analysis

CONTENTS

EXPERIMENT - 1

PLAN’S CONSTANT

Aim: To determine the Value of Plank’s constant with the help of Photocell.

Apparatus: Photo Cell, Light Source, Power Supply, Colour Filters, Connecting Wires, Voltmeter and Micro Ammeter.

Photocell:

It consists of an electrode made up of Photoelectric metal and another electrode sealed in an evacuated glass tube.

Principle:

When light is incident on alkali metals like Sodium, Potassium, Lithium, Cesium etc, electrons are emitted. The emission of electrons from the metal surfaces under the action of radiation is known as Photoelectric effect. This phenomenon was first observed by Hertz in 1887. The electrons so emitted are called photoelectrons. If such metal surface is given a negative potential then electrons fly from the cathode and reach anode thereby constituting a current called as Photocurrent.

Einstein explained photoelectric effect in 1905 on the basis of quantum theory of light. Einstein equation for photoelectric effect is given by

$$h\nu=(1/2)mv^2+W_o$$

Where h= Planck’s constant

ν= Frequency of incident radiation

m= mass of electron

v= velocity of the electron

W_o =Work function

Work function: The amount of work done in liberating or extracting electrons from the metal surface is known as work function Wo.

Stopping Potential: For a particular frequency of radiation, the current stops at a particular negative potential. The negative potential that stops the current is known as stopping potential (or) the negative potential of electrode that can stop the most energetic photoelectrons is called as stopping potential.

When photo metal is at stopping potential, the photocurrent becomes zero.

Threshold Frequency: For a particular metal if frequency of radiation is gradually decreased, the photoelectric effect ceases at a particular frequency called threshold frequency. It means that electrons are liberated from the metal surface with zero velocity.

Procedure:

(a) To Study the Characteristics of Photocell:

1) The circuit diagram to study characteristics of photocell is shown in fig1. The potential is made positive with respect to another electrode. The potential between cathode and anode are applied by means of a potential divider and the applied potential is measured. A micro ammeter is used to measure the current.

2) The light from the source is passed through the optical filter and made to fall on the photometal. The filter allows a light of known frequency. The photo current is measured for a given potential difference.

3) The photocell is placed at various distances (say 15, 20, 25 cms) and the potential difference is varied keeping intensity and frequency constant, the variation in current is noted. A set of observations of current and voltage are noted. As voltage is increases, current increases linearly and reaches saturation.

4) The variation of the photocurrent (I) with potential (V) is shown by plotting a graph taking voltage on X-axis and current I on Y-axis for various distances as shown in fig 2.

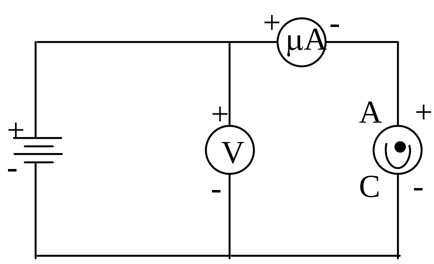


Fig. 1

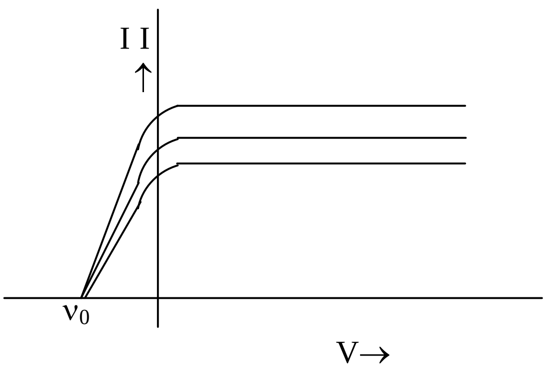


Fig. 2

(b) To determine and Planck's constant, work function and cut off frequency.

i) The circuit diagram to determine Planck's constant, work function and cut off frequency is as shown figure(3) The white light from a strong source is passed through the optical filter . The filter allows light of known frequency. The potential difference is adjusted so that the current becomes zero. The minimum value of the potential difference is noted.

ii) The experiment is repeated with number of optical filters and voltages are found. A graph is plotted between the known frequency on X-axis and the corresponding stopping potentials on Y-axis as shown in fig 4. A straight line is obtained. We get the following information from the graph.

Threshold frequency:

The intersection of the extrapolated straight line with X-axis gives threshold frequency ν_0. We know that work function Wo= $h\nu o$ where ν_0= threshold frequency. Now using Einstein's equation we get

$h\nu=(1/2)mv^2+Wo$

At stopping potential $(½)mv^2=eV_S$

Where V_S= Stopping potential

Therefore $h\nu=e\ V_S+W_0$

$eV_S=h\nu-W_0$

$eVs=h(\nu-\nu o)$

$h=eVs/(\nu-\nu o)$ here $e= 1.6x10^{-19}$ coulombs

iii) The extension of the straight line onto the negative Y-axis gives the valued of (W_0/e). From the slope of the straight-line we get the value of (h/e). From these values of h can be calculated. Hence the values of the h and Wo are found.

Circuit Diagrams:

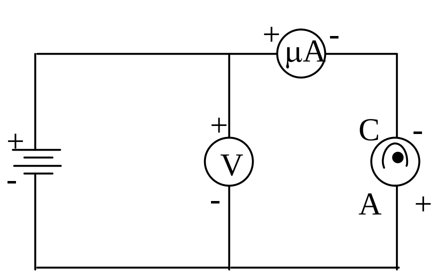


Fig. 3

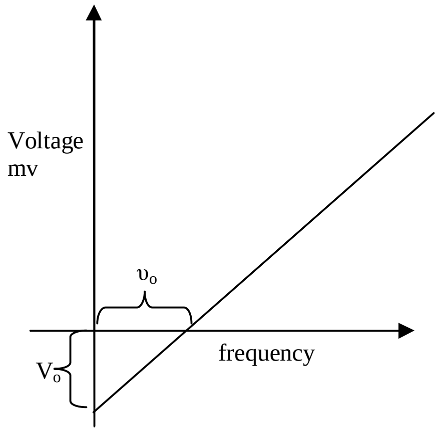


Fig. 4

Observations:

(a) To Study the Characteristics of Photocell:

Photocell at a distance of 15 cms.		Photocell at a distance of 20 cms.		Photocell at a distance of 25 cms.	
Voltage (V) volts	Current (I) MA	Voltage (V) volts	Current (I) mA	Voltage (V) volts	Current (I) MA

(b) To determine and Planck's constant, work function and cut off frequency.

S.No.	Filter	Wave length (A^o)	Voltage (V)	Frequency(Hz)

Precautions: 1) The photo electrode cell should be carefully handled.

2) The connections should be done carefully.

3) The stopping potentials should be noted carefully.

Result: Standard value of h =……. Joule- sec

Calculated Value of h =……. Joule- sec.

Work function of the given metal = …….Joule

EXPERIMENT - 2

TWIN - T FILTER

Aim: To study the frequency response characteristics of Twin - T - filter circuit and to find its cut off frequency.

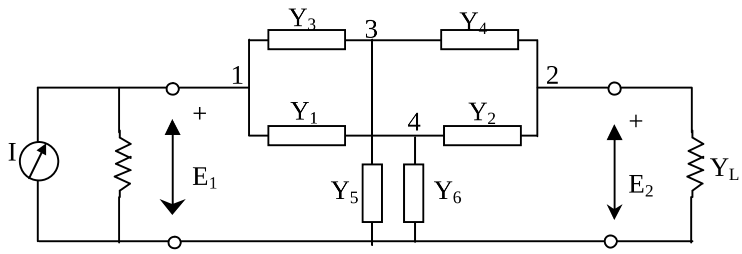
Apparatus: AF signal generator, capacitors, Resistances, Multimeter and connecting wires.

Formula:

Cut off frequency = 1/2ΠRC Hz

Where C is capacitance in microfarads, R is resistance in Ohms.

Circuit:

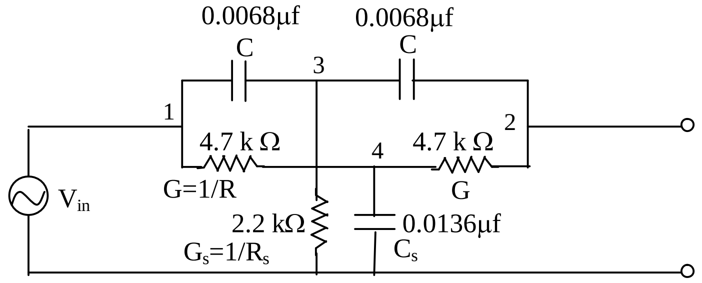


Theory: The Twin - T - Filter is used as a good frequency selector. Here the Twin - T - Filter consists of capacitors and resistors as shown in the FIG. Here by observing the circuit carefully we find that there are two T - type filters. So, this circuit is named as Twin-T-Filter. Here the input kept constant and in every step out put decreases first and increases in the second phase.

The twin-T circuit exhibits a selectivity curve which may closely resemble that of the antiresonant circuit, and interestingly enough this curve may be obtained without the use of inductance. Furthermore, the effective Q can be made much greater than that obtainable in the usual antiresonant circuit.

This selective property of the twin-T network is used so often in practice that it is well worth investigating. It is usual in this application to use equal resistance's for the Y_1 and Y_2 elements, equal capacitance's for Y_3 and Y_4, resistance for Y_5, and capacitance for Y_6. Thus, for the circuit

Have shown in fig. (1)



$Y_1 = Y_2 = G,\ Y_3 = Y_4 = j\omega C,\quad Y_5 = G_s,\ \ Y_6 = j\omega C_s$ 0

Then, substituting into the equation of null

$Y_3Y_4\,(Y_1+Y_2+Y_6)+Y_1Y_2\,(Y_3+Y_4+Y_5) = 0$

$-(\omega_o C)^2(2G+j\omega_o C_s)+G^2(j2\omega_o C+G_s)=0$

where ω_o is $2\prod$ times the null frequency. Then, equating reals,

$2(\omega_o C)^2 G = G^2 G_s$

and imaginaries

$(\omega_o C)^2\omega_o C_s = 2\omega_o C\, G^2$

hence, from the last two equations, the null frequency may be determined for

$$\omega_o^2 = \frac{GG_s}{2C^2} = \frac{2G^2}{C_s C}$$

Thus given the circuit components, it is possible to determine the frequency at which the null occurs.

In order to simplify the procedure, it is convenient to define a design parameter n in the following manner: Rearranging the two right-hand members of above equation

$$n=\frac{G_s}{2G} = \frac{2C}{C_s}$$

then ω_o^2 becomes

$$\omega_o^2 = \frac{GG_s}{2C^2} = \frac{G}{2C^2} 2Gn = n\frac{G^2}{C^2}$$

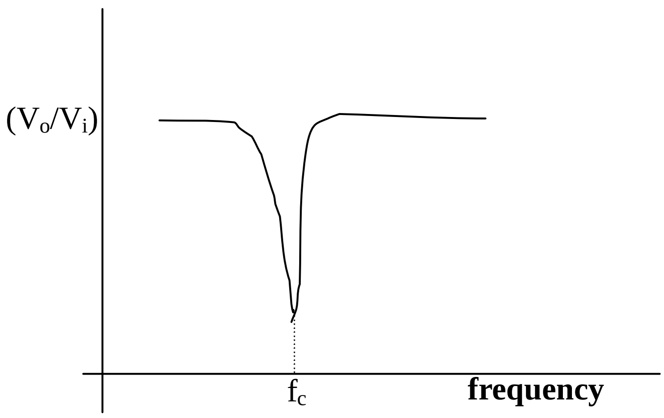
$$\omega_o = \frac{\sqrt{n}}{RC}$$

It is found that n=1gives the most selective curve.

Then the cut off frequency of the circuit is given by $f_c = 1/2\Pi RC$ Hz where R is resistance in ohms is Capacitance in microfarads.

Procedure: The circuit connections are made as shown in the figure 2. The output of the AF signal generator is kept constant (1 volt). Now keeping generator voltage constant increases the frequency and the output voltage is taken at each stage.

Graph: A graph is drawn between frequencies and gains taking frequencies on X-axis and gain on Y-axis.



Observations:

S.No.	**Frequency (kHz)**	**Input voltage V_I (volts)**	**Output voltage V_o (volts)**	**Gain (V_o/V_I)**

Precautions:

1) All the connections must be made as per the circuit given.

2) The observations are taken carefully.

3) The input voltage must be kept constant for each measurement.

Result:

The frequency response characteristics of Twin-T-filter are studied and the cutoff frequency is f_c(theoretical) =

f_c(Experimental) =

EXPERIMENT - 3

NEWTON'S RINGS

Aim: To determine

a) The wavelength of Sodium Vapour lamp

b) The radius of curvature of the surface of the lens by forming Newton's Rings.

Apparatus:

Newton's rings set and plane mirror. Convex lens of large radius of curvature, a perfectly plane glass plate, black paper, travelling microscope, reading lens, sodium vapour lamp, reflecting glass plate fixed at a small stand.

Theory:

Let R be the radius of curvature of the surface of lens in contact with glass plate (P_i)

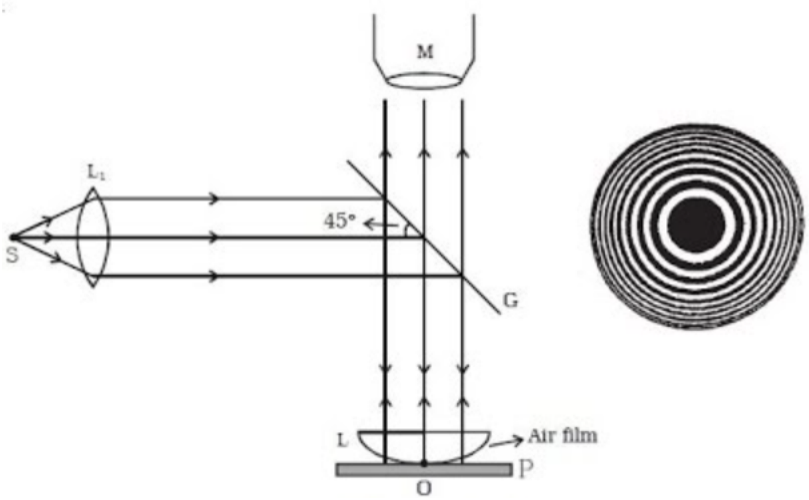
D_1 – diameter of the n_1^{th}ring

D_2 – Diameter of the n_2^{th} ring

Then the relation is given as the wave length of light

$\lambda = (D_2^2 - D_1^2)/4R(n_2 - n_1)$ ----- (1)

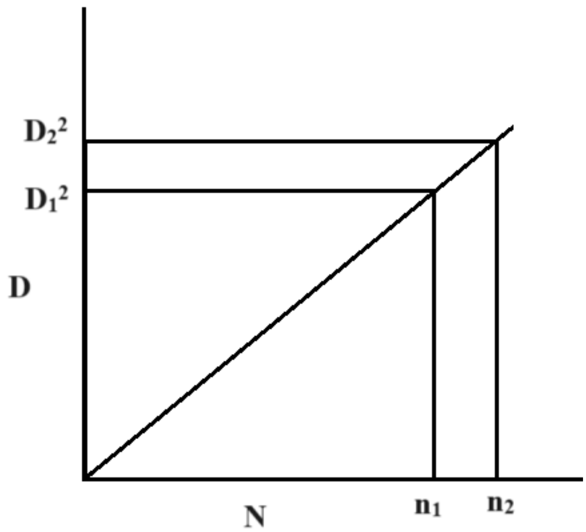
The radius of curvature of the lens determined with spectrometer the values D_1 and D_2 are very small and occur to the second power in equation (1). Hence, they are measured carefully with travelling microscope. Newton Ring is a series of concentric light and dark colored bands observed between two pieces of glass when one is convex and rests on its convex side on another piece having a flat surface. Thus, a layer of air exists between them. This phenomenon is caused by the interference of light waves i.e., the superimposing of trains of waves so that when their crests coincide the light is brightness but when trough and crest meet, the light is destroyed (dark). Light waves reflected from both bottom and top surfaces of air film between two pieces of glass interference. The interference is in constructive and reflected waves 180^o out of phase dark fringe is observed.



Procedure:

The apparatus consists of a light source. The light form it is rendered parallel by means of a convex lens the parallel rays are incident on a plane glass plate through the magnifying glass plate incident at 45 to the path of incident rays. Alternative bright and dark rings can be observed through a travelling microscope brought to the center of ring system. Bring the cross wires on one of the rings by moving travelling microscope, say left across the field of view counting the number of rings. After passing beyond 25^{th} ring the direction of motion of the microscope is observed and cross wire is set at the 20^{th} dark ring tangential to it. Note the reading on the microscope scale. Similarly the readings with the cross wires set on 18^{th}, 16^{th}, 14^{th}, 12^{th} etc dark rings are to be noted. Movethe microscope in the same direction and note the readings corresponding to the 2^{nd}, 4^{th}, 6^{th}, etc dark rings on the right side. Readings are to be taken without moving the microscope and avoid errors due to backlash. Record the observations in table. Take the plano-convex lens out from the travelling microscope and determine the radius of curvature by a spectrometer.

Draw a graph with number of rings on X-axis and square of diameter of the rings on Y-axis. The nature of the graph will be a straight line as shown in the figure below.



From the graph, note the values of D_{12} and D_{22} for corresponding two numbers n_1 and n_2. Using these values in equation (1) the above source L can be calculated to determine the radius of curvature R of the lens. Use standard tables for value of the wave length of the source.

Observations:

S. No.	No. of Rings	Readings of Microscope								Diameter of the Ring	D^2
		Left				Right					
		MSR	VC	VC x LC	Total	MSR	VC	VC x LC	Total		

Precautions:

1) Preliminary adjustments of the telescope must be done prior to the experiment.

2) Don't disturb the setup of Newton's Rings till the experiment is completed.

3) Cunt the rings without parallel axis error.

Results:

a) The wavelength of Sodium lamp λ =

b) The radius of curvature of the plano convex lens from graph is

EXPERIMENT - 4

DIFFRACTION GRATING - NORMAL INCIDENCE

Aim:

To determine the wavelength of a given light radiation using diffraction grating with normal incident method.

Apparatus:

Spectrometer, mercury vapour lamp, Diffraction grating, reading lens and spirit level.

No. of rulings per inch on the grating is 15,000

1 inch = 0.0254 metre

N = $\frac{15000}{0.0254}$ = 590551.181 = 5905

N = 5.9 $\times 10^5$ lines/metre

Principle:

At normal incidence,

Sinθ = N n λ where

θ = angle of diffraction

N = No. of lines per meter of the grating

n = order of the spectrum

and λ = Wavelength of light used in metre.

Having found the value of N, the wavelengths of found the value of N, the wavelengths of the other prominent lines can be determined using the formula,

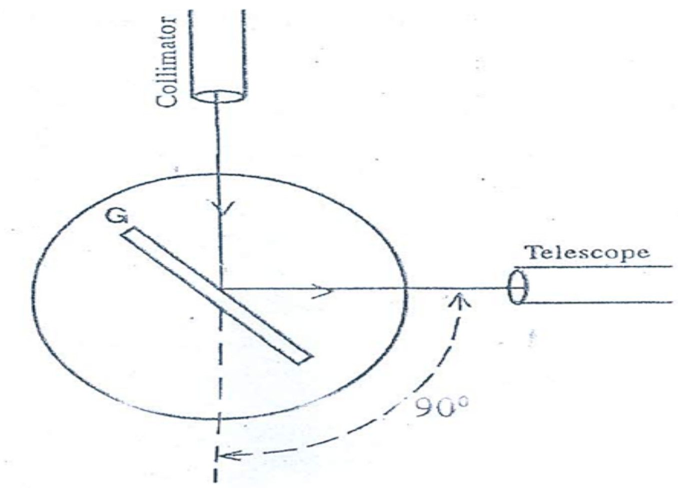
λ = Sinθ /n N

Procedure:

1) TO ARRANGE THE GRATING FOR NORMAL INCIDENCE:

The preliminary adjustments of the spectrometer are made. The slit is made narrow. The telescope is brought in line with the collimator. The telescope is adjusted so that the point of intersection of the cross-wires coincides with the fixed edge of the image of the slit. The telescope is then clamped. The vernier table is unclamped and adjusted so that the reading of vernier I is 0 deg and the reading of vernier II is 180 degThe vernier table is then clamped. The telescope is then unclamped and rotated exactly through 90 deg and then clamped. The grating is then mounted on the grating table, with it's ruled surface facing the collimator. The grating table alone is rotated so that the reflected image of the slit coincides with the point of intersection of the cross-wires. The reflected image will be white in colour. (There may be two reflected images. The brighter one is chosen.) Now the angle of incidence is 45 deg

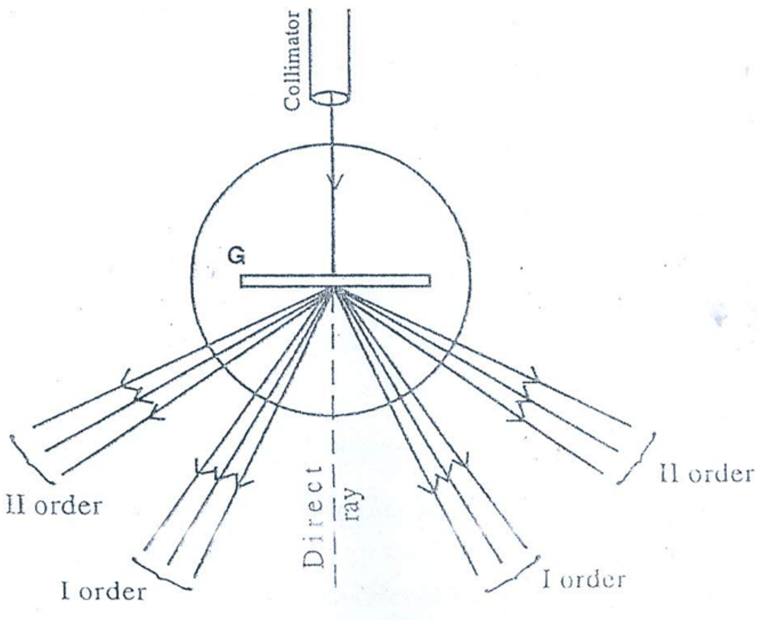
The vernier table is now unclamped and rotated exactly through



45° in such a direction that the ruled surface of the grating faces the collimator. The vernier table is then clamped. The grating is now in the normal incidence position.

2) TO STANDARDISE THE GRATING:

The telescope is unclamped and brought in line with the collimator. The direct image of the slit (white in colour) is observed. From this position, the telescope is slowly rotated towards left. The first order spectrum of mercury light is observed. The telescope is adjusted so that the cross-wire coincides with the green line. The readings of vernier I and vernier II are noted. The telescope is then rotated to the right of the direct image and adjusted so that the cross-wire coincides with the green line of the first order spectrum in the right. The readings of vernier I and vernier II are noted. The difference in readings of the corresponding verniers on the left and the right sides is determined. The average value of the difference gives 20. Then the angle of diffraction for the first order green line, θ, is found. Assuming the wavelength of green line



3) TO DETERMINE THE WAVELENGTHS OF THE OTHER LINES.

The angles of diffraction for the different lines in the first order spectrum are determined as before. Then, the corresponding wavelengthsare calculated using the formula,

$\lambda = (\sin \theta) / (Nn)$

where n=1 for the first order.

The experiment is repeated for the second-order spectrum (n=2) also. The mean wavelengths of different lines are found.

Telescope Reading of Spectrum										
S.No.	**Colour**	**Left**			**Right**			$\boldsymbol{\theta_1 = \frac{V_1 - V_1}{2}}$	$\boldsymbol{\theta_2 = \frac{V_2 - V_2}{2}}$	$\boldsymbol{\theta}$
		MSR (deg)	**VSR (Sec)**	**Total**	**MSR (deg)**	**VSR (Sec)**	**Total**			
1	Green V_1 V_2									
2	Yellow V_1 V_2									
3	Violet V_1 V_2									
4	Orange V_1 V_2									

Calculations:

Green:

$\lambda = (\sin \theta) / (Nn)$

Yellow

$\lambda = (\sin \theta) / (Nn)$

Violet

$\lambda = (\sin \theta) / (Nn)$

Orange

$\lambda = (\sin \theta) / (Nn)$

Precautions:

1) The grating should not be touched with hand or rubbed.
2) It should always be held by means of fingers kept on the opposite edges of the grating.
3) Grating should be perfectly normal to the axis of the collimeter.
4) The turn table must be levelled optically. The slit should be as narrow as possible.
5) All the preliminary adjustments of the spectrometer must be made before starting the experiment.
6) While taking observations the turn table must remain clamped.
7) Readings for both the Verniers should be taken.

Results:

The wavelength of different colours are by the diffraction grating normal incidence method are determined.

EXPERIMENT - 5

THERMISTOR

Aim: To draw the resistance versus temperature and voltage - current characteristics of a given thermistor.

Apparatus: Thermistor, Heating bath, Thermometer, Voltmeter, Ammeter.

Theory: Thermistors are semiconductors, which act as temperature sensitive devices and exhibit negative temperature coefficient of resistance. i.e, the resistance of thermistor decreases as temperature is increased. Commercial thermistor consists of sintered mixtures of oxides NiO, Mn_2O_3 and Cr_2O_3. As the temperature increases more charge carriers are liberated which results in increased conductivity. The decrease in resistivity of thermistor follows as exponential curve with temperature. Thermistor finds its applications in thermometry in measurement of microwave frequency power, as a thermal relay (sensors) and in control devices. The resistance of a given thermistor varies with temperature according to the relation $R = Ae^{B/T}$

Where A and B are constants and T is absolute temperature. The constants A and B are characteristics of thermistor used. Taking logarithms on both sides

$\log_e R = \log_e A + (B/T)$

$2.303 \log_{10} R = 2.303 \log_{10} A + (B/T)$

$\log_{10} R = \log_{10} A + 0.4343(B/T)$

A graph is drawn between $\log_{10}$ R and (1/T) It is a straight line graph as shown in figure 2. The slope XY/YZ gives the value of 0.4343 B. Hence B can be calculated. The constant A can be calculated from the formula $\log_{10} A = \log_{10} R - 0.4343(B/T)$.

By finding R at a known temperature T and substituting the value of B in the above equation A can be found.

Circuit Diagram:

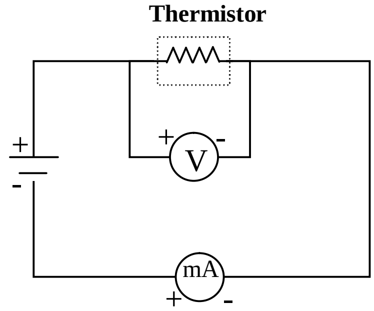


Fig (a)

Procedure:

Make the connections as per circuit diagram. Insert thermometer in the socket provided on the front panel. Keep D.C voltage selector to 5V. Switch ON the D.C supply as well as heater. Note down the ammeter reading for equal and sufficient intervals of time.

Graph:

Plot the graph between resistance of thermistor and temperature.

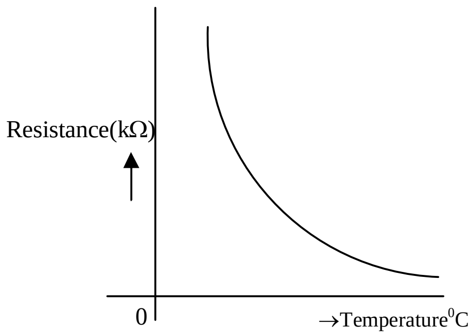


Fig. 1

A graph is drawn. between $\log_{10}R$ and (1/T) It is a straight line graph as shown in figure 2. From the graph the vales of A and B are calculated. The voltage-current characteristics can be studied by drawing a graph between varying voltage and current noted. The graph is as shown in fig.3, which is a non-linear indicating that thermistor is a non-Ohmic device.

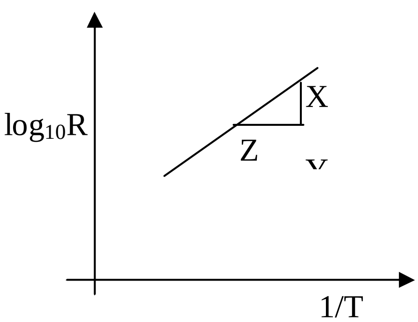


Fig. 2

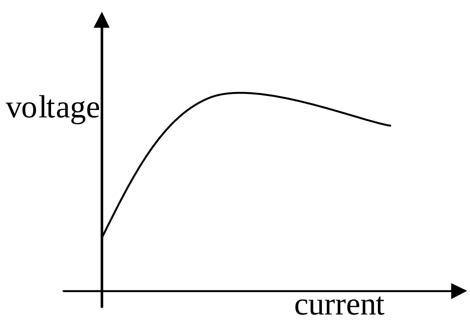


Fig. 3

Observation Table:

S.No.	Temperature ^{0}C	Voltage(V)	Current (mA)	Resistance (kΩ) R=V/I

Precautions:

1) The connections should be done carefully.
2) The resistance should be noted carefully.
3) Do not over heat the thermistor.
4) Handle the thermometer carefully.

Result:

Resistance versus Temperature characteristics of a given thermistor has been studied.

EXPERIMENT - 6

MESH METHOD ANALYSIS

AIM:

To identify the theoretical and practical values of mesh method analysis.

Apparatus:

Two resistors (2.2 kΩ), Variable resistance (0.1 to 1 kΩ), DC regulator power supply (0-20 V), connecting wires and multimeter.

Formula:

$$I_1 = \frac{-I_1 R_3}{R_1 + R_2}\ \mu A$$

$$I_2 = \frac{V(R_1 + R_3)}{R_1 R_2 + R_2 R_3 + R_3 R_1}\ \mu A$$

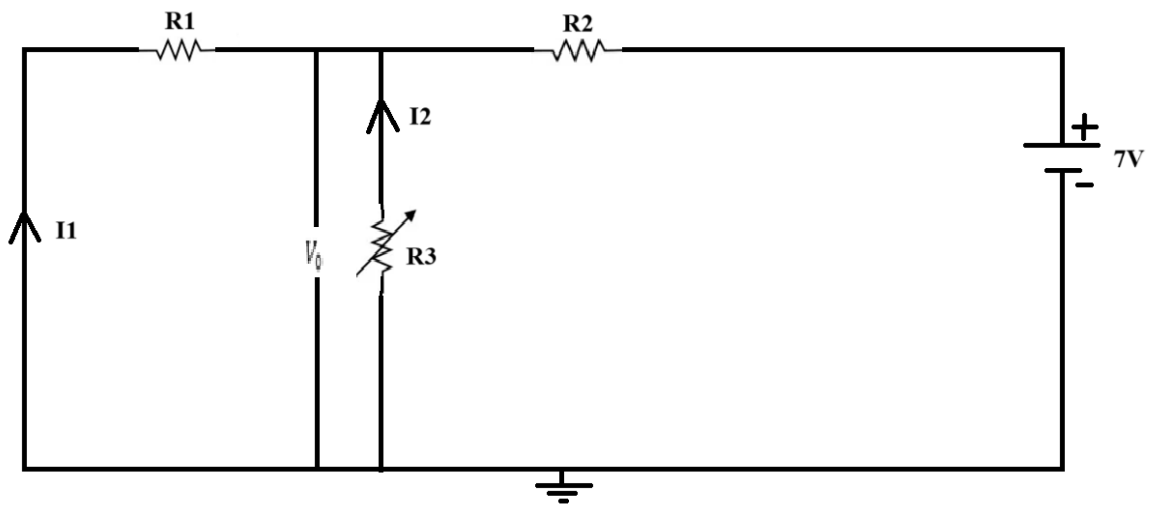
I_1, I_2 = Current

R_1, R_2 = resistors of 2.2 kΩ

R_3 = Variable resistor

V = Volume

Circuit Diagram:



From the Circuit:

$$V = I_1 R_3 + I_2 (R_2 + R_3)$$

$$I_1 = \frac{-I_1 R_3}{R_1 + R_2} \mu A \qquad (1)$$

$$I_2 = \frac{r(R_1 + R_3)}{R_1 R_2 + R_2 R_3 + R_3 R_1} \mu A \qquad (2)$$

Kirchoff's postulates theorem they are

1) Kirchhoff's current law (1^{st} law)
2) Kirchoff's voltage law (2^{nd} law)

Kirchhoff's Current Law:

The algebraic sum of all currents entering into junctions is equal to the sum of the all currents leaving into the junctions.

Kirchoff's Voltage Law:

The algebraic sum of the potential is zero.

By using these two theorems we can calculate the voltage across the R_3 the circuit diagram shows mesh method analysis.

Calculation:

Precautions:

1) Carefully connect the circuit as per the circuit diagram.
2) Loose connections should be avoided.
3) The power supply should be switched off while connecting the circuit and before the circuit.
4) There should be no short circuit while connecting the circuit.

Result:

The theoretical and practical values of mesh method analysis are verified.