GENERAL PHYSICS (SPECTROSCOPY)
PRACTICAL - I
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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 Semester-II

PRACTICAL- I, Paper-V

205PH24-General Physics (Spectroscopy)

1. LC Lowpass and High pass filter
2. RC Lowpass and High pass filter
3. Network Theorem
4. Elastic Constant
5. Ultrasonic Interferometer
6. Cauchy's Constant
7. Diode Laser

CONTENTS

Experiment.1

High & Low Pass LC RF Filter Design

Aim: 1) To Design the LC high pass and low pass filter.

2) To Calculate the lower cut off and higher cut-off Frequency.

3) To Calculate the gain .

Equipment's Required:- 1) Function Generator 2) Bread Board 3) DSO
Components required:-Inductor (1mH) Capacitors(0.01 uF)

Both high and low pass filters are widely used within RF circuits - also for RF applications they are normally based around both inductors and capacitors.

These LC filters provide much better performance than just RC filters and accordingly they tend to be used for RF applications.

The design of both low and high pass LC filters can be relatively straightforward. However when using the tabular approach with tables of values scaled for the particular frequency and impedance, the low pass filter design is normally the starting point, and this is transformed to provide the equivalent high pass filter.

Low pass filter design techniques

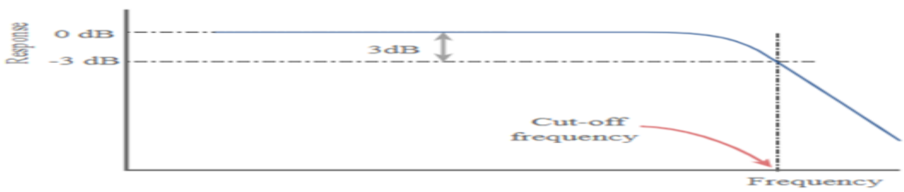
When designing either a high or low pass RF filter, normally a low pass filter forms the starting point. If a high pass filter is required the low pass configuration is transformed to provide the high pass filter design.

Once the basic design has been achieved, the high pass filter design can then be effected by easily transforming the values to give the required high pass filter functionality.

By using the low pass filter design as the starting point for high pass filters, the number of tables required for the design of any given level of performance can be halved. The transformation from low pass filter design to high pass is relatively straightforward and cut the number of tables required by half.

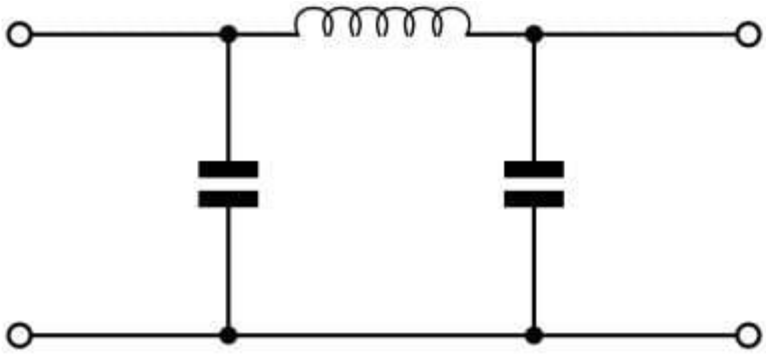
High & low pass filters

In many respects low pass and high pass filters are the inverse of each other. The low pass filter passes signals below the cut-off frequency, and not appreciably attenuating the signal within the pass-band as shown.



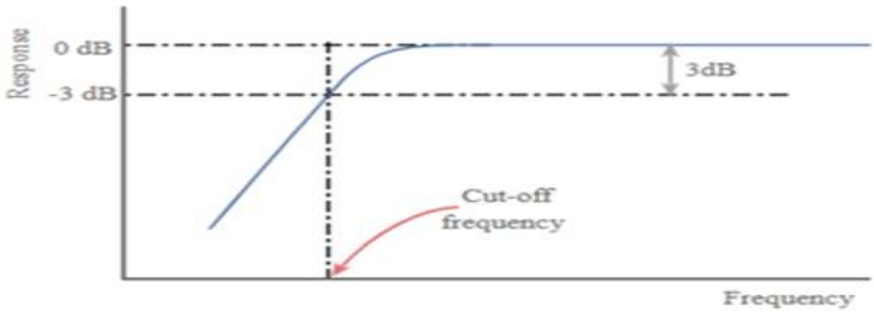
Low Pass Filter Response

To provide a low pass response, the filter typically has series inductors and parallel capacitors. A Pi (Π) section would look like that in the diagram below.



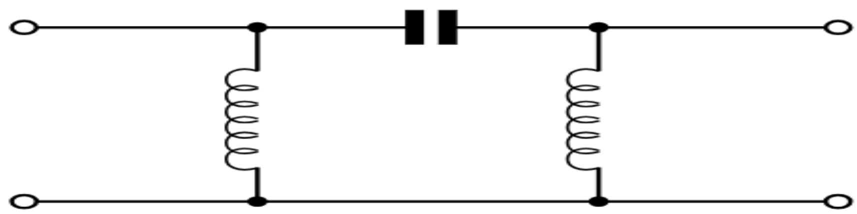
Generic 3 pole LC low pass RF filter

Conversely a high pass filter passes signals above the cut-off frequency, and attenuates those below it as shown.



Generic high pass filter response

To produce the high pass response, the inductors and capacitors are exchanged from the low pass filter to form the high pass filter. Accordingly there is a series capacitor, and two inductors from the line to ground.



Generic 3 pole LC high pass RF filter

In view of the similarities, the design and values are linked. Accordingly it has been possible to only generate the table of values for low pass filters and then transform them for the

High pass filter design basics

Although there are programmes that will enable the design of a high pass filter circuit, often a more manual method may be required. The typical approach that is used is to design a low pass filter, and then transform this to a high pass filter design.

Circuit design software

When choosing the basic requirements for the high pass filter design, elements such as in-band ripple will remain the same.

It is possible to utilise the same response curves by inverting the f/fc axis. This is because the response of the high pass filter is the inverse of the low pass filter in frequency terms. In other words in a high pass filter design, it is necessary to measure the attenuation at frequencies at a proportion below the cut-off frequency rather than above the cut-off frequency. For example an attenuation level at 1/2 the cut-off frequency may be required for a high pass filter design rather than 2 times the frequency.

Using this information and any other it is possible to find a response that satisfies the requirements. The next stage is to determine the values of the circuit elements for the normalised low pass filter version. $X_L = X_C$

$$\omega L = 1/\omega C$$

$$f_C = 1/2\pi\sqrt{LC}$$

Bandwidth cut off frequency measurement (LPF and HPF)

V_{in} = 10 Volt (pk-pk)	Frequency(f_{in})	V_{out}	Gain in dB
	50Hz		
	100Hz		
	500Hz		
	1Khz		
	2khz		
	3KHz		
	4Khz		
	5KHz		
	6KHz		
	7KHz		
	8KHz		
	9KHz		
	10KHz		

Calculated fc= 1/2π$\sqrt{LC}$		**Measured fc**	
Lowpass	**Highpass**	**Lowpass**	**Highpass**

Results:

The LC high pass and low pass filter is designed,

lower cut off frequency =

and higher cut-off frequency =

and gain =

Experiment.2

Design of RC low Pass Filter and High Pass Filter

Aim: 1) To Design the high pass and low pass filter.

2) To Calculate the lower cut off and higher cut-off Frequency.

3)To Calculate the gain.

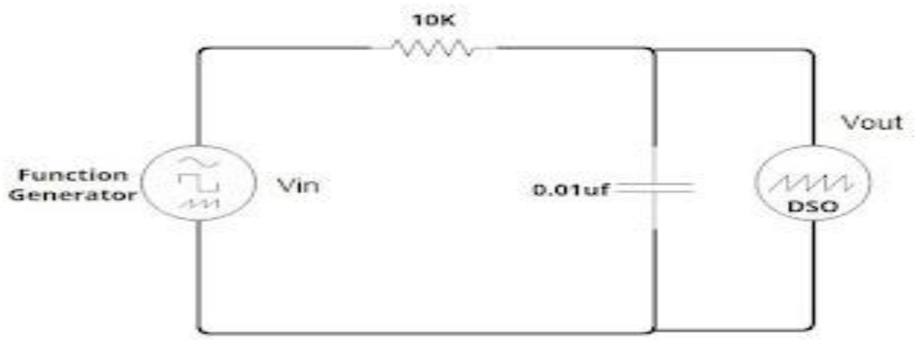
Equipment's Required:- 1) Function Generator 2) Bread Board 3) DSO

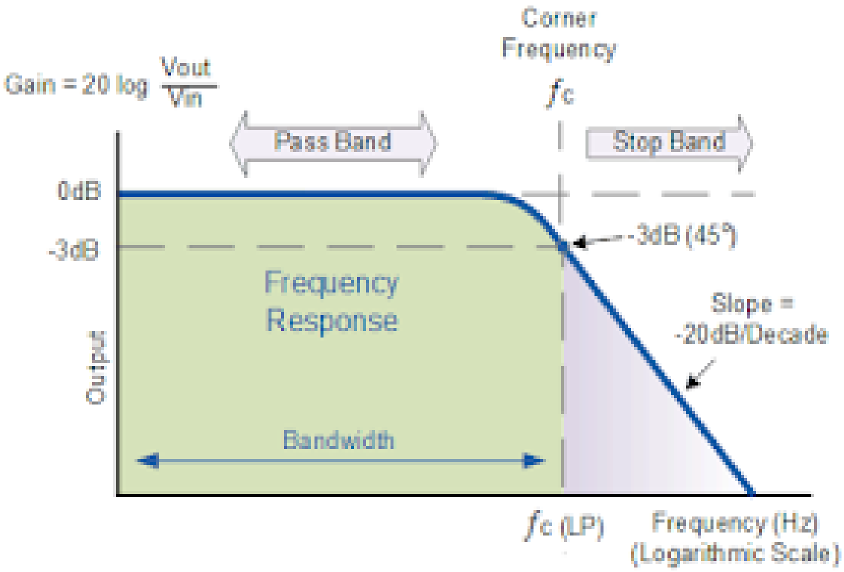
Components required:- Resistors (10K) Capacitors (0.01 uF)

Theory:-A **filter** is a circuit that passes a specific range of frequencies while rejecting other frequencies. A **passive filter** consists of passive circuit elements, such as capacitors, inductors, and resistors. The most common way to describe the frequency response of a filter is to plot the filter voltage gain (V_{out}/V_{in}) in **dB** as a function of frequency **(f).** The frequency at which the output power gain drops to **50%** of the maximum value is called the **cut-off frequency (f_c).** When the filter **dB** voltage gain is plotted as a function of frequency on a semi log graph using straight lines to approximate the actual frequency response, it is called a **Bode plot.** A Bode plot is an ideal plot of filter frequency response because it assumes that the voltage gain remains constant until the cut-off frequency is reached. The filter network voltage gain in **dB** is calculated from the actual voltage gain **(A)** using the equation $A_{dB} = 20 \log A$ where **A** = V_{out}/V_{in}.

Circuit Diagram

Low pass filter





A **low-pass filter (LPF)** is designed to pass all frequencies below the cut-off frequency and reject all frequencies above the cut-off frequency. It is simply an RC series circuit across the input, with the output taken across the capacitor. At the cut-off frequency, the capacitive reactance of capacitor C is equal to the resistance of resistor R, causing the output voltage to be 0.707 times the input voltage (-3 dB). The expected cut-off frequency (f_c) of the low-pass filter based on the circuit component values, can be calculated from

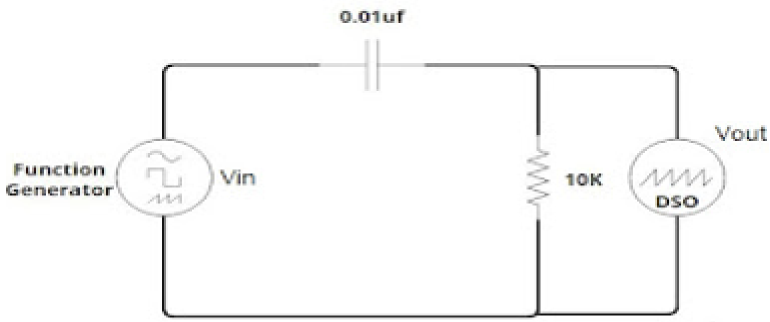
$$X_c = R$$

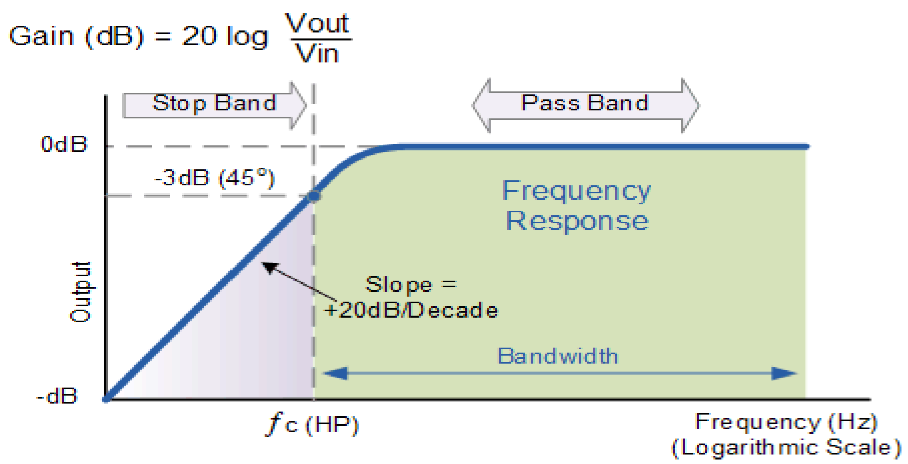
Solving for f_c produces the equation

$$f_c = \frac{1}{2\pi RC}$$

A **high-pass filter** (HPF) is designed to pass all frequencies above the cut-off frequency and reject all frequencies below the cut-off frequency.It is simply an RC series circuit across the input, with the output taken across the resistor. Similar to LPF expected cut-off frequency (f_c) of the HPF is given as

$$f_c = \frac{1}{2\pi RC}$$





PROCEDURE

1. Set up the circuit as shown taking the output across the capacitor (For HPF set the circuit as shown and take the output across resistor). The input for the filter is taken from output of function generator. The output is connected to channel 2 of the DSO.
2. Vary the frequency of the input signal over a wide frequency range (but keep the input amplitude fixed). Note the Values of V_{out} for each frequency and calculate the corresponding Gain.
3. Plot the values of Gain vs Frequency in a semi-log graph paper and find out the cut-off frequency from it (higher cut-off for LPF and lower cut-off for HPF).

Bandwidth cut off frequency measurement (LPF and HPF)

V_{in} = 10 Volt (pk-pk)	Frequency (f_{in})	V_{out}	Gain in dB
	50Hz		
	100Hz		
	500Hz		
	1Khz		
	2khz		
	3KHz		
	4Khz		
	5KHz		
	6KHz		
	7KHz		
	8KHz		
	9KHz		
	10KHz		

Calculated fc= 1/2πRC		**Measured fc**	
Lowpass	**Highpass**	**Lowpass**	**Highpass**

Results: The RC high pass and low pass filter is designed,

lower cut off frequency =

and higher cut-off frequency =

and gain =

Experiment No. 3

VERIFICATION OF NETWORK THEOREMS

(A) VERIFICATION OF THEVENIN'S THEOREM

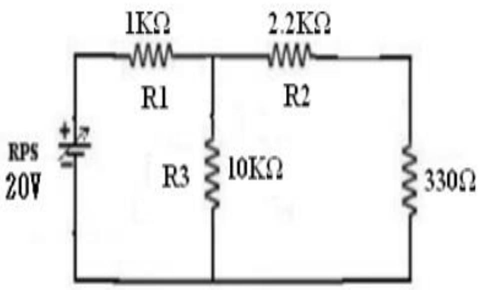
Aim : To verify Theremin's theorem for the given circuit.

APPARATUS REQUIRED:

S.No	Name of The Equipment	Range Type	Quantity
1	Voltmeter	(0-20)V Digital	1 NO
2	Ammeter	(0-20)mA Digital	1 NO
3	RPS (regulated power supply)	0-30V Digital	1 NO
4	Resistors	10K Ω,1K Ω	1 NO
		2.2Ω	1 NO
		330 Ω	1 NO
5	Breadboard	- -	1 NO
6	DMM (digital multi meter)	- Digital	1 NO
7	Connecting wires Required number		

CIRCUIT DIAGRAM:

GIVEN CIRCUIT:



PRACTICAL CIRCUIT DIAGRAMS: TO FIND I_L:

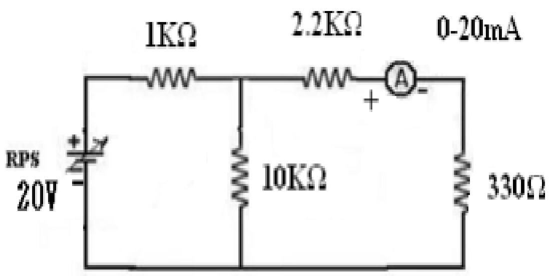


Fig.1

TO FIND V_{Th}

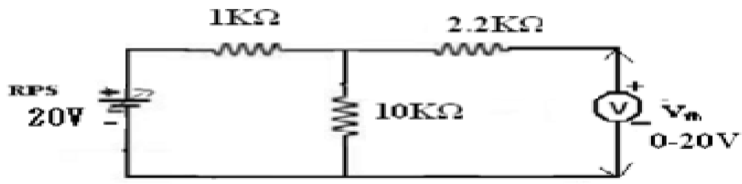


Fig.2

TO FIND R_{th}

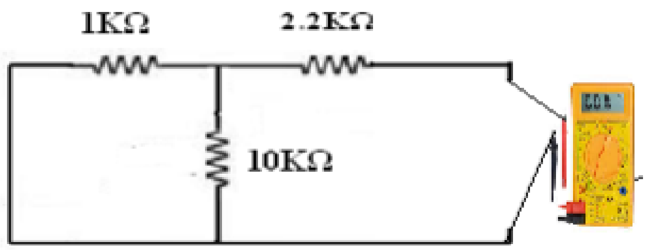
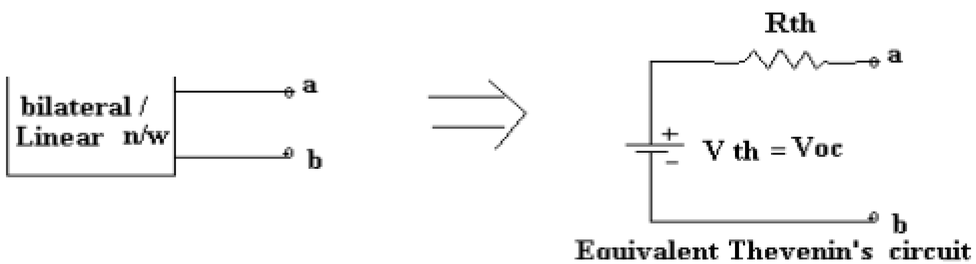


Fig.3

THEORY:

THEVENIN'S THEOREM: Thevenin's theorem states that any two terminal linear network having a number of voltage sources and resistances can be replaced by a simple equivalent circuit consisting of a single voltage source in series with a resistance, where the value of the voltage source is equal to the open circuit voltage across the two terminals of network, and resistance is equal to the equivalent resistance measured between the terminals with all the energy sources are replaced by their internal resistance.



V_{th} = Open-circuit voltage
R_{th} = Equivalent Thevenin's Resistance seen from the output terminals

Thevenin's Theorem

The values of V_{Th} and R_{Th} are determined as mentioned in Thevenin's theorem. Once the Thevenin equivalent circuit is obtained, then current through any load resistance R_L connected across AB is given by:

$$I = \frac{V_{Th}}{R_{Th} + R_L}$$

Thevenin's theorem is applied to d.c. circuits as stated below:

Any network having terminals A and B can be replaced by a single source of e.m.f. V_{Th} in series with a source resistance R_{Th}:

1. The e.m.f V_{Th} is the voltage obtained across the terminals A and B with the load, if any, removed; i.e., it is the open-circuited voltage between terminals A and B.
2. The resistance R_{Th} is the resistance of the network measured between the terminals A and B with the load removed and sources of e.m.f replaced by their internal resistances. Ideal voltage sources are replaced with short circuits and ideal current sources are replaced with open circuits.

To find V_{Th}, the load resistor R_L is disconnected, then:

$$V_{Th} = \frac{V}{R_1 + R_2} \times R_3$$

To find R_{Th}:

$$R_{Th} = R_2 + \frac{R_1 R_3}{R_1 + R_3}$$

Thevenin's theorem is also called "Helmholtz Theorem."

PROCEDURE:

1. Connect the circuit as per fig (a)
2. Adjust the output voltage of the regulated power supply to an appropriate value (Say 20V).
3. Note down the response (current, IL) through the branch of interest i.e. AB (ammeter reading).
4. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
5. Disconnect the circuit and connect as per the fig (2).
6. Adjust the output voltage of the regulated power supply to 20V.
7. Note down the voltage across the load terminals AB (Voltmeter reading) that gives Vth.
8. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
9. Disconnect the circuit and connect as per the fig (3).
10. Connect the digital multi-meter (DMM) across AB terminals and it should be kept in resistance mode to measure Thevenin's resistance (R_{Th}).

Tabulation for Thevenin's Theorem:

THEORITICAL VALUES (Units)	PRACTICAL VALUES (Units)
V_{th} =	V_{th} =
R_{th} =	R_{th} =
I_L =	I_L =

PRECAUTIONS:

1. Initially keep the RPS output voltage knob in zero volt position.
2. Avoid loose connections.
3. Avoid short circuit of RPS output terminals.

RESULT:

(B) VERIFICATION OF NORTON'S THEOREM

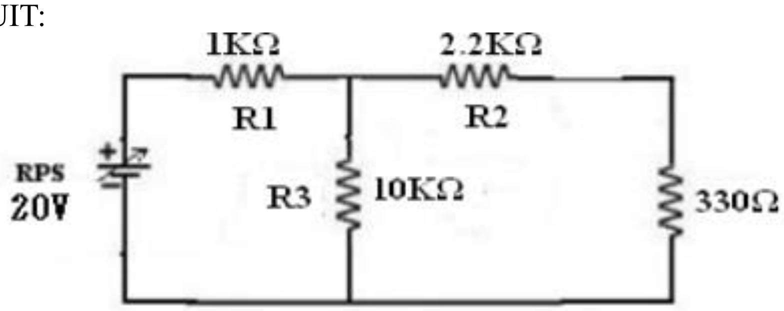
AIM: To verify Norton's theorem for the given circuit.

APPARATUS REQUIRED:

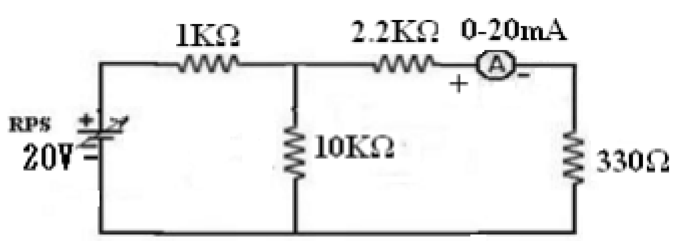
S.NO	Name of the equipment	Range	Type	Quantity
1	Voltmeter	(0-20)V	Digital	1 NO
2	Ammeter	(0-20)mA	Digital	1 NO
3	RPS	0-30V	Digital	1 NO
4	Resistors	10K Ω,1K Ω		1 NO
		2.2Ω		1 NO
		330 Ω		1 NO
5	Breadboard	-	-	1 NO
6	DMM	-	Digital	1 NO
7	Connecting wires Required number			

CIRCUIT DIAGRAM:

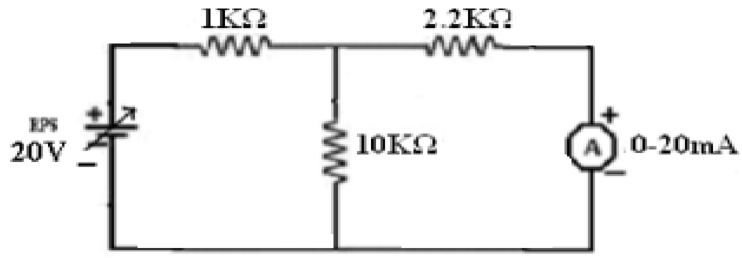
GIVEN CIRCUIT:



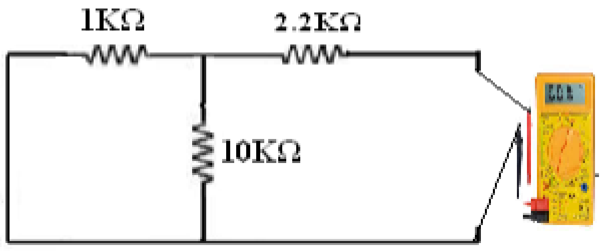
PRACTICAL CIRCUIT DIAGRAMS: TO FIND I_L:



TO FIND I_N:



TO FIND R_N



THEORY:

NORTON'S THEOREM: Norton's theorem states that in a lumped, linear network the equivalent circuit across any branch is replaced with a current source in parallel a resistance. Where the current is the Norton's current which is the short circuit current though that branch and the resistance is the Norton's resistance which is the equivalent resistance across that branch by replacing all the sources with their internal resistances.

For source current

$$I = \frac{V}{R^1} = \frac{V(R_2 + R_3)}{R_1R_2 + R_1R_3 + R_2R_3}$$

For Norton Current

$$I_N = I\ x\ \frac{R_3}{R_3+R_2} = \frac{VR_3}{R_1R_2+R_1R_3+R_2R_3}$$

Load Current through Load Resistor $I_L = I_N$ x $[R_N / (R_N + R_L)]$

PROCEDURE:

1. Connect the circuit as per fig (1)
2. Adjust the output voltage of the regulated power supply to an appropriate value (Say 20V).
3. Note down the response (current, IL) through the branch of interest i.e. AB (ammeter reading).
4. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
5. Disconnect the circuit and connect as per the fig (2).
6. Adjust the output voltage of the regulated power supply to 20V.
7. Note down the response (current, IN) through the branch AB (ammeter reading).

8. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
9. Disconnect the circuit and connect as per the fig (3).
10. Connect the digital multi meter (DMM) across AB terminals and it should be kept in resistance mode to measure Norton's resistance(RN).

Tabulation for Norton's Theorem:

THEORITICAL VALUES (Units)	PRACTICAL VALUES (Units)
V_N =	V_N =
R_N =	R_N =
I_L =	I_L =

PRECAUTIONS:

1. Initially keep the RPS output voltage knob in zero volt position.
2. Avoid loose connections.
3. Avoid short circuit of RPS output terminals.

RESULT:

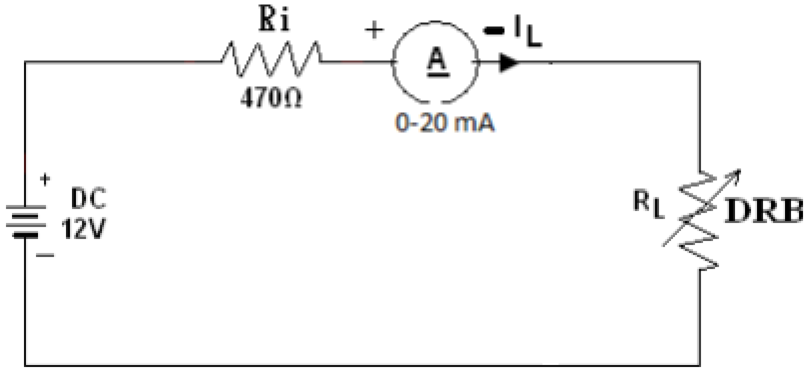
(C) MAXIMUM POWER TRANSFER THEOREM

AIM: To Verify The Maximum Power Transfer Theorem For The Given Circuit

APPARTUS REQUIRED:

SI.	No Equipment	Range	Qty
1	Bread board	-	1 NO
2	DC Voltage source	0-30V	1 NO
3	Resistors	470 Ω	1 NO
4	Decade resistance box	0-10k Ω	1 NO
5	Ammeter	0-20mA	1NO
6	Connecting wires	1.0.Sq.mm	As required

CIRCUIT DIAGRAM:



THEORY:

STATEMENT: It states that the maximum power is transferred from the source to load when the load resistance is equal to the internal resistance of the source. (or) The maximum transformer states that " A load will receive maximum power from a linear bilateral network when its load resistance is exactly equal to the Thevenin's resistance of network, measured looking back into the terminals of network.

Consider a voltage source of V of internal resistance R_i delivering power to a load **Resistance R_L**

Circuit current = $\frac{V}{R_L+R_i}$

Power delivered $P = I^2 R_L$

$$= \left|\frac{V}{R_L+R_i}\right|^2 R_L$$

for maximum poewer $\frac{d(p)}{dt} = 0$

RL+Ri cannot be zero,

Ri – RL = 0

$$R_L == Ri$$

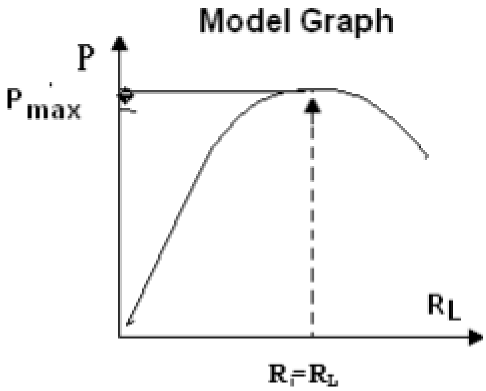
$$\mathbf{Pmax} = \frac{V^2}{4R_L} \text{ watts}$$

PROCEDURE:

1. Connect the circuit as shown in the above figure.
2. Apply the voltage 12V from RPS.
3. Now vary the load resistance (RL) in steps and note down the corresponding
4. Ammeter Reading (IL) in milli amps and
5. Load Voltage (VL) volts
6. Tabulate the readings and find the power for different load resistance values.
7. Draw the graph between Power and Load Resistance.
8. After plotting the graph, the Power will be Maximum, when the Load Resistance will be equal to source Resistance.

TABULAR COLUMN:

S.No	R_L	I_L(mA)	Power(P max) = $I_L^2 * R_L$(mW)



Theoretical Calculations:-
R = (Ri + R_L) = ...Ω

I_L = V / R =…mA

Power = (I_L^2)

RL =…mW

PRECAUTIONS:

1. Initially keep the RPS output voltage knob in zero volt position.
2. Avoid loose connections.
3. Avoid short circuit of RPS output terminals.

RESULTS

Experiment No : 4

ELASTIC CONSTANTS

Aim : To determine the young's modulus, Poisson's ratio, Bulk modulus and Rigidity modulus of the given transparent plate like glass plate/Perspex.

Apparatus : X-Y microscope, H-stand, Transparent plate, double convex lens, knife edges, Weight hanger, Screw gauge, Vernier callipers.

Formula :

1. **Young's modulus of the beam**,

$$Y = \frac{12mgl}{bd^3(m-n)\lambda\left(\frac{1}{K_2} - \frac{1}{K_1}\right)}$$

Where,

l	=	Distance between knife edge and the load suspended
b	=	Mean breadth of glass plate
d	=	Mean thickness of glass plate
λ	=	Wavelength of light used (Sodium)
g	=	Acceleration due to gravity
m	=	Mass attached to the glass plate

2. **Poisson's ratio**:

$$\sigma = \left[\frac{\frac{1}{K_2^1} - \frac{1}{K_1^1}}{\frac{1}{K_2} - \frac{1}{K_1}}\right]$$

K_1 → Mean value of ($\rho_m^2 - \rho_n^2$) in the longitudinal direction for weight "W_1"gms.

K_1^1 → Mean value of ($\rho_m^2 - \rho_n^2$)in the transverse direction for weight "W_1"gms.

K_2 → Mean value of ($\rho_m^2 - \rho_n^2$) in the longitudinal direction for weight "W_2" gms.

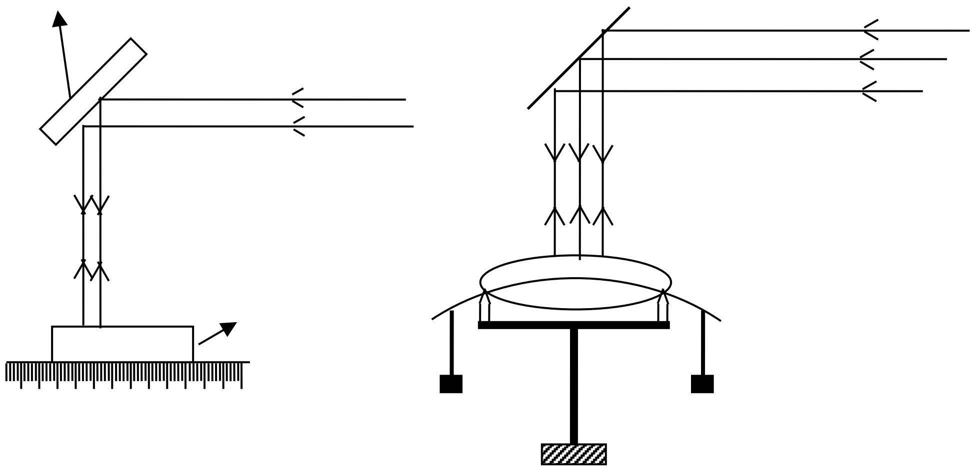
K_2^1 → Mean value of ($\rho_m^2 - \rho_n^2$) in the transverse direction for weight "W_2"gms.

3. **Bulk Modulus :**

$$\eta = \frac{Y}{2(1+\sigma)} Nm^{-2}$$

4. **Rigidity Modulus**: $K = \frac{Y}{3(1+2\sigma)} Nm^{-2}$

Experimental Set up:



Procedure

The experimental glass plate is put over the knife edge such that equal projections are made on either side. Two weight hangers with a load of W_1 = 150 gms are attached to the plate near the edges at equal distances to provide uniform bending. With sodium light elliptical fringes are formed using a convex lens.

Now the microscope is focussed at the centre of the ring system. The microscope is moved so that the cross wire passes over 'n' dark rings (say 30).Then the microscope is moved back and readings are noted for (n-5), (n-10), (n-15) etc., until the central fringe is reached. The microscope readings corresponding to 5, 10, 15, 20 - - - n on the other side of the centre are noted. From these values find $(\rho_m^2-\rho_n^2)$ for m-n = 5. The mean values of $(\rho_m^2-\rho_n^2)$ is noted K_1. Repeat the above procedure in transverse direction and note down as K_1^1.

The experiment is repeated for another load W_2 (say 200 gms), and the mean values are noted as K_2 and K_2^1 for longitudinal and transverse directions.

Observations

Table 1

Longitudinal (K_1^1) W_1 gms L.C =…

Number of Fringes	Micro scope Reading Left(cm)	Right(cm)	Difference 2ρ cm	ρ cm	ρ^2	$(\rho_m^2 - \rho_n^2)$
n+18 n+15 ' " n						

Mean

Table 2 **W_1 gms**

Transverse (K_1^1)

Number of Fringes	Microscope Reading Left(cm)	Right(cm)	Difference 2ρ cm	ρ cm	ρ^2 10^{-4} m^2	$(\rho_m^2 - \rho_n^2)10^{-4}$ m^2
N+18 N+15 ‘ ‘n						
					Mean	

Table 3

Transverse (K_2) W_2 gm

Number of Fringes	Microscope Reading Left(cm)	Right(cm)	Difference 2ρ cm	ρ cm	ρ^2 10^{-4} m^2	$(\rho_m^2 - \rho_n^2)$ 10^{-4} m^2
n+18 n+15 ‘ “ n						
					Mean	

Table 4

W_2 gm

Transverse (K_2^1)

Number of Fringes	Microscope Reading		Difference 2ρ cm	ρ cm	ρ^2 10^{-4} m^2	$(\rho_m^2 - \rho_n^2)10^{-4}$ m^2
	Left(cm)	Right(cm)				
n+18 n+15 “ n						
					Mean	

To find the breadth of the glass plate (b) [using Vernier callipers]

Least count =

S.no	M.S.R	V.S.R	V.S.R×L.C	T.R=M.S.R+(VSC XL.C)
				Mean

To find the thickness of the glass plate (d) [using screw gauge]

Least count=…. Zero Error=….

Zero Correction=….

S.no	PSR×L.C (a)	HSR(b)	T.R (a+b)	CR= TR+ Zero correction
1 2 3 4 5				

Precautions:

1. The lens and glass plate is to be cleaned without dust before doing the experiment.
2. The readings are taken without parallax error.
3. Weights should be added without disturbing the setup.
4. The microscope should be moved in one direction only.

Result:

The Young's modulus of the given beam =

Poisson's ratio =

Bulk modulus of the given beam =

Rigidly modulus of the given beam =

Experiment No. 5

ULTRASONIC INTERFEROMETER

Aim: - (a) To determine ultrasonic velocity in liquids using Ultrasonic Interferometer.

(b) To determine adiabatic compressibility of given liquid.

Apparatus: - Ultrasonic Interferometer, Micrometer, cell, noncorrosive liquids like Benzene (C_6H_6), Carbon tetrachloride (CCl_4), distilled water, measuring jar and beaker.

Working principle:

An ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity in liquids with a high degree of accuracy. The principle used in the measurement of velocity v is based on the accurate determination of the wavelength λ in the medium. Ultrasonic waves of known frequency (f) are produced by large piezoelectric crystal coated corrosive resistant conducting material like gold with fixed at the bottom of the cell. These waves are reflected by the movable the metallic plates kept parallel to the piezoelectric crystal. If the separation between the two plates is exactly a whole multiple of the sound wavelengths, standing waves are formed with in the medium. This acoustic resonance gives rise to electric reaction on the generating piezoelectric crystal and the anode current of the generator become maximum.

If the distance is now increased or decreased, whenever the variation is exactly one-half wavelength ($\lambda/2$) or multiples of it, anode current becomes maximum at those points. The knowledge of separation between two alternate maxima is the wavelength (λ) of ultrasonic wave gives the velocity V by the relation $V = \lambda f$

Description: -

The Ultrasonic Interferometer consists of two parts

i) The high frequency generator that drives the piezoelectric crystal.

ii) The measuring cell with a movable plate 12c.c of liquid is required to fill the cell.

The high frequency generator: - The high frequency generator consists of 2MHz crystal-controlled oscillator and produces a high frequency. The H.T current to the output is fed, through a bridge network including a microammeter in such a way that the changes in the plate current can be observed on the microammeter. There are two controls, of these one is used for sensitivity regulation and other for initial current adjustments.

The measuring cell: -This is connected to the high frequency generator through a shielded cable. In order to perform the experiment at high temperatures a heat jacket is provided. Heating liquid is circulated through the liquid jacket around the liquid chamber.

A piezoelectric crystal is fixed horizontally at the bottom of the measuring cell. The Ultrasonic waves move normally from this crystal and is reflected back from the movable plate.

Standing waves are formed in the liquid, in between the reflected plate and piezoelectric crystal. This reflector plate can be raised or lowered by means of a micrometer screw reading up to 0.001cm, keeping its plane parallel to the quartz crystal.

Procedure:

(a) Determination of ultrasonic velocity in liquids:

The experimental liquid is poured in to the cell. The micrometer screw is slowly moved up and down till the microammeter shows a maximum and the reading is noted. The distance between the crystal and the reflected plate is now an integral multiple of the half wavelength of the wave. Now moving the screw displaces the reflector plate and the Position of the next maxima is noted. Like these five or six readings are noted and their readings are tabulated. The total distance moved by the reflector is then given by d= n.λ/2 where n is the no. of maximas, wavelength λ can be calculated from the notation λ =2.d/n

The frequency f of the high frequency generator is 2 M Hz. (in the present case); the velocity V of Ultrasonic waves in the liquid can be calculated according to relation

Velocity = wavelength X frequency. V= λ *f*

(b) Determination of adiabatic compressibility of given liquid

1. Determine the ultrasonic velocity of the given liquid at room temperature using the above method.
2. Determine the density (ρ) of the liquid following any standard method. Check whether it is agreeing with the standard value given in the Lange's tables.
3. The adiabatic compressibility is related to the Ultrasonic velocity by the relation

$$V = \sqrt{\frac{1}{\beta_{ad}\rho}}$$

Taking the ratio of specific heats as known (for any standard liquid), the isothermal compressibility can be determined from the relation

$$V = \sqrt{\frac{\gamma}{\beta_{iso}\rho}}$$

Ex: For benzene

	Standard values at temp t^0c	Calculated values at temp t^0c
D		
γ		
β_{iso}		
β_{ad}		

β_{ad} and β_{iso} at different temperatures can be obtained by measuring ultrasonic velocity in the given liquid at various temperatures.

Observations:

Least count of the micrometer screw gauge LC =

S.No.	MSR (a)	PSR X LC (b)	a+b	Distance (d)	λ =2d/n

Precautions:

i) Do not switch on the equipment with the interferometer cell empty.
ii) Do not switch on the equipment unless the shielded R.F cable is connected to the interferometer cell
iii) After using the cell, drain out the liquid and wash the cell with suitable solvent and then with distilled water and completely dry the cell.
iv) Clean the cell with cotton. If there is any sediment, wash the cell with benzene or acetone to remove them. After that use water to flush any remaining matter. Dry the cell and then fill with experimental liquid.
v) Do not use the liquids which may react with the crystal plating or the cell walls.
vi) Do not move the micrometer screw forward and backward quickly as this will produce backlash error. Move the screw slowly in one direction only until all the readings are taken.

Result:

The velocity of given liquid is ………

The adiabatic compressibility is measured to be ……………….

Experiment No. 6

CAUCHY's CONSTANTS

Aim : To determine the Cauchy's constants in the Cauchy's relation using spectrometer and prism

Apparatus : Spectrometer, Mercury vapour lamp, spirit level, prism, telescope, magnifying lens, and mirror.

Principle : The refractive index increases with decrease in wavelength according to the relation This relation is known as Cauchy's relation, where μ is refractive index of

$$\mu = A + \frac{B}{\lambda^2}$$

given material for

The wavelength λ, A and B are constants of the medium to be determined. If μ_1 and μ_2 are refractive indices corresponding to the wavelengths λ_1 and λ_2 respectively. Then

$$\mu_1 = A + \frac{B}{\lambda_1^2} \qquad \mu_2 = A + \frac{B}{\lambda_2^2}$$

Solving the two equations A = $(\mu_1\lambda_1^2-\mu_2\lambda_2^2) / (\lambda_1^2-\lambda_2^2)$ cm^2

B = $(\mu_2-\mu_1)\, \lambda_1^2\lambda_2^2 / (\lambda_1^2-\lambda_2^2)$ cm^2

Knowing μ_1 and μ_2 , λ_1 and λ_2 for any of the spectral colors A and B are calculated.

Procedure

The preliminary adjustments are done for the spectrometer. To determine the angle of the prism, the prism is mounted on the prism table with refracting edge of the prism perpendicular to the axis of the collimator. The position of the telescope is adjusted until the vertical crosswires coincides with the image of the slit. The reading of the Vernier scales is taken. The telescope is now rotated towards the second polished surface of the surface and the vertical crosswires is made to coincide with the reflected image of the slit. The readings of the Vernier scales are taken, the difference of the readings in Vernier 1 and Vernier 2 is equal to 2A. From this we can calculate the angle of prism(A).

Determination of refractive index (μ)

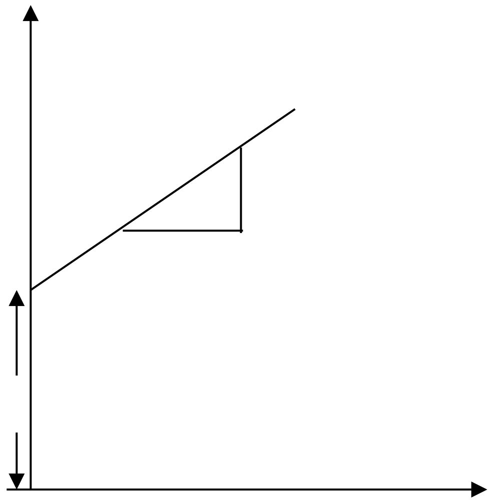
The spectrometer is placed opposite to the source. The width of the slit is adjusted viewing through the telescope. A small mirror strip is attached to the telescope of the spectrometer near over its eyepiece perpendicuType equation here.lar to the axis of the telescope. At a distance of about one meter another telescope is arranged with a horizontal scale.

Now the telescope is focussed on the image of the scale seen in the mirror. The prism is adjusted for portion of minimum deviation so that the violet line of the spectrum is brought into the focus of the telescope and made to coincide with the cross wires of the telescope of the spectrometer. Now looking through the telescope, the scale reading that coinciding with the vertical crosswire is noted.

This experiment is repeated by making the other spectral lines coincide with the vertical crosswire and the corresponding scale reading is noted.

Graph

A graph is drawn between μ and $1/\lambda^2$. Taking $1/\lambda^2$ values on X-axis and μ values on Y-axis. A straight line is obtained. The slope of the straightly line gives the value of "B". The y intercept gives the value of A.



Ray	Ver. A	Ver. B	2A		Mean 2A	A
			Ver. A	Ver. B		
Reflected from One face						
Reflected from other face						

Spectrum Colour	Spectrometer reading		Angle of Min. Deviation		Mean D	μ	Calculated wavelength	Standard wavelength
	Ver. A	Ver. B	Ver. A	Ver. B				
Violet-1								
Violet-2								
Blue-1								
Blue-2								
Green-1								
Green-2								
Yellow-1								
Yellow-2								
Orange-1								
Orange-2								
Red-1								
Red-2								

Calculations

$$S_0 = S_1 - \frac{(S_3 - S_1)}{\dfrac{(\lambda_1 - \lambda_2)(S_3 - S_2)}{(\lambda_2 - \lambda_3)(S_2 - S_1)} - 1}$$

$$C = \frac{(\lambda_1 - \lambda_2)(S_1 - S_0)(S_2 - S_0)}{(S_2 - S_1)}$$

$$\lambda_{ob} = \lambda_1 - \frac{C}{S_1 - S_0}$$

$$\lambda_{cal} = \lambda_0 + \frac{C}{S_1 - S_0}$$

Observations

Least count of the spectrometer = S/N =

To find the angle of prism

Colour	μ	$1/\lambda^2$
Violet		
Blue		
Bluish Green		
Green		
Yellow		
Orange		
Red		

Precautions:

1. The telescope is adjusted by focussing the object perfectly.
2. The spectrometer is adjusted in such a way that the prism table, collimator, telescope are in same plane.
3. Readings are taken without parallax error.

Result:

Cauchy's constants are determined.

	Theoretical values	*Practical values*
	A =	
	B =	

Experiment 7

DETERMINATION OF WAVELENGTH OF Diode LASER

Aim: To determine the wavelength of light from solid state laser (Diode) from diffraction pattern.

Apparatus: Laser source (Diode), grating, scale

Theory: The light from solid state laser is red and monochromatic.

Formula:

$$\theta = \text{Tan}^{-1}\left(\frac{d}{2D}\right)$$

where θ= angle of diffraction

d = distance between centre spot of laser to either side of spot in cm

D = distance between the wall and grating in cm

By this formula we can calculate the angle θ

when a beam of parallel laser is normally incident on the surface of the plane diffraction angle is related to wavelength by equation.

$$\text{Sin}\,\theta = Nn\lambda$$

where n = order of the spectrum

λ = wavelength

N= number of lines per cm

θ= angle of diffraction

Principle: Laser beam is a coherent beam of light from a source. When this coherent beam of light is incident normally on a grating, a diffraction pattern of spots is obtained. The number of spots obtained is related to order of spectrum depends on intensity of laser. By calculating the angle θ, the wavelength of the laser can be calculated.

Procedure: A laser is used as a source of the laser beam. A grating is placed normal to the direction of incidence of the beam. The beam is projected on a wall, which is at a distance of more than one meter. A diffraction pattern with a bright central spot is obtained. Two more spots are observed on each side of the central spot. Now, the distance between the wall to the grating, D, is calculated by means of a scale.

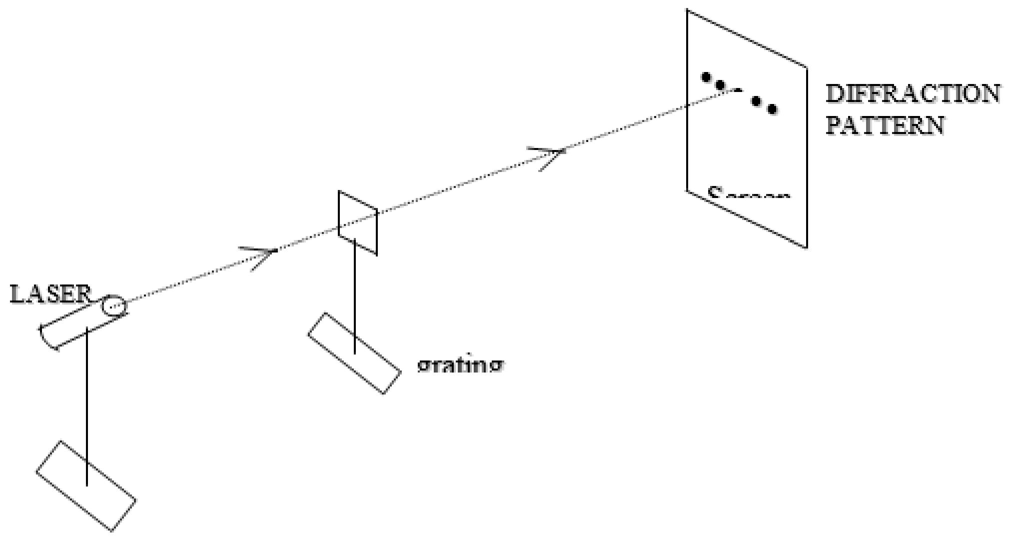
The distance between the central spot to the either side of the spot is also calculated for both 1st ,2nd ,…….nth order spots . Thus, the angle θ is calculated using the formula,

$\theta = \text{Tan}^{-1}(\frac{d}{2D})$.Now the wavelength of laser is given by

$\lambda = \sin\theta / Nn$

N = number of lines per cm on grating=

Standard wavelength of laser =



Observations:

Least Count: = S/N =

S.NO	ORDER	D (cm)	LEFT(d/2) (cm)	RIGHT(d/2) (cm)	MEAN(d/2) (cm)	θ

Calculation: $\theta = \text{TAN}^{-1}(d/2D)$, θ = angle of diffraction,

'd'= distance between centre spot of laser to either side of spot in cm

D- distance between the wall and grating in cm

$\lambda = \frac{\sin\theta}{Nn}$ where n = order of the spectrum, N= number of lines per centimetre in grating.

Precautions:

1. The readings are taken when the spherical lines are in normal incidence position.
2. Readings are taken without parallax error.

Result:

The standard wavelength of laser is 6328 A^0

The calculated wavelength for the 1st order (λ_1)= ,

2 nd order (λ_2) =