

K.T.H.M.College, Nasik

Department of Physics

*S.Y.B.SC.(Physics)
Practical Manual*

Prepared By ---

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Instructions to students in the laboratory

- 1) Student should come equipped with rough record book ,calculator, scales, pencils, white papers, graph sheets, tracing paper etc. for compiling the report and other stationery items required for data recording and analysis.
- 2) Be prepared for your work in the laboratory. Read all procedures thoroughly before entering the laboratory.
- 3) Follow all written and verbal instructions carefully. If you do not understand a direction or part of a procedure, ask your teacher before proceeding with the activity.
- 4) Switch off your mobile in the laboratory.
- 5) When first entering a Laboratory, do not touch any equipment, or other materials in the laboratory area until you are instructed to do so.
- 6) Do not switch on any instrument or circuit unless checked by respective teacher.
- 7) Observe good housekeeping practices. Work areas should be kept clean and tidy at all times.
- 8) Maintain silence in the lab. Work quietly and carefully (the whole purpose of experimentation is to make reliable measurements!) and equally share the work with your partners.
- 9) Student should get their record book checked by respective faculty after completion of experiment.
- 10) No change in timetable or batches is allowed.
- 11) On the very first day of the lab familiarize yourself with the power supply, function generator, oscilloscope, bread board, and digital multi-meter (DMM). Student may request for the copies of respective manual. You may also request the Lab Assistant or the instructor to guide you in learning these basic operations.
- 12) Be honest in recording and representing your data. Never make up readings or manipulate them to get a better fit for a graph. If a particular reading appears wrong repeat the measurement carefully. In any event all the data recorded in the tables have to be faithfully displayed on the graph
- 13) Disconnect circuits & Switch off instruments after completion of experiment.
- 14) Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- 15) Answer all questions posed in the handout. And each experiment's sheet should be checked in respective next week only.
- 16) Multiple violations of the Laboratory Safety Guidelines could result in disciplinary actions, which can include cancellation of admission.
- 17) Any kind of feedback on the improvement of this course is always welcome.

S.Y.B.Sc. (Physics) Practical

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Expt NO.:- 1

**Section- I
LOG DECREMENT**

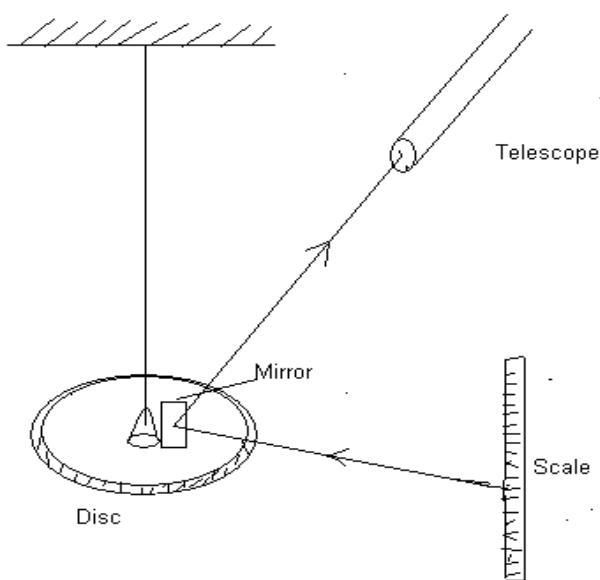
Aim -To determine the log decrement λ in air and in water of Suspended disc.

Apparatus:- Disc with mirror , Telescope, Scale and lamp , Stopwatch etc.

Formula:- The log decrement (λ) is given by

- 1) $\lambda_{\text{air}} = (2.303 / n) \log_{10} (\alpha_1 / \alpha_2)$
- 2) $\lambda_{\text{water}} = (2.303 / n) (1/t) \log_{10} (\alpha_1 / \alpha)$

Diagram:-



Part I:- Log decrement in air

Procedure:-

Arrange the apparatus as shown in fig. Focus the telescope on the mirror and adjust zero. Give the torsional oscillations to the disc and try to bring nearly equal reading on left and right side.

Start the stop watch and immediately record the successive amplitudes from first reading a_1 on the left to right up to a_{20} . Now wait for some time so that amplitude decreases to half of its initial amplitude (i.e. $a_{n+1} = a_1 / 2$) then stop the stopwatch & again record successive amplitude readings from a_{n+1} to a_{n+20} . Also record time in stopwatch (t). Record the reading as shown in the observation table.

Measure time for 20 oscillations and hence determine the periodic time T .

Observations:-

- 1) Periodic time in air $T = \dots\dots\dots$ Sec.
- 2) Time required for the amplitude to fall from a_1 to a_{n+1} (i.e. $a_1/2$) = $t = \dots\dots$ Sec.
- 3) Number of half oscillations (n) from a_1 to $a_{n+1} = n = 2t/T = \dots\dots\dots$

Observation Table:-

Turning Point		Elongation cm	Turning Point		Elongation cm
Left	Right		Left	Right	
$a_1 =$	$a_2 =$	$A_1 = a_1 + a_2 =$	$a_{n+1} =$	$a_{n+2} =$	$A_{n+1} = a_{n+1} + a_{n+2} =$
$a_3 =$	$a_4 =$	$A_2 =$	$a_{n+3} =$	$a_{n+4} =$	$A_{n+3} =$
$a_5 =$	$a_6 =$	$A_5 =$	$a_{n+5} =$	$a_{n+6} =$	$A_{n+5} =$
$a_7 =$	$a_8 =$	$A_7 =$	$a_{n+7} =$	$a_{n+8} =$	$A_{n+7} =$
$a_9 =$	$a_{10} =$	$A_9 =$	$a_{n+9} =$	$a_{n+10} =$	$A_{n+9} =$
$a_{11} =$	$a_{12} =$	$A_{11} =$	$a_{n+11} =$	$a_{n+12} =$	$A_{n+11} =$
$a_{13} =$	$a_{14} =$	$A_{13} =$	$a_{n+13} =$	$a_{n+14} =$	$A_{n+13} =$
$a_{15} =$	$a_{16} =$	$A_{15} =$	$a_{n+15} =$	$a_{n+16} =$	$A_{n+15} =$
$a_{17} =$	$a_{18} =$	$A_{17} =$	$a_{n+17} =$	$a_{n+18} =$	$A_{n+17} =$
$a_{19} =$	$a_{20} =$	$A_{19} =$	$a_{n+19} =$	$a_{n+20} =$	$A_{n+19} =$

$$\alpha_1 = \Sigma A = A_1 + A_3 + A_5 + \dots\dots\dots + A_{19} = \dots\dots\dots \text{ cm.}$$

$$\alpha_2 = \Sigma A_{n+1} + A_{n+3} + A_{n+5} + \dots\dots\dots + A_{n+19} = \dots\dots\dots \text{ cm.}$$

Calculations:- Calculate log decrement in air by using given formula

$$\lambda_{\text{air}} = (2.303/n) \log_{10} (\alpha_1 / \alpha_2)$$

Part II:-Log decrement in water.**Procedure:-**

Immerse the disc in water. Record time for 10 oscillations. Hence calculate periodic time (T) of disc in water. Adjust zero on scale. Give the torsional oscillations to the disc and record successive amplitudes only on one side. (left or right) Plot the graph of amplitude against time. & determine log decrement.

Observation Table:-

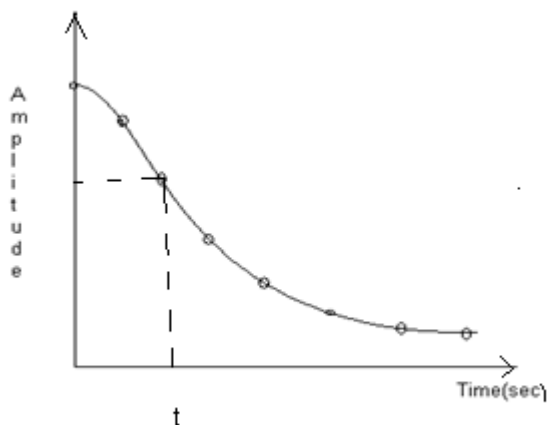
Periodic time in water = $T = \dots\dots\dots$ Sec.

Obs.No.	Time (t) Sec	Amplitude (cm)
1	0 =	$\alpha_1 =$
2	T =	$\alpha_3 =$
3	2T =	$\alpha_5 =$
4	3T =	$\alpha_7 =$
5	4T =	$\alpha_9 =$
6	5T =	$\alpha_{11} =$
7	6T =	$\alpha_{13} =$
8	7T =	$\alpha_{15} =$
9	8T =	$\alpha_{17} =$
10	9T =	$\alpha_{19} =$

Graph and Calculations: - Plot graph of amplitude A (Y-axis) against time t (X-axis) as shown in figure

From graph determine α and t hence calculate λ using given formula.

$$\lambda_{\text{water}} = (2.303 / n) (1 / t) \log_{10} (\alpha_1 / \alpha_2)$$



Result:- 1) Log decrement in air $\lambda_{\text{air}} = \dots\dots\dots$
 2) Log decrement in water $\lambda_{\text{water}} = \dots\dots\dots$

Questions :

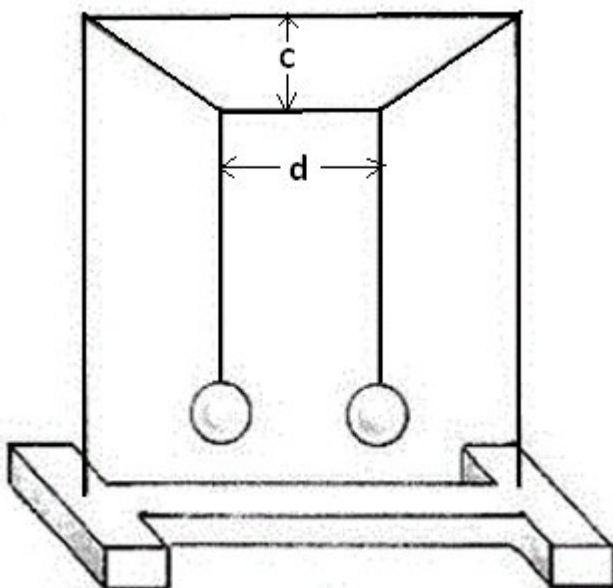
- 1) What are different types of oscillation ?
- 2) Define Log Decrement. What is its unit ?
- 3) What are Torsional Oscillations?
- 4) What are Damped Oscillations?
- 5) Which are damping factors ?
- 6) Define –Periodic Time.
- 7) What are factors on which log decrement depend ?

Expt No: 2**COUPLED OSCILLATOR**

Aim : To study a simple coupled system comprising of two simple pendulums.

Appratus : Two simple Pendulums , Thread, Stopwatch, Meter scale etc

Figure :

**Procedure :**

- 1) Displace both the bobs by equal amount in the same direction and release. The system will go on oscillating with the displacement ratio always remaining in the ratio 1:1 .This is one normal mode. Measure the period of oscillation T_1 by counting 100 oscillations.
- 2) Now displace the two bobs in opposite directions by equal amounts and release. The displacement ratio will now remains $1 : (-1)$. This is second normal mode. Measure the period of oscillation T_2 by counting 100 oscillations.
- 3) Now displace only one bob and release. This is mixed mode. Measure the time for 2 cycles of energy transfer back & forth .Let the period of oscillation be T_3 .Let the corresponding frequencies for the three modes be $\nu_1 = 1/T_1$, $\nu_2 = 1/T_2$, $\nu_3 = 1/T_3$ resp.
- 4) Find $|\nu_1 - \nu_2|$ and verify that it is equal to ν_3 .
- 5) Now vary the parameter c & d and repeat the experiment.

Observation Table :

Ob No	C cm	d cm	Mode			T1 = t1/100 sec	T2 = t2/100 sec	T3 = t3 /2 sec	$v_1 =$ 1/ T ₁ Hz	$v_2 =$ 1/ T ₂ Hz	$v_3 =$ 1/ T ₃ Hz	v ₁ -v ₂ Hz
			I	II	Mixed							
			t 1 sec	t2 sec	t3 sec							
1												
2												
3												
4												
5												
6												
7												
8												

Calculation :

Calculate the corresponding periods & frequencies by using given formula & Compare the frequency difference.

Result :

- 1) Every time , $|v_1 - v_2| = v_3$
- 2) The value of frequency v_3 changes when parameters c & d are changed.

Questions :

- 1) What are coupled Oscillations ?
- 2) What is coupling coefficient ?
- 3) Define-Period & Frequency of oscillation.
- 4) Define SHM.
- 5) What are different modes of Oscillations ?

Expt NO. 3**FREQUENCY OF A.C.**

Aim: - To determine the frequency of AC by using sonometer.

Apparatus: - Sonometer, Magnets, Transformer, Connecting wires, Weights etc.

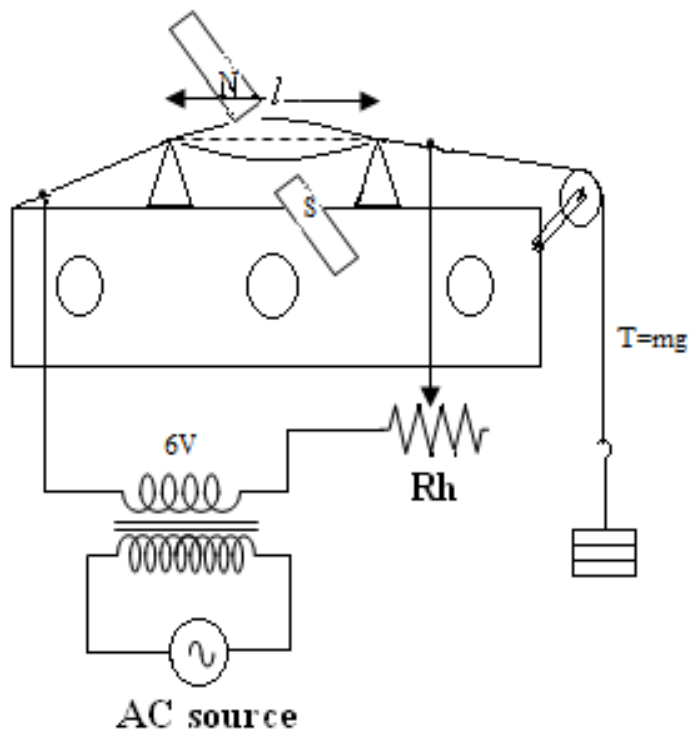
Formula:

The frequency of A.C. main (f) is given by

$$f = \frac{1}{2l} \sqrt{\frac{T}{m}} = \frac{1}{2\sqrt{m}} \left(\text{mean} \frac{\sqrt{T}}{l} \right) \quad \text{by calculation.}$$

$$f = \frac{1}{2\sqrt{m}} \times \text{slope} \quad \text{by graph.}$$

Experimental set up:

**Introduction:**

The experiment requires a metal wire subjected to a known and adjustable tension T . The length l of vibrating segment of the wire can be varied by means of two knife edges or bridges. As already mentioned, a strong magnetic field, perpendicular to the length of wire, is produced by arranging two powerful bar magnets placed horizontally on opposite sides of the wire. Obviously mutually attracting poles of the magnets should be facing the wire. Generally, this experiment is used to determine the frequency of mains A.C. supply. A current of about 2A is required for the experiment. For this, a step down transformer giving 6 to 12 volt at the secondary coil and having a current capacity of 3A (with enough safety margins) is used as the A.C. source. It is connected to two points on the sonometer wire, much beyond the bridges with

the help of crocodile clips. A 5 Ω or 10 Ω rheostat having current capacity of 3A is connected in series in order to adjust a convenient current passing through the wire.

Procedure

Arrange the apparatus as shown in the fig. Adjust a suitable tension along the wire. Switch ON the supply and pass a suitable amount of current in the wire.

Move the bridges until the wire is observed to vibrate with greatest amplitude between the bar magnets. Measure and record the resonating length l of the wire for given tension T . Switch OFF the power supply. Repeat the process for different values of tension T . Take at least five readings.

Observations: -

1. Mass per unit length of the wire $m = \text{----- gm/cm.}$
2. Acceleration due to gravity $g = 980 \text{ cm/sec}^2$

Observation Table:

Obs. No.	Mass M gm	Tension $T=Mg$ dyne	Tension \sqrt{T} dyne	Resonating length l cm				$\frac{\sqrt{T}}{l}$ dyne/cm	Mean $\frac{\sqrt{T}}{l}$
				i	ii	iii	mean		
1									
2									
3									
4									
5									
6									

Graph & Calculations:

From the observation table, it is found that $\frac{\sqrt{T}}{l}$ remains nearly constant. Find the mean of different readings and calculate frequency of AC.

Plot a graph of \sqrt{T} against l using (0, 0) origin. The graph will be a straight line passing through origin. Measure the slope of this straight line. It corresponds to the mean value of $\frac{\sqrt{T}}{l}$. hence calculate frequency of A.C.main.

Result:

Frequency of A.C. supply:

1) $f = \text{----- Hz}$ by calculation.

2) $f = \text{----- Hz}$ by graph

Question :

- 1) What is Resonance ?
- 2) What is Resonating length ?
- 3) Define Frequency. What is its unit ?
- 4) State principle of sonometer.
- 5) State the laws of vibrating string.
- 6) What are nodes & antinodes ?
- 7) State conditions for stationary wave.?



Expt NO.:- 4**VELOCITY OF SOUND**

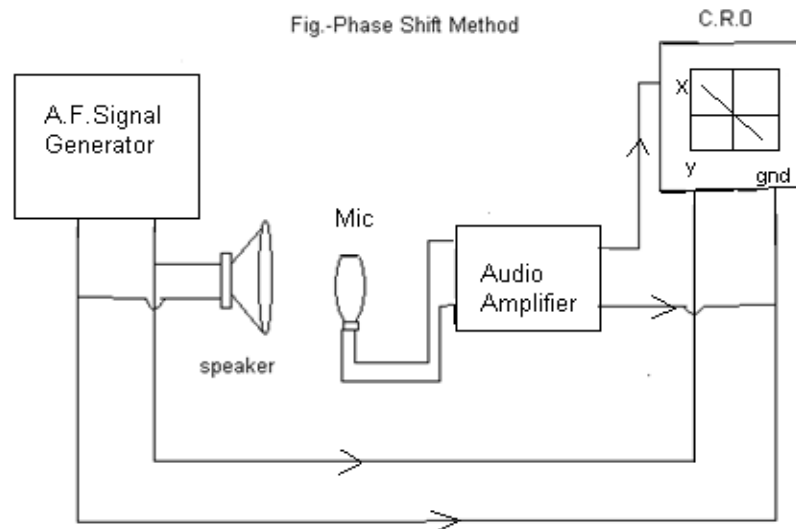
Aim:- To determine velocity of sound in air by using phase shift method.

Apparatus:- A.F. signal generator, Audio Amplifier, Good quality speaker, Sensitive Microphone, C.R.O., Meter scale, etc.

Formula:- Velocity of Sound in Air (V) is given by

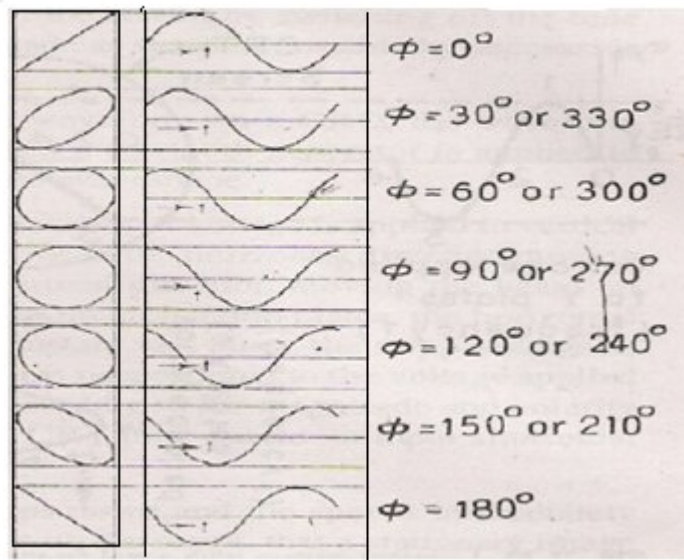
$$V(\text{Velocity}) = n(\text{frequency}) \times \lambda(\text{wavelength})$$

Diagram:-



Lissajous Figures

Phase Angle



Lissajous Figures:-

When two sinusoidal voltages of equal frequencies and equal amplitudes with different phases are applied to CRO . then resultant pattern on screen is straight line ,circle, ellipse depending on phase difference. These figures are called Lissajous figures as shown in fig(2)

Procedure:-

- 1) Connect circuit diagram as shown in figure (1) and set the apparatus as shown in diagram.
- 2) Keep the microphone in front of speaker at certain distance (about 100 cm). Set frequency 300 Hz on A.F. signal generator.
- 3) Switch on the signal generator , Amplifier and CRO.
- 4) Move the microphone through suitable distance so that Lissajous figure on CRO is straight line or ellipse in Ist & IIIrd quadrant. Mark position of microphone on table with chalk (A).
- 5) Then move the microphone through some distance so that Lissajous figure on screen is straight line or ellipse in the opposite quadrant. Mark the position of microphone (B). The distance between the two marking is the distance AB between two successive antinodes which is equal to $(\lambda/2)$ cm. and hence λ is calculated.
- 6) Repeat the experiment for different frequencies i.e. 300Hz, 400Hz,..... 900Hz and Measure the distance $(\lambda/2)$ cm and find the mean velocity of sound (V) in m/s

Observation Table:-

Obs. No.	Frequency (n) Hz	Distance between Successive antinodes $(\lambda/2)$ cm	Wavelength (λ) cm	Velocity of sound in air $V=n\lambda$ cm/s
1	300			
2	400			
3	500			
4	600			
5	700			
6	800			
7	900			

Mean V = ----- cm/sec

Calculation:- Calculate velocity of sound in air by using formula $V= n\lambda$

Result:-

Velocity of sound in air by phase shift method

V=.....cm/s.

V=.....m/s.

Questions :

- 1) Define sound Intensity, Pitch of sound
- 2) Sound velocity depend on which factors ?
- 3) Define wavelength & frequency of wave. How they are related ?
- 4) State functions of Amlifier,,MIC & Loudspeaker in circuit.
- 5) What is phase of oscillation
- 6) What are Lissajous figures ?
- 7) State applications of Lissajous figure.
- 8) What are node & antinode ?

Expt NO.:- 5**NEWTON'S RING****Aim :**

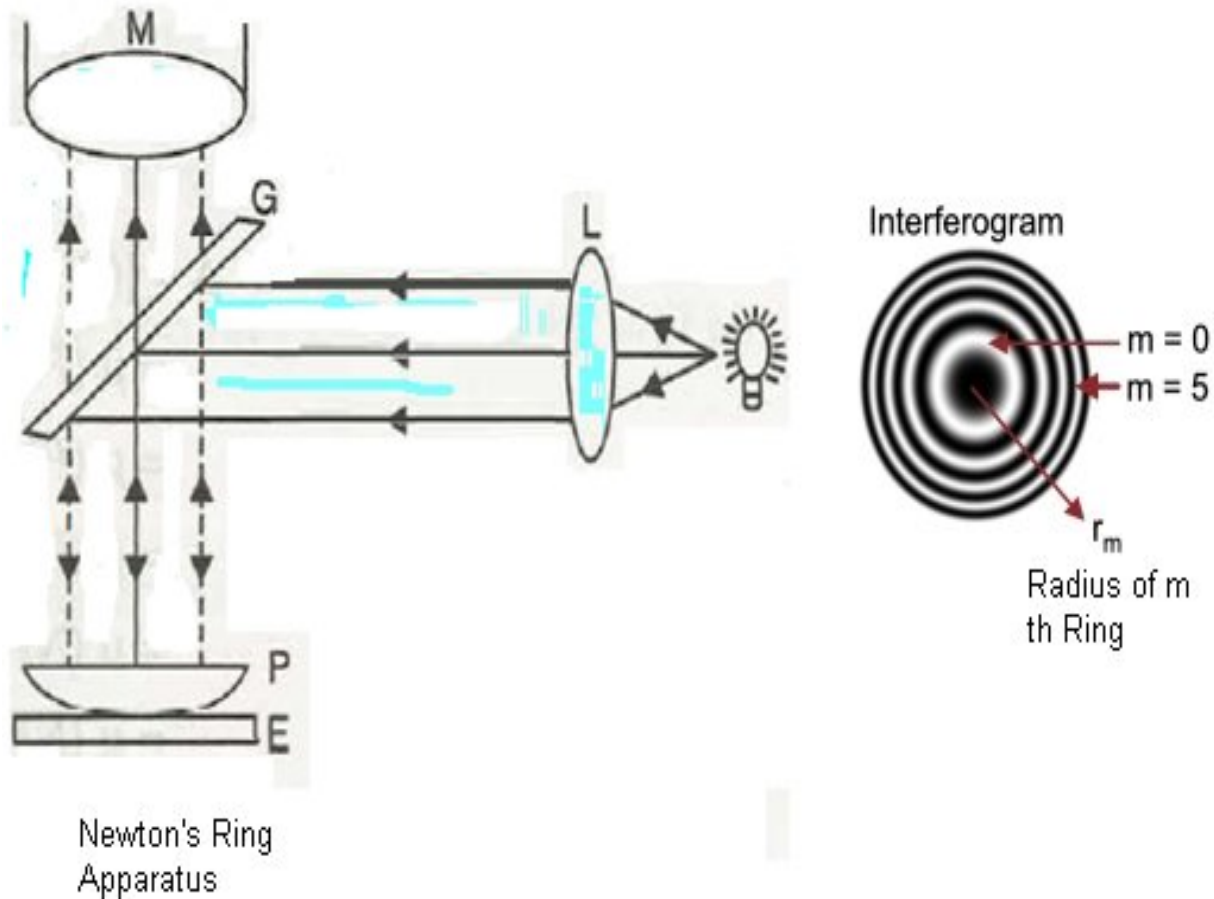
To find the wavelength of sodium light by measuring diameters of Newton's ring.

Apparatus:-

A travelling microscope, Newton's Ring Apparatus, Spherometer, Magnifying lens, Sodium lamp, Electric lamp, Level bottle etc.

Diagram:

S =Source , M=Microscope , L=Lens ,G= Glass Plate , P =Planoconvex Lens, E= Plane glass Plate

**Formula:-**

The wavelength of light is given by

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

Where:-

R = Radius of curvature of given lens

λ = Wave length of Sodium light

D_n = Diameter of n^{th} ring

D_m = Diameter of m^{th} ring

Observation:-

- 1) Radius of curvature of given lens $R = \dots\dots\text{cm}$
- 2) L.C.of Microscope = $\dots\dots\dots\text{cm}$

Observation Table:-

Obs. No.	No. of Rings N	Microscope Reading		Diameter $D = X_1 - X_2$ (cm)	D^2 (cm ²)	$D_n^2 - D_m^2$ (cm ²)
		Left $X_1(\text{cm})$	Right $X_2(\text{cm})$			
1	20				$D_{20}^2 =$	$D_{20}^2 - D_{10}^2 =$
2	18				$D_{18}^2 =$	$D_{18}^2 - D_8^2 =$
3	16				$D_{16}^2 =$	$D_{16}^2 - D_6^2 =$
4	14				$D_{14}^2 =$	$D_{14}^2 - D_4^2 =$
5	12				$D_{12}^2 =$	$D_{12}^2 - D_2^2 =$
6	10				$D_{10}^2 =$	-----
7	8				$D_8^2 =$	-----
8	6				$D_6^2 =$	-----
9	4				$D_4^2 =$	-----
10	2				$D_2^2 =$	-----

Mean $D_n^2 - D_m^2 = \dots\dots\dots$

Calculations :-

Determine λ using $n-m=10$ & substituting mean of $D_n^2 - D_m^2$ in given formula

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

Graph :- Plot graph of D^2 (Y-axis) against No. of ring N (X-axis) which is straight line .

Determine slope of line hence calculate wavelength by using formula

$$\text{Slope} = \frac{D_n^2 - D_m^2}{(n-m)} \quad (\text{cm}^2)$$

$$\lambda = \frac{\text{Slope}}{4R} \quad (\text{cm})$$

Result :- Wave length of given Sodium Source

- 1) By Calculations $\lambda = \dots\dots\dots \text{\AA}$
- 2) By Graph $\lambda = \dots\dots\dots \text{\AA}$

- 1) What are different types of fringes ?
- 2) What is diffraction ?
- 3) Why monochromatic source is required in this experiment ?
- 4) State different types of diffraction.
- 5) Why Newtons rings are circular ?
- 6) What is coherent source ?



Exp. No.6**DISPERSIVE POWER**

Aim: - To determine the dispersive power of the material of the given prism.

Apparatus: - Spectrometer, prism, spirit level, magnifying lens, mercury source, table lamp, etc.

Formula: - Dispersive power of material of the prism is given by,

$$(1) \omega = \frac{\delta_v - \delta_r}{\delta_y} \quad \text{and} \quad (2) \omega = \frac{\delta_2 - \delta_1}{(\delta_1 + \delta_2)/2}$$

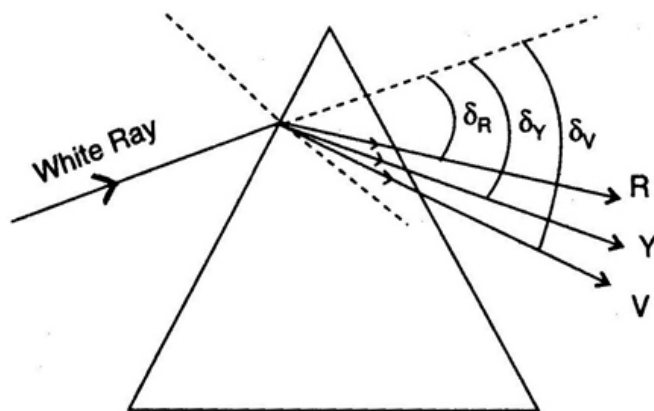
where δ_1 & δ_2 are angle of deviations for any two colour.

δ_v = angle of deviations for violet colour.

δ_r = angle of deviations for red colour.

δ_y = angle of deviations for yellow colour.

Diagram:-



Observations:-

- (1) Smallest division on main scale = S =
- (2) Total No. of division on vernier scale N =
- (3) Least count of spectrometer = S/N =
- (4) Angle of prism = A = 60°
- (5) Source used = Mercury.

Observation Table:-

Colour	Obs No.	Spectrometer Reading		Angle of minimum deviation $\delta_m = X - Y$	Mean δ_m
		Minimum deviation Position (X)	Direct Position (Y)		
Red	(1)				$\delta_r =$
	(2)				
Yellow	(1)				$\delta_y =$
	(2)				
Violet	(1)				$\delta_v =$
	(2)				

Calculation:-

Calculate dispersive power of material of prism by given formula

Result:-

Dispersive power of material of prism

$\omega = \dots\dots\dots$ By formula (1)

$\omega = \dots\dots\dots$ By formula (2)

Questions :

- 1) What is Dispersion ?
- 2) Define-Dispersive power. What is its unit ?
- 3) Explain Schuster's method for adjusting spectra for parallel light .
- 4) What is minimum deviation position ?
- 5) State laws of refraction ?
- 6) What is reflection & refraction ?
- 7) List different parts of spectrometer with their use.

Expt NO. 7**DIFFRACTION BY RAZOR BLADE**

Aim: - To determine thickness of edge of razor blade using diffraction.

Apparatus: - LASER source, Razor blade, Stand, Meterscale etc.

Formula: - The wavelength of LASER beam(λ) is given by

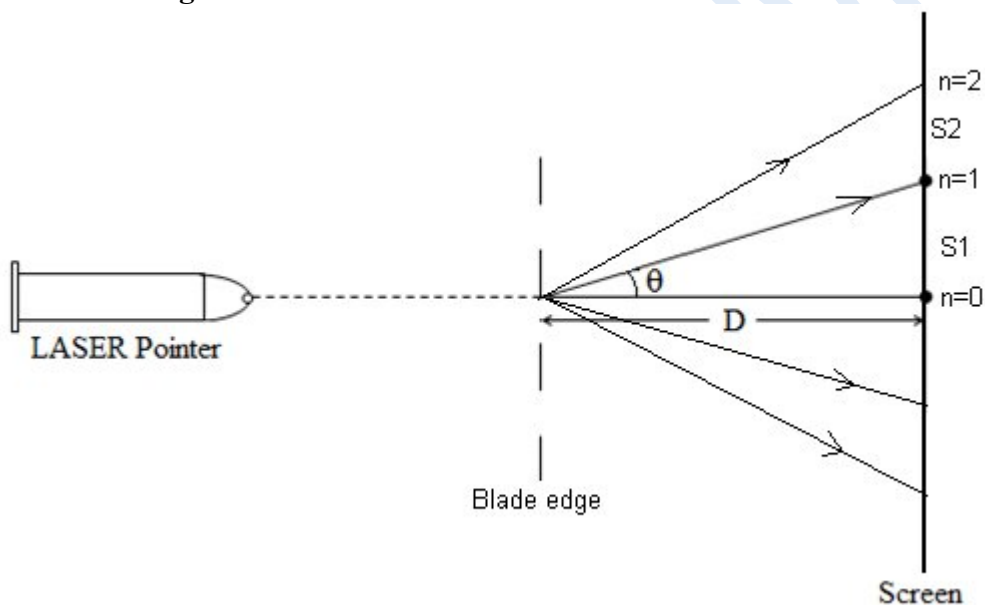
$$d \sin \theta = n \lambda$$

where, θ = angle of diffraction

d = Thickness of razor blade

n = order of spectrum

Experimental Arrangement: -



Procedure:-

Make the arrangement as shown in the figure and get the diffraction pattern. Measure the distance D of screen from the grating and S for first/second order diffraction pattern from central principle maxima. Calculate the diffraction angle θ in each case. Find the thickness of blade d by using the given formula.

Observations:- 1) Wavelength of Laser beam λ = ----- cm
2) Distance between blade and screen D = ---- cm

Observation Table:

Order no.	Distance between spot & central maxima		Mean distance S cm.	$\sin\theta = \frac{S}{\sqrt{S^2 + D^2}}$	Thickness $d = n\lambda/\sin\theta$ cm	Mean d in cm
	One side S1 cm	Other side S2 cm				
n =1						
n =2						

Theory:

LASER means **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. Laser produces a very intense, highly directional, monochromatic and coherent beam of light. There are various lasers such as He-Ne, N₂, CO₂ etc. which operate in visible, ultraviolet and infrared regions of electromagnetic spectrum.

Mechanism of Laser:

Consider a system of atoms in a cavity. Let E_1 be the ground state and E_2 , the excited state energy. An atom remains for unlimited time in ground state energy level. This atom can be excited either by absorption of radiation or by electrical discharge. It acquires the higher energy level E_2 , but it stays there for very limited amount of time. This excited atom gives away the energy in the form of radiation and returns back to ground state. The emitted photon has frequency ν such that $h\nu = E_2 - E_1$. Such a natural transition is called as **spontaneous transition**. In discharge tubes, spontaneous transition is predominant. Einstein has shown that when the atoms are in the excited state, then in the presence of radiation, the de-excitation process is stimulated by the radiation. The excited atom returns back to ground state by giving away the energy in the form of radiation along with the incident radiation of the same wavelength. This process is called **stimulated emission** of radiation. When stimulated emission is predominant over the spontaneous transition, light amplification takes place.

Applications: -

The Laser beams are widely used in various applications. Communication, Computer devices, printers, medical field, holography, industry are some of the areas where lasers are extensively used

Result: - The thickness of razor blade by diffraction = $d = \dots\dots\dots$ cm.

Questions :

- 1) What is Diffraction ?
- 2) What is LASER ? State characteristics of LASER.
- 3) State applications of LASER.
- 4) State Bragg's law of diffraction ?
- 5) State types of diffraction.
- 6) What is spontaneous & stimulated emission ?



Expt NO.:- 8**DOUBLE REFRACTING PRISM**

- Aim:-** i) To determine the refractive indices of a given prism for ordinary and extra ordinary light.
- ii) To determine the nature of double refracting prism whose optic axis is known

Appratus:- Spectrometer, Double Refracting Prism, Mercury lamp, Polaroid, Magnifying lens, Table lamp etc.

Formula:- The refractive indices of a given prism for ordinary and extra ordinary light is given by

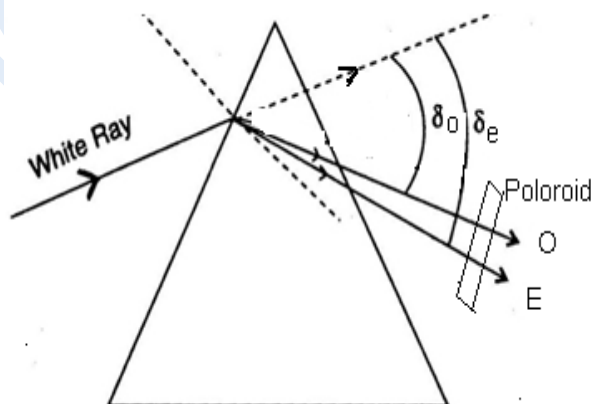
$$\mu_0 = \frac{\sin (A + \delta_0) / 2}{\sin (A/2)}$$

$$\mu_e = \frac{\sin (A + \delta_e) / 2}{\sin (A/2)}$$

where δ_0 & δ_e are angle of minimum deviation for ordinary and extra ordinary beam resp. and A is angle of prism

If $\mu_0 > \mu_e$ crystal is negative and if $\mu_0 < \mu_e$ the crystal is positive crystal.

Diagram:-



Observation:-

- 1) Smallest division on main scale S =
- 2) Total no. of division on vernier scale N =

- 3) Least count of Spectrometer = $S/N = \dots$
 4) Angle of Prism = $A = 60^\circ$

Observation Table :

Ray	Colour of line	Spectrometer Reading		Angle of minimum deviation $\delta_m = \theta_1 - \theta_2$	Refractive Index μ
		Minimum deviation reading (θ_1)	Direct reading (θ_2)		
Ordinary Ray	Yellow				
	Blue				
Extraordinary Ray	Yellow				
	Blue				

Calculations:-

Calculate refractive indices of given prism for ordinary and extra ordinary light for each colour. Hence determine nature of crystal.

Result:-

- I) Refractive Index of an ordinary ray
 $\mu_o = \dots\dots\dots$ (Yellow)
 $\mu_o = \dots\dots\dots$ (Blue)
 II) Refractive Index of an extraordinary ray
 $\mu_e = \dots\dots\dots$ (Yellow)
 $\mu_e = \dots\dots\dots$ (Blue)
 III) Crystal is Negative / Positive .

Questions :

- 1) What is double refraction ?
- 2) Define –Refractive Index.
- 3) What are conditions for positive & negative crystal ?
- 4) Distinguish between Ordinary & Extraordinary Rays.
- 5) Explain Schuster's method for adjusting spectra for parallel light .
- 6) What is minimum deviation position ?
- 7) State use of Polaroid.

Expt NO.:- 9**Section- II
CIRCUIT THEOREMS**

Aim: To verify (i) Maximum Power Transfer Theorem

(ii) Thevenin's Theorem

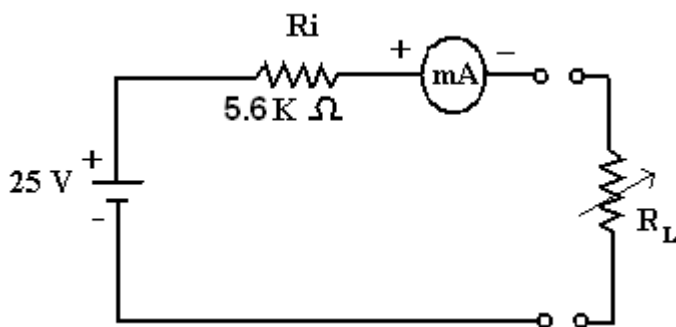
(iii) Norton's Theorem

Apparatus: Battery (25 V), Resistances (5K Ω , 10 K Ω), Voltmeter, Milliammeter, Resistance box, Multimeter etc.

(I) Maximum Power transfer Theorem

Maximum power transfer theorem states that when the internal resistance of the two terminal network is equal to external resistance (load) , then the power delivered by a source to the load is maximum.

Diagram:



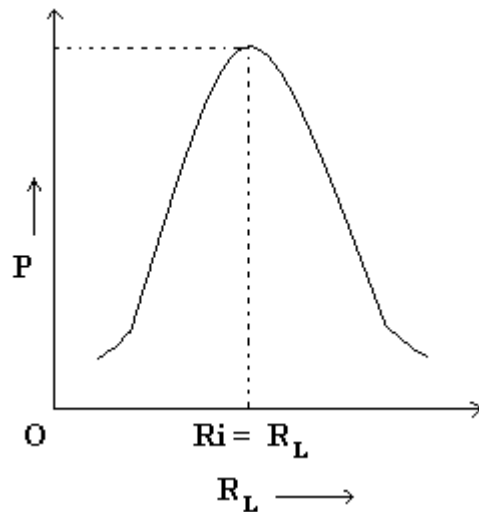
Procedure:

- (i) Connect the circuit as shown in the figure.
- (ii) Keep $R_1 = 5.6 \text{ K}\Omega$ constant.
- (iii) Vary R_L from $1 \text{ K}\Omega$ to $10 \text{ K}\Omega$ in steps of $1 \text{ K}\Omega$ and record the current I in mA.
- (iv) Calculate the power $I^2 R_L$ for each load.
- (v) Plot the graph of power P versus load resistance R_L . Find the load for maximum power.

Observation Table

Obs. No.	$R_L \text{ (K}\Omega\text{)}$	$I \text{ (mA)}$	Power $P = I^2 R_L \times 10^{-3} \text{ Watt}$
1	3		
2	4		
3	5		
4	5.5		
5	6		
6	7		
7	8		
8	9		

Graph: A graph of power (P) against load (R_L) is as shown in the figure. The power is maximum when $R_L = \dots\dots\dots \Omega$

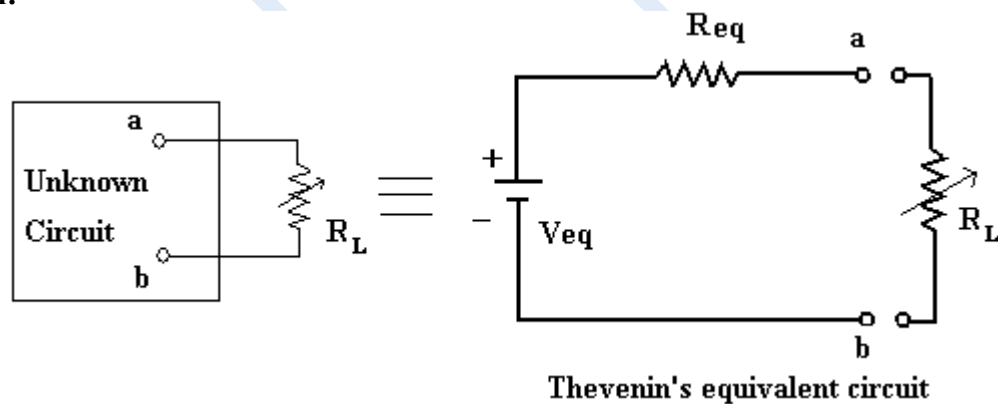


Result: The power delivered to the load is maximum when $R_L = R_i$. Hence maximum power transfer theorem is verified.

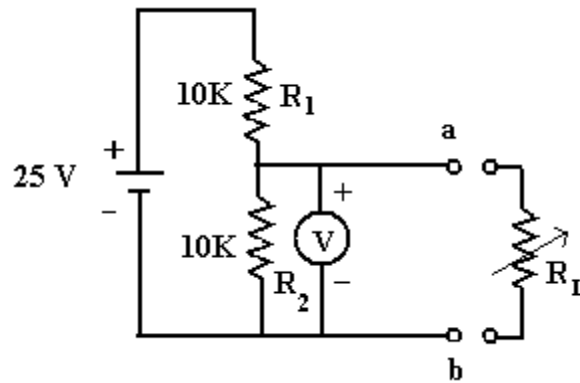
(II) Thevenin's Theorem

Any network of resistances and source having two output terminals can be replaced by a series combination of (i) An ideal voltage source (V_{eq}) equal to open circuit voltage and (ii) A resistance measured at the two output points with the ideal voltage source shorted.

Diagram:



Circuit Diagram:-



Procedure:

- (i) Connect the circuit as shown in the figure.
(ii) Remove load resistance (R_L), connect voltmeter between terminals a & b, put on the source and read the voltmeter reading. This gives V_{eq} measured experimentally.

Thus $V_{eq} = \dots\dots\dots$ Volts (experimentally)

- (iii) Find V_{eq} theoretically by using the formula

$$V_{eq} = \frac{R_2}{R_1 + R_2} V = \frac{10K}{10K + 10K} \times 25 V$$

$$V_{eq} = 12.5 V \text{ (Theoretically)}$$

- (iv) Now connect R_L across a and b such that the voltmeter indicates the reading (voltage) exactly equal to $V_{eq}/2$ (i.e. half deflection). This gives value of R_{eq} experimentally.

Thus $R_{eq} = R_L = \dots\dots\dots \Omega$ (experimentally)

- (v) Find R_{eq} theoretically by using formula

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{10K \times 10K}{10K + 10K} = \frac{100}{20} K \Omega$$

$$R_{eq} = 5 K \Omega \text{ (Theoretically)}$$

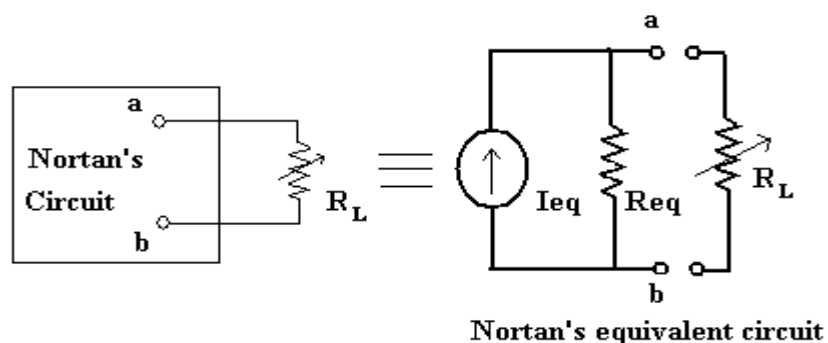
Result: Thevenin's theorem is verified.

$$V_{eq} = \dots\dots\dots V \quad \text{and} \quad R_{eq} = \dots\dots\dots K \Omega$$

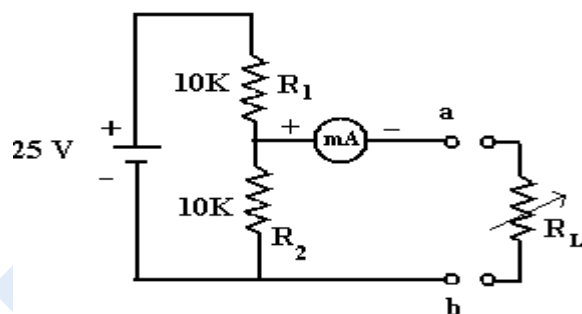
(III) Norton's Theorem:

“ Any network of sources and resistances having two output terminals can be replaced by a parallel combination of a current source (I_{eq}) equal to short circuit current (I_{sc}) and equivalent resistance (R_{eq}).”

Equivalent Circuit:



Circuit Diagram:



Procedure:

- (i) Remove load resistance $10\text{ K } \Omega$. Short the output terminals a and b by connecting ammeter. Put on the source, record the ammeter reading. This gives I_{sc} experimentally.
 $I_{sc} = \dots\dots\dots \text{mA (experimentally)}$

- (ii) The theoretical value of I_{sc} is

$$I_{sc} = \frac{V}{R_2} = \frac{25}{10\text{K}} = 2.5 \times 10^{-3} \text{ A} = 2.5 \text{ mA (Theoretically)}$$

- (iii) Now to find G_{eq} , i.e. equivalent conductance, vary the load (R_L), such that ammeter shows exactly the half the value of I_{sc} . i.e.

Therefore, $G_L = G_i$. Note the load, hence conductance G_L is

$$G_L = \frac{1}{\text{Load resistance}} = \dots\dots\dots \text{millimho.}$$

Result: Norton's theorem is verified.

$I_{sc} = \dots\dots\dots \text{mA}$

$G_L = \dots\dots\dots \text{millimho.}$

Questions :

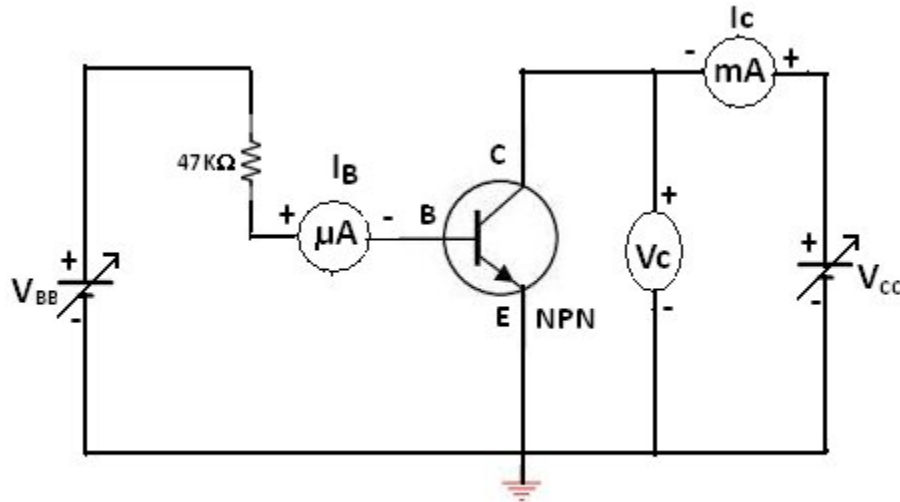
- 1) State maximum power Theorem , Norton's Theorem & Thevenin's Theorem.
- 2) What is meant by open circuit voltage ?
- 3) What is short circuit current ?
- 4) What is conductance ? State its unit.
- 5) Define Power ,State its unit.
- 6) State ohms law.
- 7) State superposition Theorem.
- 8) What is constant current & constant voltage source ?

Expt NO.:- 10**TRANSISTOR CHARACTERISTICS**

Aim:- To Study transistor output characteristics in common emitter configuration.

Apparatus:- NPN transistor, Milliammeter, Microammeter, Voltmeter, Power Supply etc.

Diagram:-



Common Emitter Configuration Circuit

Observation Table:- For common emitter configuration.

Obs. No.	$I_{B1} = 10\mu A$		$I_{B2} = 20\mu A$		$I_{B3} = 30\mu A$	
	I_C (mA)	V_C (volt)	I_C (mA)	V_C (volt)	I_C (mA)	V_C (volt)
1		0		0		0
2		1		1		1
3		2		2		2
4		3		3		3
5		4		4		4
6		5		5		5
7		6		6		6
8		7		7		7
9		8		8		8
10		9		9		9

Calculation & Graph:-

- i) Plot a graph of output current (I_c) vs output voltage (V_c) for different base currents (I_B) as shown in figure.
- ii) To find β of transistor, plot a straight line on output characteristics at proper value of V_c . This straight line will intersect the curves. For these points find the corresponding value of I_c . Plot a graph of I_c Vs I_B as shown in figure. Find the slope of the curve over linear region which is current gain or current amplification factor (β) . Thus Slope = $\beta = \Delta I_c / \Delta I_b$,Hence calculate value of current amplification in common base configuration (α) by using formula $\alpha = \beta / (1 + \beta)$

Result : 1) α of transistor =
2) β of transistor =

Questions :

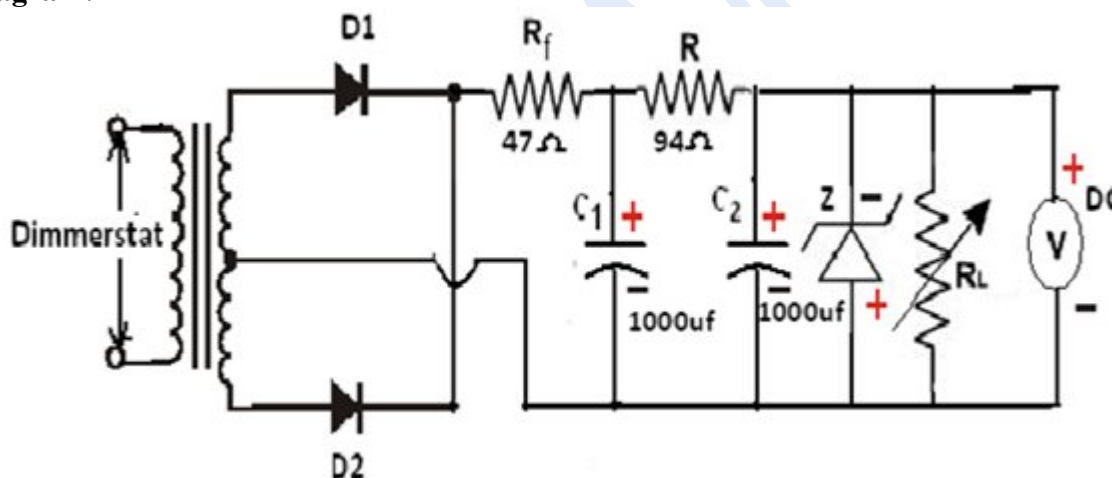
- 1) What are different types of Transistor configuration circuits ?
- 2) Define-Current gain
- 3) State relation between α & β .
- 4) What are different types of Transistor ?
- 5) How three terminals of transistor are identified ?
- 6) Distinguish between UJT & BJT.

Expt NO.:- 11**ZENER AS REGULATUR****Aim:-**

To study zener stabilized power supply, to measure the d.c. output voltage and to determine percentage line and load regulation.

Apparatus:-

Dimmerstat, D.C. Voltmeter, A.C. Voltmeter, Multimeter, Resistance box, Full wave power supply gadget with Π section filter and Resistor box, Multimeter etc.

Circuit diagram:-

- 1) To find R_f :- The value of R_f should be chosen such that the impedance given by it must be much higher than that of the capacitor reactance of C_1 and C_2 .
- 2) To find R :-

$$R = (V_u - V_z) / (I_L + 0.2 I_{zmax})$$

Where:- V_u is unregulated Voltage
 V_z is voltage across Zener
 I_L is load current
 I_z is current through Zener

PART (A):- Line Regulation

(Stabilization of output voltage against input line voltage for a given load)
 It is defined as the change in regulated output voltage due to change in ac input voltage in a specified range of $230V \pm 10\%$ at a constant load current.

Procedure:-

- 1) Connect the circuit as shown in figure.

- 2) Keep load resistance $R_L = 500 \Omega$ from resistance box constant.
- 3) Now slowly change the input (dimmerstat) voltage so that input to the power supply transformer varies in steps of 25 V.a.c. i.e.25v,50v,75v,100v.....etc
- 4) For each a.c.input , measure corresponding d.c. output voltage with zener and without zener .
- 5) Plot graph of input voltage (X axis) against out put voltage (Y axis) with and without zener. Find slope of graph with zener & without zener.
- 6) Calculate % line regulation = Slope X 100 with zener & without zener.

Observation Table:-

Load Resistance $R_L = 500 \Omega$

Obs.No.	Input A.C. Voltage V_i (Volt)	Output D.C.Voltage	
		Without Zener V_o (Volt)	With Zener V_o (Volt)
1	20		
2	40		
3	60		
4	80		
5	100		
6	120		
7	140		
8	160		
9	180		
10	200		
11	220		
12	240		

PART (B):- Load Regulation

(Variation of output voltage with load)

It is defined as the change in regulated output voltage due to change in load current from minimum (no load) to maximum (full load) .

Procedure:-

- 1) Connect the circuit as shown in figure.
- 2) Keep the line voltage fixed at $V_i = 230V$.
- 3) Take the load resistance R_L of 50Ω from resistance box and measure corresponding d.c. output voltage with & without zener diode.
- 4) Now increase load resistance by steps of 50Ω & measure d.c. output voltage with &without zener diode.
- 5) Repeat the procedure for few readings of R_L i.e. $R_L=100, 150, 200, 250, 300, 400, 500\Omega$
- 6) Plot graph of load R_L (X axis) against D.C. output voltage V_o (Y axis) with and without zener. Find slope hence calculate % load regulation

Observation Table:-Input (Line) Voltage $V_{in} = 230$ Volt

Obs. No	Load Resistance (R_L) Ω	Output D.C.Voltage	
		Without Zener V_o (Volt)	With Zener V_o (Volt)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Graph:-

- 1) Plot graph of input voltage (X axis) against d.c out put voltage (Y axis) with and without zener.
- 2) Plot graph of load R_L (X axis) against d.c. output voltage (Y axis) with and without zener
- 3) Calculate % line regulation and % load regulation using formula.

Result:-

- 1) Zener stabilised power supply is designed. The line regulation and load regulation graph are plotted and output d.c.voltage is stabilised atvolt
- 2) % line regulation =.....%
- 3) % load regulation=.....%

Questions :

- 1) What is line regulation & load regulation ?
- 2) What is rectifier ? State its different types.
- 3) Draw block diagram of regulated power supply.
- 4) What is function of filter ? State types of filters.
- 5) State types of transformer.
- 6) What is breakdown voltage of

Expt NO.:- 12

OPERATIONAL AMPLIFIER

Aim: To built and test inverting & Non-inverting amplifier using OPAMP &
To find gain .of amplifier.

Objectives:

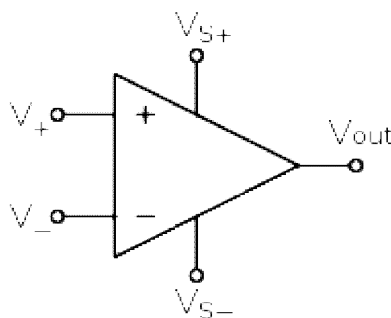
1. To built & test inverting amplifier using OPAMP.
2. To built & test Non-inverting using OPAMP.
3. To find gain of amplifier in inverting & Non-inverting mode.

Components: IC-741 (OPAMP), Dual power supply, Resistors, Wires, Bread board, Multimeters etc.

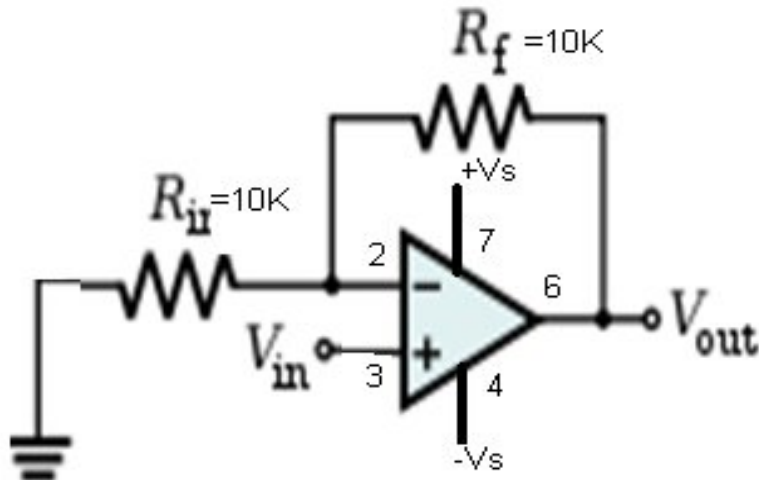
Theory: An operational amplifier is a DC-coupled high-gain electronic voltage amplifier with differential inputs and, usually, a single output. Typically the op-amp's very large gain is controlled by negative feedback, which largely determines the magnitude of its output ("closed-loop") voltage gain in amplifier applications, or the transfer function required (in analog computers). Without negative feedback, and perhaps with positive feedback for regeneration, an op-amp essentially acts as a comparator. High input impedance at the input terminals (ideally infinite) and low output impedance (ideally zero) are important typical characteristics.

The op-amp is one type of differential amplifier. The circuit symbol for an op-amp is shown to the right, where:

V_+ is non-inverting input.
 V_- is inverting input
 V_{out} is output terminal.
 V_{S+} is+ ve supply terminals &
 V_{S-} is -ve supply terminals.



1. Non-inverting amplifier



Formula:- $\text{Gain} = V_{\text{OUT}} / V_{\text{in}} = 1 + (R_f / R_{\text{in}})$

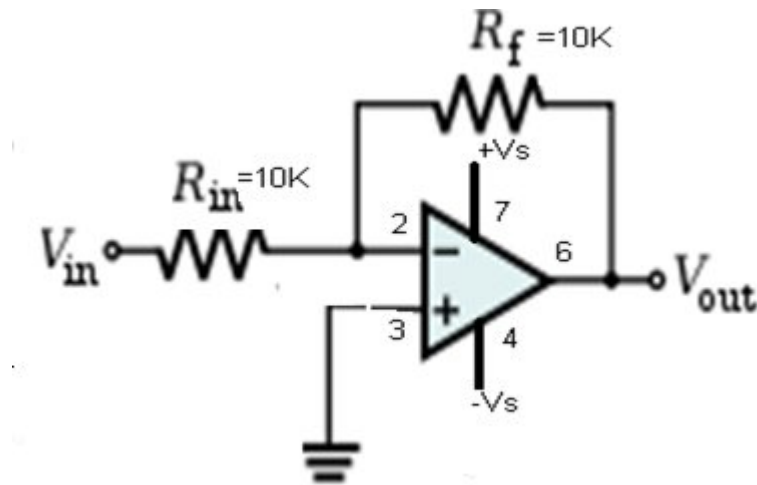
Procedure:-

1. Connect the circuit as per the circuit diagram.
2. Give the input signal as specified in observation table.
3. Switch on the dual power supply.
4. Observe output and input entities.
5. Note down output from CRO or multimeter.
6. Draw graph of output voltage (Yaxis) against input voltage(X axis) .
7. Calculate gain of amplifier by using given formula & by using graph.

Observation table:

Obs .No	Input Voltage V_{in} Volts	Output Voltage V_{out} Volts	Gain $= V_{\text{out}} / V_{\text{in}}$
1			
2			
3			
4			
5			
6			
7			
8			

2. Inverting amplifier



Formula:- $\text{Gain} = V_{\text{Out}} / V_{\text{in}} = (-R_f / R_{\text{in}})$

Procedure:-

1. Connect the circuit as per the circuit diagram.
2. Give the input signal as specified in observation table.
3. Switch on the dual power supply.
4. Observe the output and input entities.
5. Note down output from CRO or multimeter.
6. Draw graph of output voltage (Yaxis) against input voltage(X axis) .
7. Calculate gain of amplifier by using given formula & by using graph.

Observation table:

Obs. No	Input Voltage V_{in} Volts	Output Voltage V_{out} Volts	Gain $= V_{\text{out}} / V_{\text{in}}$
1			
2			
3			
4			
5			
6			
7			
8			
9			

Results:

1. In Non-Inverting amplifier output has same polarity (phase) as that of the i/p signal.
 2. In Inverting amplifier output has opposite polarity (phase) as that of the i/p signal.
 3. In Inverting amplifier when $R_{in} = R_f$ the amplifier acts as a unity gain amp.
 4. Gain of inverting amplifier = ----- (By formula)
= ----- (By graph)
 5. Gain of Noninverting amplifier = ----- (By formula)
= ----- (By graph)
-

Questions :

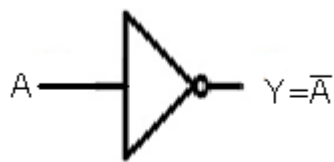
- 1) What is operational amplifier ? Why it is called so ?
- 2) What is difference between inverting & noninverting amplifier ?
- 3) What is concept of virtual ground ?
- 4) Define gain of Amplifier. What is its unit ?
- 5) What are parameters for ideal Op-amplifier ?
- 6) What is attenuation?

Aim:- 1) To build the circuits for various logic gates, to state and verify their truth tables.
2) To verify De Morgan's first and second theorem.

Apparatus:- Project board, D.C. Power supply, Logic gate IC's, LED, Indicator ,wires etc.

Logic Symbol , IC pin configuration & Truth tables.

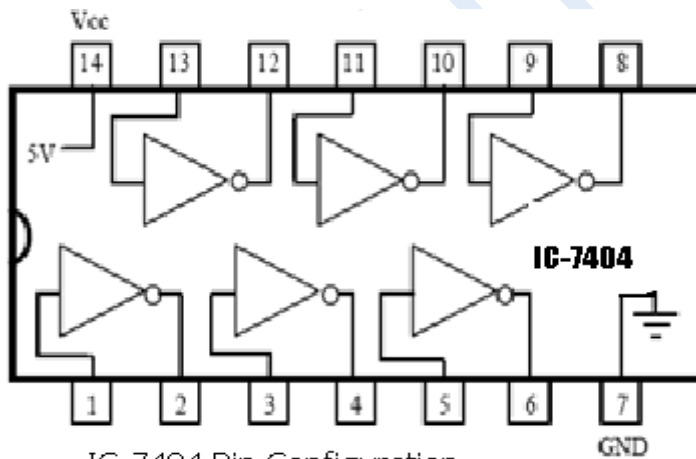
1) Inverter or NOT Gate-



Logic Symbol

Truth Table

A	$Y = \bar{A}$
0	1
1	0



IC-7404 Pin Configuration

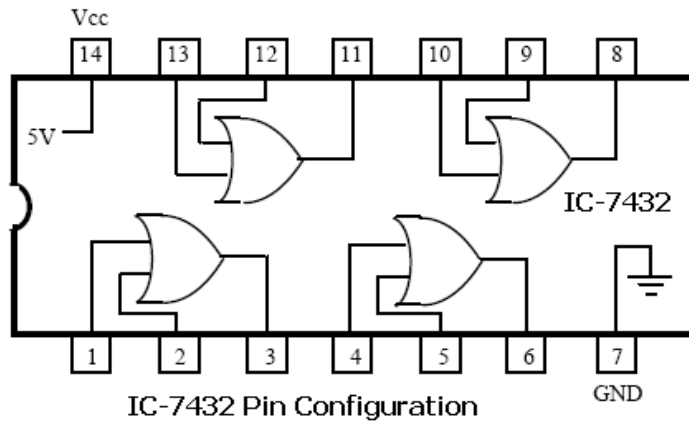
2) OR Gate:-



Logic Symbol

Truth Table

A	B	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

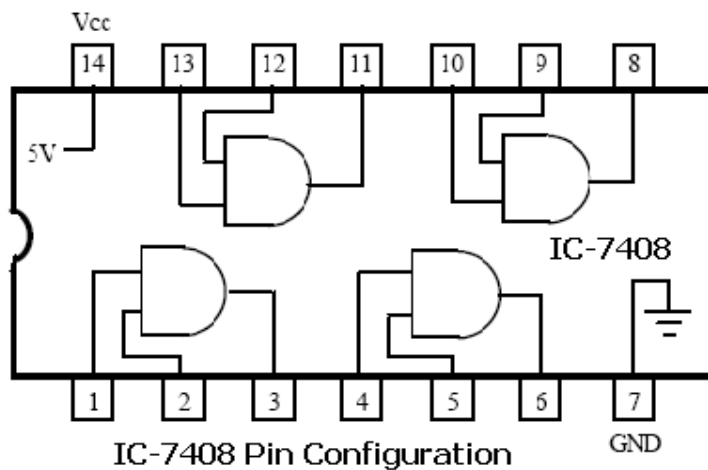


3) AND Gate:-

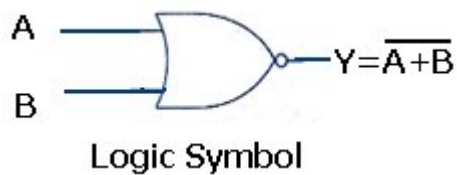


Truth Table

A	B	Y=A.B
0	0	0
0	1	0
1	0	0
1	1	1

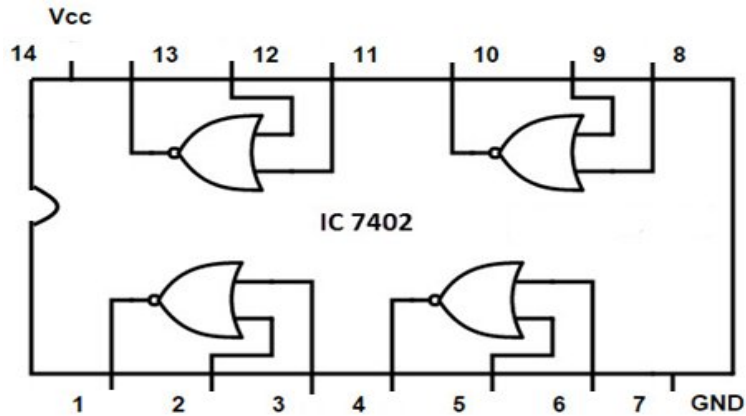


4) NOR Gate:-



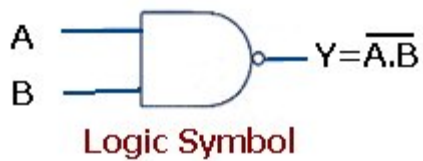
Truth Table

A	B	Y= $\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0



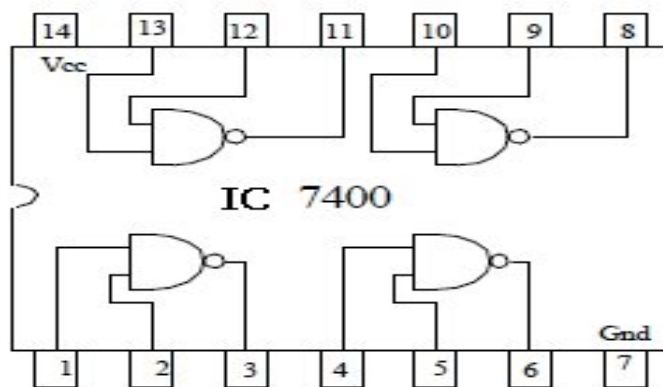
IC-7402 Pin Configuration

5) NAND Gate:-



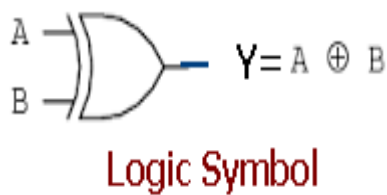
Truth Table

A	B	Y = $\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0



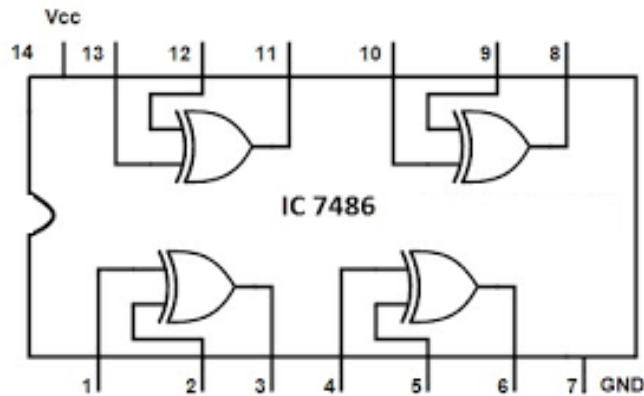
IC-7400 Pin Configuration

6) EX-OR Gate:-



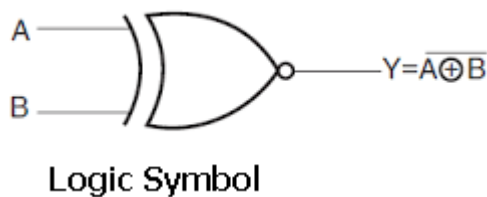
Truth Table

A	B	Y = $A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0



IC-7486 Pin Configuration

7) EX-NOR Gate:-



Truth Table

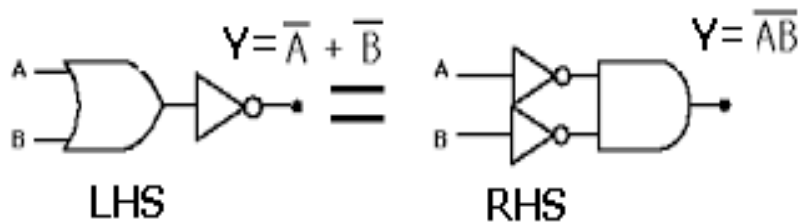
A	B	Y = $\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

De-Morgan's Theorem:-

1) It states that the complement of a sum is equal to the product of the complement. i.e.

$$\overline{A + B} = \overline{A} \cdot \overline{B}$$

Logical Diagram:-

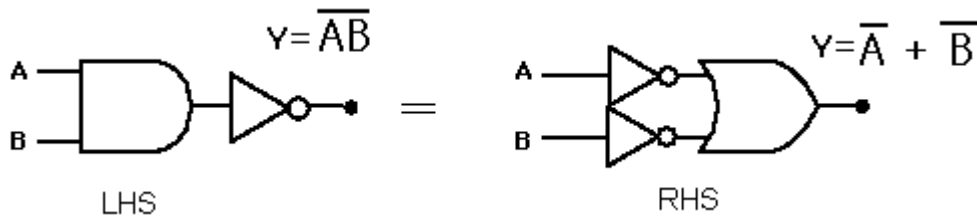


A	B	\overline{A}	\overline{B}	$A + B$	$\overline{A + B}$ (LHS)	$\overline{A} \cdot \overline{B}$ (RHS)	Remark
0	0	1	1	0	1	1	LHS = RHS Hence DE Morgan's first theorem is verified
0	1	1	0	1	0	0	
1	0	0	1	1	0	0	
1	1	0	0	1	0	0	

II) It states that the complement of a product is equal to the sum of the complement. i.e.

$$\overline{AB} = \overline{A} + \overline{B}$$

Logical Diagram:-



<i>A</i>	<i>B</i>	<i>A̅</i>	<i>B̅</i>	<i>A.B</i>	<i>A̅.B̅</i> (LHS)	<i>A̅ + B̅</i> (RHS)	Remark
0	0	1	1	0	1	1	LHS = RHS Hence De Morgan's second theorem is verified
0	1	1	0	0	1	1	
1	0	0	1	0	1	1	
1	1	0	0	1	0	0	

Result:

- 1) Truth tables of NOT, OR, NOR, AND, NAND, X-OR, X-NOR gates are verified.
- 2) De-Morgan's first and second theorem are verified.

THEORY :

Logic gates are the basic building blocks of the digital instruments. These circuits deals with two voltage levels , high designed as 1 and low designed as 0 .This is equivalent to switch action. Number of such switches can be combined to perform different circuit actions. A gate is a logic circuit with one output for one or more inputs. The basic logic gates are NOT (Inverter), OR , NOR , AND , NAND which are represented by logically in figure.

Inverter(NOT) gate : This is single input logic circuit which produces output as 1 when input is 0 or it gives output as 0 when input is 1 i.e. input is complemented. The truth table is as shown in figure.

OR gate : This logic gate gives output in state 1 if either A or B or both are in state 1. Its truth table is as shown in figure.

NOR gate : This gate produces output in state 0 when either input A or B or both are in state 1 NOR gate is obtained by inverting the output of an OR gate. The truth table is as shown in figure.

AND gate : This gate output as 1 when both A and B are in state 1. Output is 0 when any or both input are 0. The truth table is as shown in figure.

NAND gate : Output of NAND gate can be obtained by inverting the output of AND gate. It produces 0 output if its two inputs are simultaneously 1 . Its truth table is as shown in figure

X-OR gate:- This logic gate is such that its output is in 1 state only when A or B (and not both) is in 1 state. Its truth table is as shown in figure.

X-NOR gate:- This gate is equivalent of X-OR gate followed by NOT gate. Its truth table is as shown in figure.

Questions :

- 1) What is logic gate ?
- 2) Which are the universal building block of gates ?
- 3) What is 1's complement and 2's complement ?
- 4) State De-Morgans first & second theorem
- 5) How decimal number is converted into binary number ?
- 6) Where logic gates are used ?

- Aim:** i) To measure Frequency using CRO
ii) To measure AC / Dc Voltage on CRO
iii) To measure duty cycle of square wave using CRO

Theory :

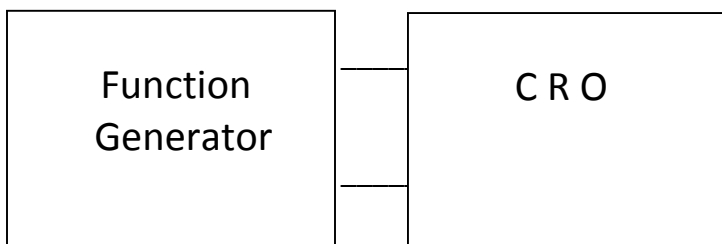
An cathode ray oscilloscope is an extremely useful laboratory instrument . It uses a cathode ray tube and associated circuits to display the waveform of an input signal on the screen of CRT. This instrument functions as a voltmeter which can measure Ac/Dc voltage. In addition if the AC is periodic , the wave form can be displayed. Accurate voltage time and phase measurement can be made on CRO. It is also used to measure frequency , to measure duty cycle of square wave and to study Lissajous figures.

Front Panel Controls of CRO :

- 1) Focus : This adjusts the Dc voltage applied to the electrode to focus the electron beam in a sharp spot.
- 2) Intensity : This potentiometer adjusts the grid cathode voltage on the CRT to change electron beam density or intensity of the display.
- 3) Sensitivity OR Volt / Div : This adjusts the input attenuator and sets the scale in volt / div on Y axis of the screen.
- 4) Time Base OR Time / Div : This adjusts the sweep speed and sets the scale in time/ div on X axis of the screen.
- 5) X-Position : This shifts the DC level of the output of horizontal amplifier and helps to move display along X axis.
- 6) Y-Position: This shifts the DC level of the output of vertical amplifier and helps to move display up or down along along Y axis.
- 7) Level : This sets the DC trigger level so as to make display steady.
- 8) INT / EXT : This selects the internal or external triggering signal.
- 9) A / B : It selects input of channel A or Channel B for triggering in a dual trace CRO.
- 10) CAL : This changes the sweep speed continuously. If this control is not on cal position the time / division will not be correct.
- 11) X 5 : This multiplies the time / div setting by five and magnifies the display five times in X direction.

(A) Frequency Measurement :

Diagram :



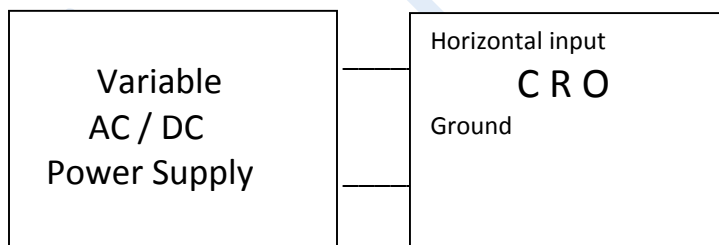
- 1) Connect signal generator to horizontal input of CRO.
- 2) Adjust the sensitivity (Volt / div) for proper display size.
- 3) Observe the display on the screen. Measure no. of divisions on X axis between two successive peaks of the waveform which are in the same phase(Peak to peak X-distance)
- 4) Calculate duration of one cycle(Period) T
- 5) Calculate frequency $f = 1/T$ Hz

Observation Table :

Obs No.	Frequency on signal generator(Hz)	No of divisions on X axis a	Time base selector(sec) b	Period $T = a \times b$ sec	Frequency $F = 1/T$ Hz

(B) AC / DC Voltage Measurement :

Diagram :-



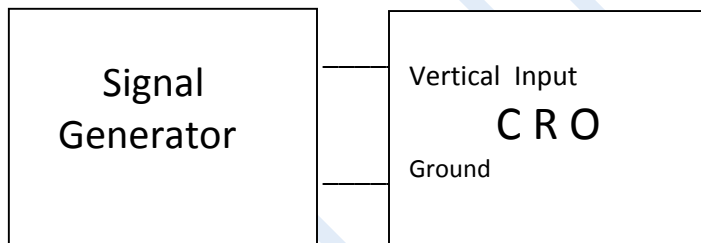
- 1) Connect the variable Ac / Dc power supply to vertical input of CRO.
- 2) Vary the AC / DC voltage of power supply.
- 3) Measure the AC / DC voltage by measuring vertical deflection or distance between positive and negative peaks.

Observation Table :

Obs No.	AC Voltage		DC Voltage	
	Voltage on signal generator (volt)	Voltage measured on CRO (volt)	Voltage on Power Supply (volt)	Voltage measured on CRO (volt)
1)				
2)				
3)				
4)				
5)				
6)				

(C) Duty cycle of Square wave :

Diagram :-

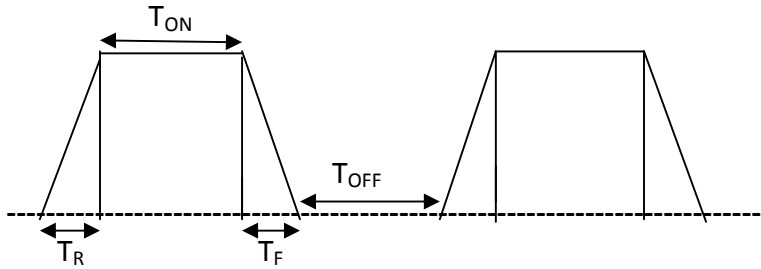


- 1) Connect signal generator to horizontal (X) or vertical (Y) input of CRO.
- 2) Obtain square wave on CRO screen.
- 3) Trace the square wave and determine rise time & fall time of square wave.
- 4) Also measure ON time & OFF time of square wave & hence calculate duty cycle.

Observation Table :

Rise time T_R (sec)	Fall time T_F (sec)	ON time T_{ON} (sec)	OFF time T_{OFF} (sec)	Duty Cycle = $T_{ON} / (T_{ON} + T_{OFF}) \times 100$

Square wave diagram:



Result :

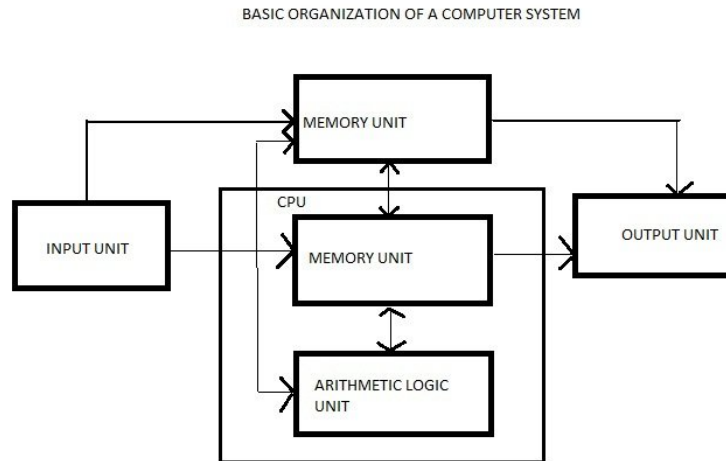
- 1) Unknown frequency = ----- Hz
- 2) Duty cycle of square wave = ----- %

Questions :

- 1) What is CRT ? State its principle.
- 2) Define Period & Frequency of wave .
- 3) Distinguish between AC & DC voltage.
- 4) What is sensitivity? State its unit.
- 5) What is use of time base knob?
- 6) What is significance of duty cycle?

Aim :-Plotting various functions using Excel software / Spreadsheet.

Computer : it is an electronic device which is capable of receiving information (data) in a particular form and of performing a sequence of operations in accordance with a predetermined but variable set of procedural instructions (program) to produce a result in the form of information or signals.



The most important software involving calculations & graph is spreadsheet. MS-Excel is one of popular spreadsheet.

Microsoft Excel is an application program providing the spreadsheet facility .It is used to perform financial analysis, budget preparation, grade calculation, sorting and analyzing data , creating charts, graphs,and picture etc. It also provides facilities for spellchecking and grammar.

The excel window displays the MS-Excel title bar along with name of current work . To the right of title bar is present the control buttons minimize, maximize, restore and close . Below the title bar is the main menu bar containing no.of menus like File, Edit,Copy , Paste ,View, Insert, Format, Tools, Data, Window, Help etc..The whole worksheet area is occupied by number of rows & columns .The intersection of row & column is a cell in which data can be stored. In Excel, each new work book contains number of sheets. Data or Text can be entered by activating particular cell.

Plotting of Graphs:-

Excel provide excellent chart facilities . To creat chart or graph, data must be arranged in tabular format. You can include any column(s) or row(s). If any changes in data are made, it changes corresponding chart.

Excel provide following types of charts:-

- Column and Bar
- Line
- Pie
- X-Y Scatter
- Area
- Doughnut
- Radar
- 3-D Surface
- Bubble
- Cylinder
- Cone
- Pyramid

All these charts are displayed in two or three dimensions. The charts can be resized or reshaped by dragging the selection handle. Excel also provide a chart wizard to draw your graph.

Plot following different functions using Excel Sheet & taking suitable data.

- 1) $Y = \text{Exp}(X)$ where $X = 0, 1, 2, 3, 4, 5, 6, 7, 8$
- 2) $Y = \text{Exp}(-X)$ where $X = 0, 1, 2, 3, 4, 5, 6, 7, 8$
- 3) $Y = \text{Sin}(X)$ where $X = \text{Angle (Degree)} = 0, 45, 90, 135, 180, 225, 270, 315, 360$
- 4) $Y = \text{Cos}(X)$ where $X = \text{Angle (Degree)} = 0, 45, 90, 135, 180, 225, 270, 315, 360$
- 5) $Y = X^2$ where $X = -4, -3, -2, -1, 0, 1, 2, 3, 4$
- 6) $Y = X^3 \text{ Tan}(X)$ where $X = 0, 1, 2, 3, 4, 5, 6, 7, 8$
- 7) $Y = \text{Log}(X)$ where $X = 5, 10, 25, 50, 75, 100, 200, 500, 800, 1000$
- 8) $Y = X^2 + 2X + 2$ where $X = 0, 1, 2, 3, 4, 5, 6, 7, 8$

Questions :

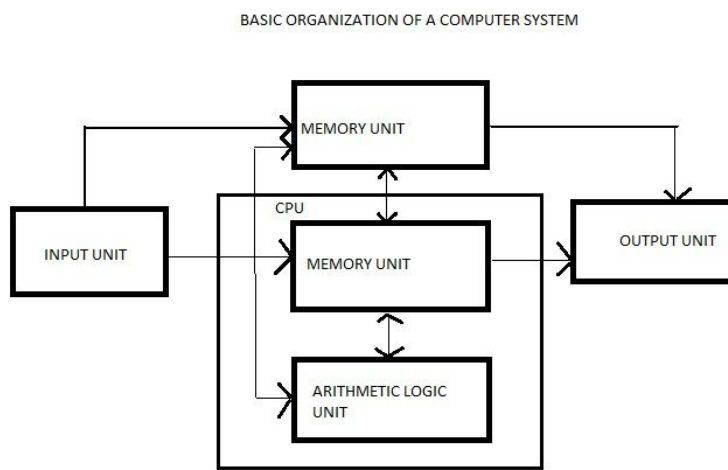
- 1) What is computer? Draw its block diagram.
- 2) State different generations of computer.
- 3) What is operating system ?
- 4) What is software & hardware ?
- 5) What is use of compiler & Interpreter ?
- 6) Define- Bit, Byte, Nibble, Word, 1KB , 1 MB & 1 GB.
- 7) What is supercomputer ?
- 8) What are different types of memory ?
- 9) What is flow chart & what is algorithm ?

Expt NO.:- 16

Computer-II

Aim :-Plotting various Conic figures using Excel software / Spreadsheet.

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- Doughnut
- Radar
- 3-D Surface a^2
- Bubble
- Cylinder
- Cone
- Pyramid

All these charts are displayed in two or three dimensions. The charts can be resized or reshaped by dragging the selection handle. Excel also provide a chart wizard to draw your graph.

Plot following conics figure using Excel Sheet & taking suitable data.

- 1) Parabola : The equation of parabola is $Y^2 = 4aX$. Take $X = -4, -3, -2, -1, 0, 1, 2, 3, 4$
- 2) Circle : The equation of circle is $X^2 + Y^2 = a^2$ Take $a=3$ & $X=-3$ to $=3$
- 3) Ellipse: The equation of ellipse is $X^2 / a^2 + Y^2 / b^2 = 1$
- 4) Hyperbola: The equation of hyperbola is $X^2 / a^2 - Y^2 / b^2 = 1$

Questions :

- 1) What is computer? Draw its block diagram.
- 2) State different generations of computer.
- 3) What is operating system ?
- 4) What is software & hardware ?
- 5) What is use of compiler & Interpreter ?
- 6) Define- Bit, Byte, Nibble, Word, 1KB , 1 MB & 1 GB.
- 7) What is supercomputer ?
- 8) What are different types of memory ?
- 9) What is flow chart & what is algorithm ?

DEMONSTRATION EXPERIMENT

Expt NO.:- 17

MICHELSON –MORLEY INTERFEROMETER

Aim:

To determine the wavelength of a laser using the Michelson interferometer.

Apparatus:

Laser light source, Michelson interferometer kit, optical bench, meter scale.

Theory:

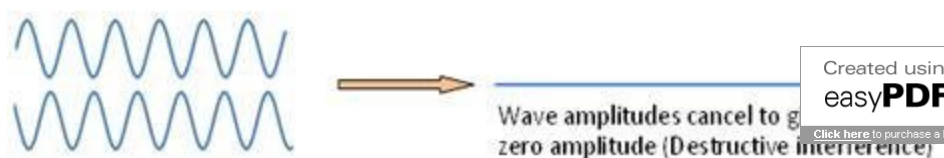
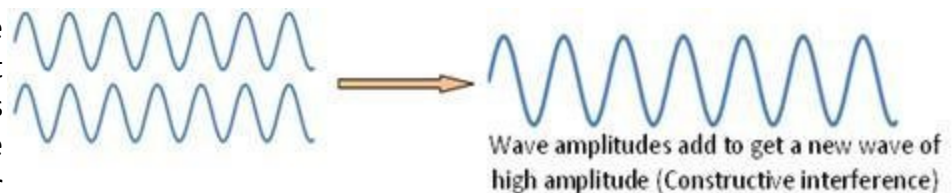
Interferometers are used to precisely measure the wavelength of optical beams through the creation of interference patterns. The Michelson interferometer is a historically important device which provides simple interferometric configuration, useful for introducing basic principles.

Interference Theory :

Light is a transverse wave. When two waves of same wavelength and amplitude travel through same medium, their amplitudes combine. A wave of greater or lesser amplitude than the original will be the result. The addition of amplitudes due to superposition of two waves is called interference. If the crest of one wave meets with the trough of the other, the resultant intensity will be zero and the waves are said to interfere destructively. Alternatively, if the crest of one wave meets with the crest of the other, the resultant will be maximum intensity and the waves are said to interfere constructively.

Suppose two coherent (*i.e.* their initial phase relationship remains constant) waves start from the same point and travel different paths before coming back together and interfering with each other. Suppose also that the re-combined waves illuminate a screen where the position on the screen depends on the difference in the lengths of the paths traveled by the two waves. Then the resulting alternating bright and dark bands on the screen are called interference fringes.

In constructive interference, a bright fringe (band) is obtained on the screen. For constructive



interference to occur, the path difference between two beams must be an integral multiple $m\lambda$ of the wavelength λ , where m is the order, with $m=0,1,2...$

If the path difference between two waves is $(m + \frac{1}{2})\lambda$, the interference between them is destructive, and a dark fringe appears on the screen.

Michelson Interferometer :

The Michelson interferometer is the best example of what is called an amplitude-splitting interferometer. It was invented in 1893 by Albert Michelson, to measure a standard meter in units of the wavelength of the red line of the cadmium spectrum. With an optical interferometer, one can measure distances directly in terms of wavelength of light used, by counting the interference fringes that move when one or the other of two mirrors are moved. In the Michelson interferometer, coherent beams are obtained by splitting a beam of light that originates from a single source with a partially reflecting mirror called a beam splitter. The resulting reflected and transmitted waves are then re-directed by ordinary mirrors to a screen where they superimpose to create fringes. This is known as interference by division of amplitude. This interferometer, used in 1817 in the famous Michelson- Morley experiment, demonstrated the non-existence of an electromagnetic-wave-carrying ether, thus paving the way for the Special theory of Relativity.

A simplified diagram of a Michelson interferometer is shown in the fig: 1.

Light from a monochromatic source S is divided by a beam splitter (BS), which is oriented at an angle 45° to the beam, producing two beams of equal intensity. The transmitted beam (T) travels to mirror M_1 and it is reflected back to BS. 50% of the returning beam is then reflected by the beam splitter and strikes the screen, E. The reflected beam (R) travels to mirror M_2 , where it is reflected. 50% of this beam passes straight through beam splitter and reaches the screen.

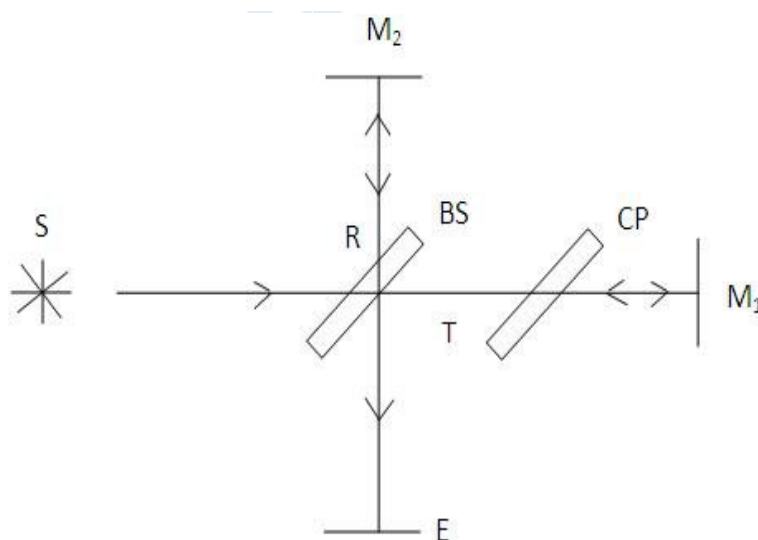


Fig. 1



Fig. 2

Since the reflecting surface of the beam splitter BS is the surface on the lower right, the light ray starting from the source S and undergoing reflection at the mirror M₂ passes through the beam splitter three times, while the ray reflected at M₁ travels through BS only once. The optical path length through the glass plate depends on its index of refraction, which causes an optical path difference between the two beams. To compensate for this, a glass plate CP of the same thickness and index of refraction as that of BS is introduced between M₁ and BS. The recombined beams interfere and produce fringes at the screen E. The relative phase of the two beams determines whether the interference will be constructive or destructive. By adjusting the inclination of M₁ and M₂, one can produce circular fringes, straight-line fringes, or curved fringes. This lab uses circular fringes, shown in Fig. 2.

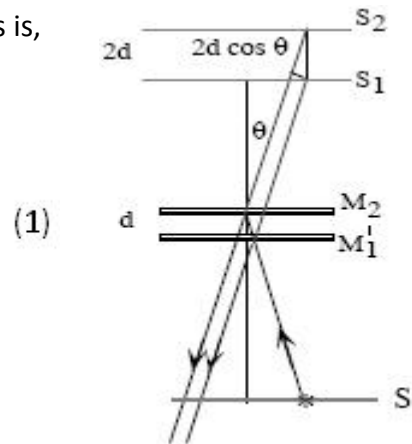
From the screen, an observer sees M₂ directly and the virtual image M₁' of the mirror M₁, formed by reflection in the beam splitter, as shown in Fig. 3. This means that one of the interfering beams comes from M₂ and the other beam appears to come from the virtual image M₁'. If the two arms of the interferometer are equal in length, M₁' coincides with M₂. If they do not coincide, let the distance between them be d , and consider a light ray from a point S. It will be reflected by both M₁' and M₂, and the observer will see two virtual images, S₁ due to reflection at M₁', and S₂ due to reflection at M₂. These virtual images will be separated by a distance $2d$. If ϑ is the angle with which the observer looks into the system, the path difference between the two beams is $2d\cos\vartheta$. When the light that comes from M₁ undergoes reflection at BS, a phase change of π occurs, which corresponds to a path difference of $\lambda/2$.

Therefore, the total path difference between the two beams is,

$$\Delta = 2d \cos \theta + \frac{\lambda}{2}$$

The condition for constructive interference is then,

$$\Delta = 2d \cos \theta + \frac{\lambda}{2} = m\lambda, \quad m = 0, 1, 2, \dots$$



For a given mirror separation d , a given wavelength λ , and order m , the angle of inclination ϑ is a constant, and the fringes are circular. They are called *fringes of equal inclination*, or *Haidinger fringes*. If M₁' coincides with M₂, $d = 0$, and the path difference between the interfering beams will be $\lambda/2$. This corresponds to destructive interference, so the center of the field will be dark.

If one of the mirrors is moved through a distance $\lambda/4$, the path difference changes by $\lambda/2$ and a maximum is obtained. If the mirror is moved through another $\lambda/4$, a minimum is obtained; moving it by another $\lambda/4$, again a maximum is obtained and so on. Because d is multiplied by

$\cos\theta$, as d increases, new rings appear in the center faster than the rings already present at the periphery disappear, and the field becomes more crowded with thinner rings toward the outside. If d decreases, the rings contract, become wider and more sparsely distributed, and disappear at the center.

For destructive interference, the total path difference must be an integer number of wavelengths plus a half wavelength,

$$\Delta_{\text{destr}} = 2d \cos \theta + \frac{\lambda}{2} = (m + \frac{1}{2})\lambda, \quad m = 0, 1, 2, \dots$$

If the images S_1 and S_2 from the two mirrors are exactly the same distance away, $d=0$ and there is no dependence on θ . This means that only one fringe is visible, the zero order destructive interference fringe, where

$$\Delta_{\text{destr}} = \frac{\lambda}{2} = (m + \frac{1}{2})\lambda, \quad m = 0$$

and the observer sees a single, large, central dark spot with no surrounding rings.

Measurement of wavelength:

Using the Michelson interferometer, the wavelength of light from a monochromatic source can be determined. If M_1 is moved forward or backward, circular fringes appear or disappear at the centre. The mirror is moved through a known distance d and the number N of fringes appearing or disappearing at the centre is counted. For one fringe to appear or disappear, the mirror must be moved through a distance of $\lambda/2$. Knowing this, we can write,

$$d = \frac{N\lambda}{2}$$

so that the wavelength is,

$$\lambda = \frac{2d}{N} \quad (2)$$

Applications

1. The Michelson - Morley experiment is the best known application of Michelson Interferometer.
2. They are used for the detection of gravitational waves.
3. Michelson Interferometers are widely used in astronomical Interferometry.

