

LAB MANUAL
RNEP
BSc III
Semester

List of the Experiments

SET – I

1. Goniometer
2. Calibration of Ballistic Galvanometer
3. Calibration of Spectrometer
4. Newton's rings.

SET - II

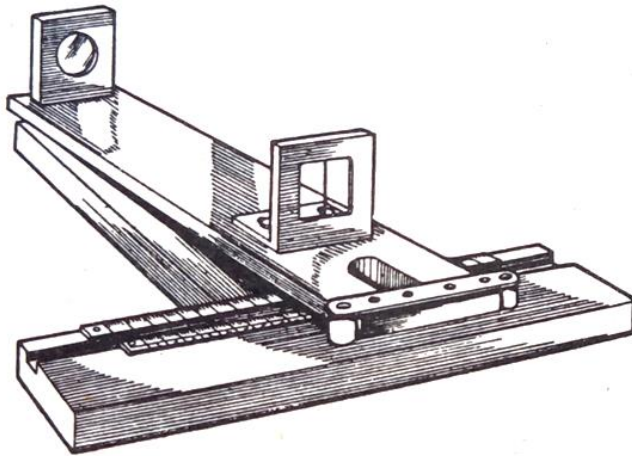
5. Turn table
6. Determination of high resistance by leakage method using BG
7. Single stage RC coupled CE amplifier
8. Zener Diode as a Voltage Regulator

B.Sc. – IV sem GONIOMETER

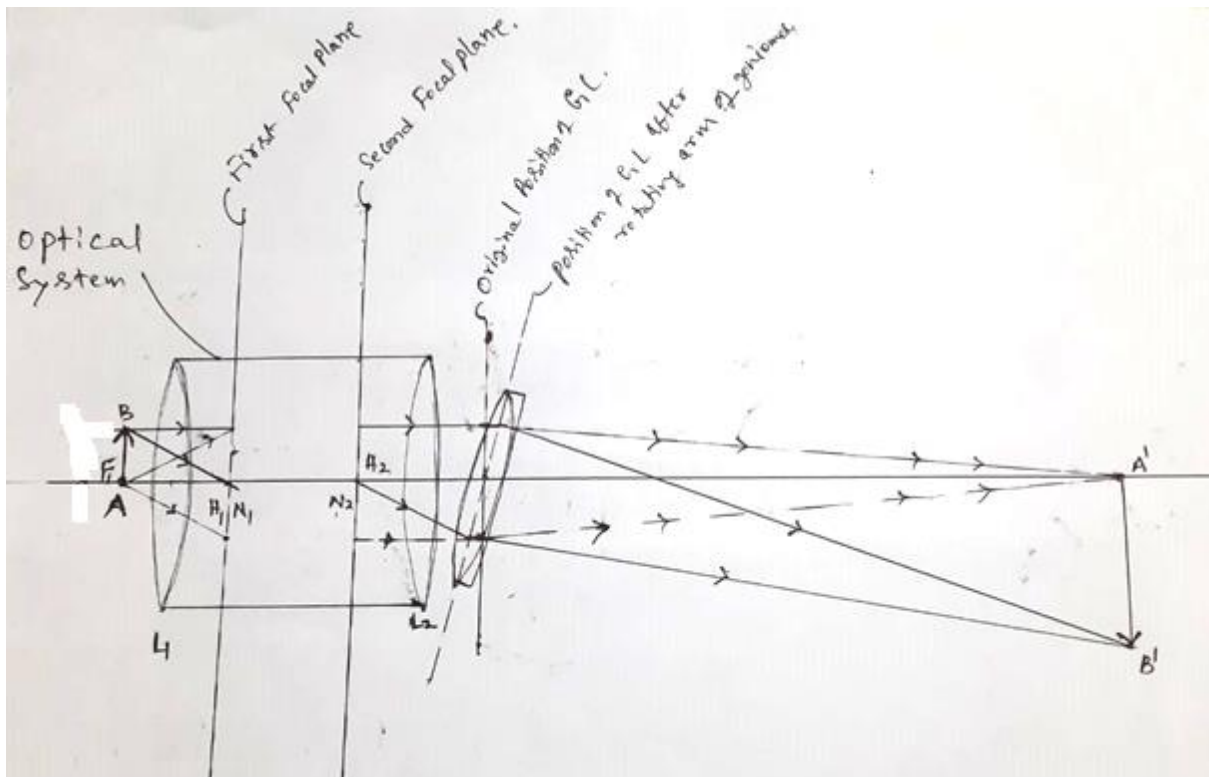
Aim: Find the equivalent focal length and cardinal points of the given optical system.

Apparatus: Goniometer, Optical systems or two lens combinations, scale plane mirror vertical wire etc.

Figure:



Experimental Set up of the Optical system:



B.Sc. – IV sem GONIOMETER

Theoretical Formula :

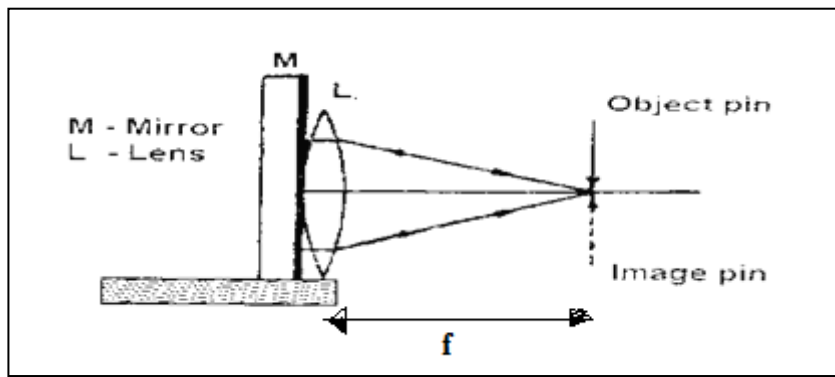
$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

where F = Focal length of the system

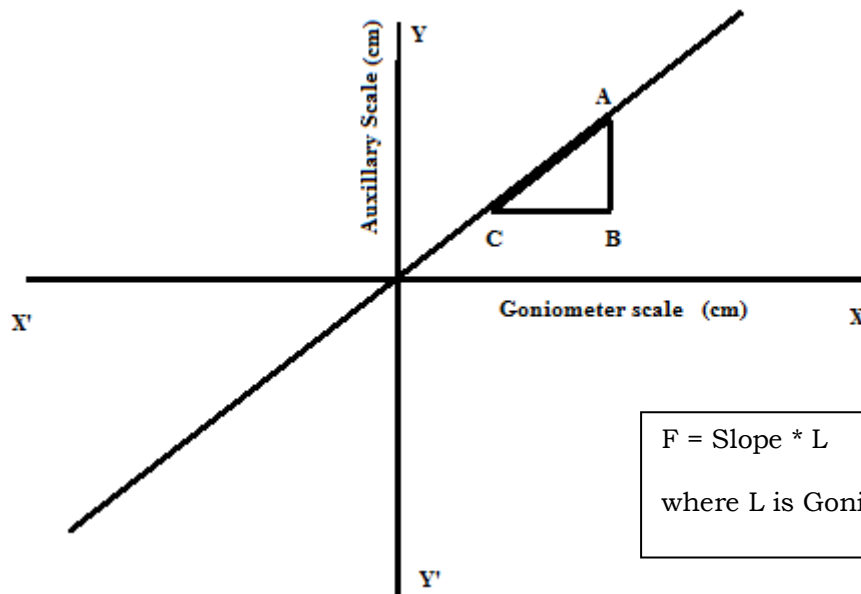
f_1, f_2 Focal lengths of individual lenses L_1 and L_2 ,

d = Separation between two lenses L_1 and L_2

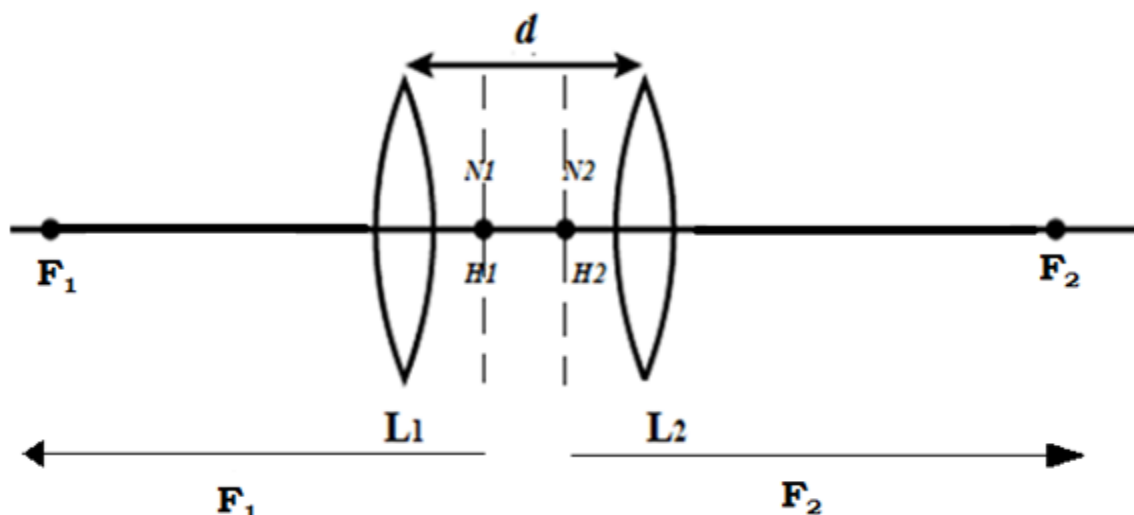
Ray diagram to find the focal length of individual lens



Nature of Graph:



B.Sc. – IV sem GONIOMETER



$L_1L_2 = d =$ Distance between two lenses

N_1 and $N_2 =$ Nodal Points

H_1 and $H_2 =$ Principal Points

F_1 and $F_2 =$ Focal Points

$L_1F_1 =$ Distance between auxillary scale and lens L_1

$L_2F_2 =$ Distance between auxillary scale and lens L_2

Observations:

- 1) Length of the Goniometer arm $L = \underline{\hspace{2cm}}$ cm.
- 2) Focal length of the lens L_1 , $f_1 = \underline{\hspace{2cm}}$ cm.
- 3) Focal length of the lens L_2 , $f_2 = \underline{\hspace{2cm}}$ cm.
- 4) Distance between the system of two lens $d = \underline{\hspace{2cm}}$ cm.

Calculation:

1. Verify the relation:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2} \quad \text{Or} \quad F = \frac{f_1 f_2}{f_1 + f_2 - d} = \underline{\hspace{2cm}} \text{ cm}$$

2. From Graph:

$$F = \frac{F_1 + F_2}{2} = \underline{\hspace{2cm}} \text{ cm}$$

To determine the equivalent focal length and the cardinal points of the given optical system:

B.Sc. – IV sem GONIOMETER

When auxillary scale is in the first focal plane of the system Distance L_1F_1 = _____ cm				When auxillary scale is in the Second focal plane of the system Distance L_2F_2 = _____ cm			
Side	Readings on			Side	Readings on		
	Auxillary Scale (in mm)	Goniometer Scale (in cm)	Shift on Goniometer Scale (in mm)		Auxillary Scale (in mm)	Goniometer Scale (in cm)	Shift on Goniometer Scale (in mm)
Left		$a_0 = 0$	$a_0 = 0$	Left		$a_0 = 0$	$a_0 = 0$
	-1	$a_1 =$	$a_1 - a_0 =$		-1	$a_1 =$	$a_1 - a_0 =$
	-2	$a_2 =$	$a_2 - a_1 =$		-2	$a_2 =$	$a_2 - a_1 =$
	-3	$a_3 =$	$a_3 - a_2 =$		-3	$a_3 =$	$a_3 - a_2 =$
	-4	$a_4 =$	$a_4 - a_3 =$		-4	$a_4 =$	$a_4 - a_3 =$
	-5	$a_5 =$	$a_5 - a_4 =$		-5	$a_5 =$	$a_5 - a_4 =$
Right		$a_0 =$	$a_0 =$	Right		$a_0 =$	$a_0 =$
	1	$a_1 =$	$a_1 - a_0 =$		1	$a_1 =$	$a_1 - a_0 =$
	2	$a_2 =$	$a_2 - a_1 =$		2	$a_2 =$	$a_2 - a_1 =$
	3	$a_3 =$	$a_3 - a_2 =$		3	$a_3 =$	$a_3 - a_2 =$
	4	$a_4 =$	$a_4 - a_3 =$		4	$a_4 =$	$a_4 - a_3 =$
	5	$a_5 =$	$a_5 - a_4 =$		5	$a_5 =$	$a_5 - a_4 =$

Result: Equivalent focal length of the system of lenses

1. Experimentally Obtained = _____ cm
2. Graphically Obtained = _____ cm

KARNATAK SCIENCE COLLEGE, DHARWAD.
Department of Physics
B.Sc III Semester

CALIBRATION OF BALLISTIC GALVANOMETER

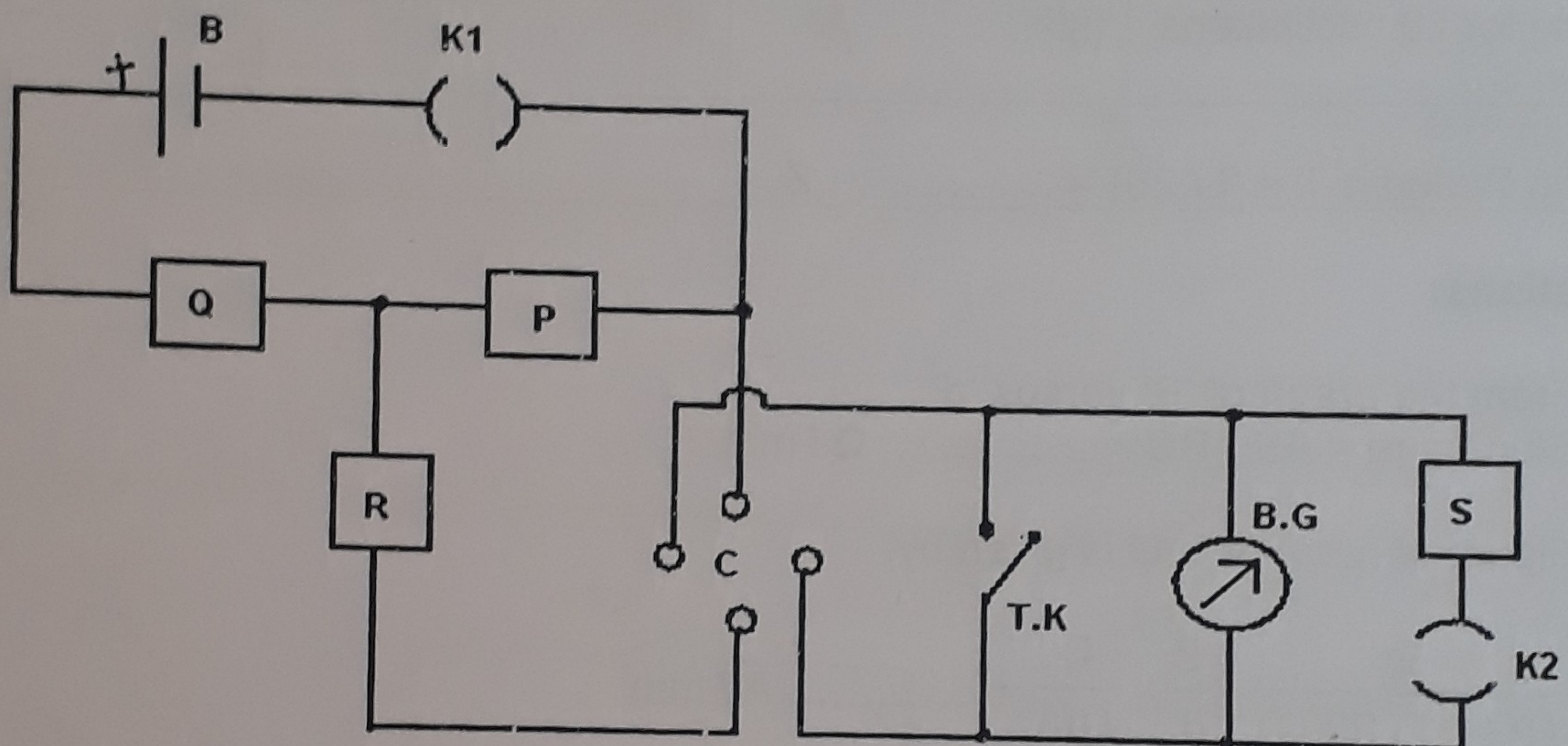
Aim: To find the figure of merit and ballistic sensitivity of the B.G and to find the resistance of B.G by half deflection method.

Apparatus: Ballistic Galvanometer, Tap key, Plug Key, Battery, Commutator, and Resistance boxes (0-100 Ω , 0-5000 Ω , 0-10000 Ω)

Observations:

- 1) E. M.F of the cell =V
- 2) Distance of the scale from the mirror of B.G = $L = \dots\dots\dots m$
- 3) Resistance = $R = \dots\dots\dots \Omega$

Circuit Diagram:

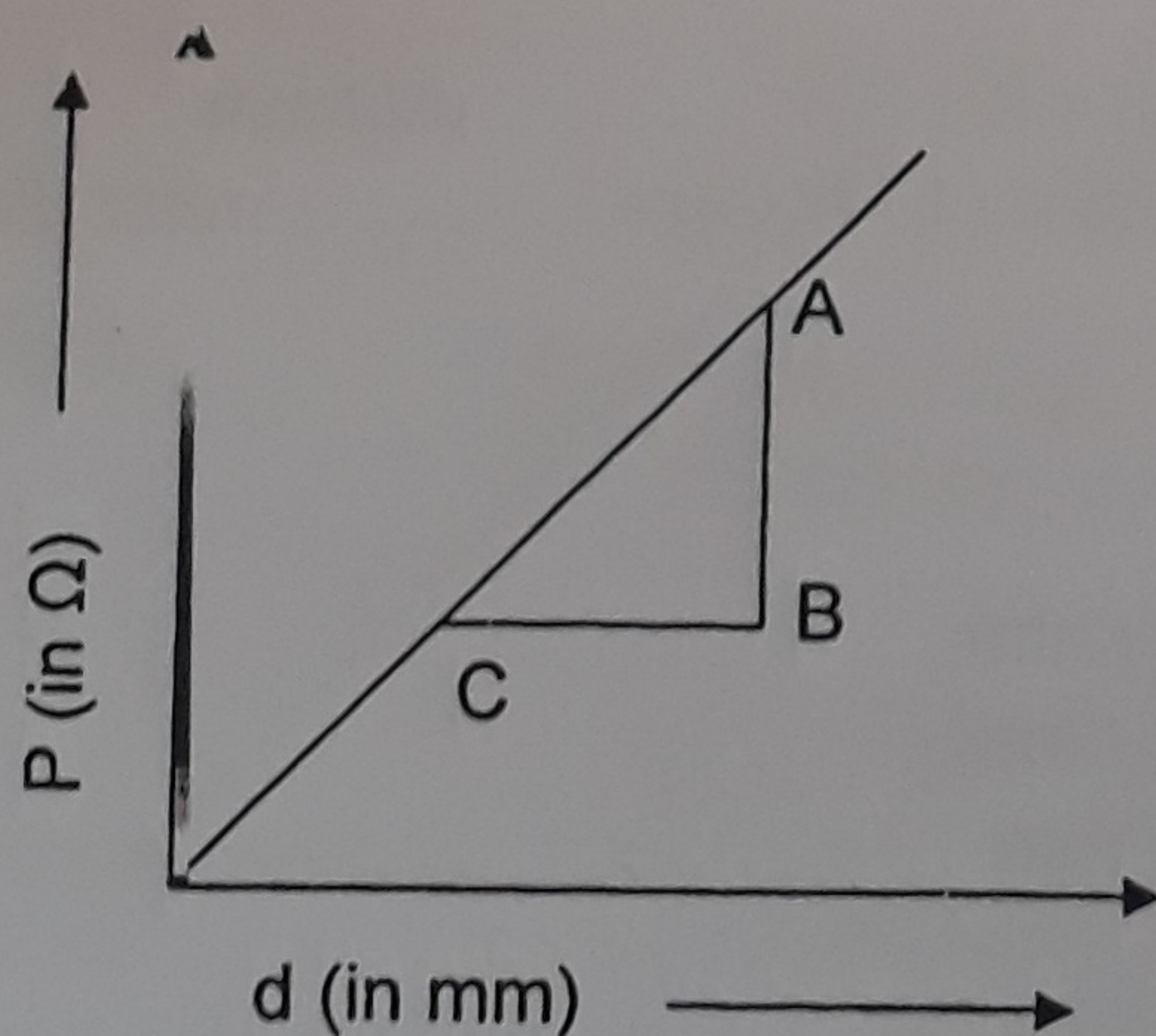


B.G – Ballistic galvanometer
P, Q, R & S – Resistance boxes
C – Commutator

T.K – Tap key
K1 & K2 – Plug keys

B - Battery Cell. (2V) of lead acid battery (6V)

Nature of the Graph:



Slope = AB / BC

Tabular Column:

Trial No.	Resistance 'P' (in Ω)	Resistance 'Q' (in Ω)	Resistance 'P + Q' (in Ω)	Deflection			Resistance 'S' (in Ω) for half deflection
				Direct 'd1' (in mm)	Reverse 'd2' (in mm)	Mean 'd' (in mm)	
1							
2							
3							
4							
5							
6							
7							
8							
Resistance of B.G = G = Mean 'S' =							

Time Period (T) of Ballistic Galvanometer:

Time for 20 oscillations 't' (in S)	(i) $t = \dots \dots \dots$ s	(ii) $t = \dots \dots \dots$ s	(iii) $t = \dots \dots \dots$ s
Mean 't' = $\dots \dots \dots$ s			
Time Period = $T = (t / 20) = \dots \dots \dots$ s			

Calculations:

1) From the graph of 'P' versus 'd'
Slope = $m = AB / BC = \dots \dots \dots \Omega / \text{mm}$

2) Figure of merit of B.G is given by,

$$K = \frac{E}{(P+Q)(R+G)} \cdot \frac{P}{d} \cdot \frac{L}{100} = \dots \dots \dots \text{A} / \text{mm}$$

$$K = \frac{E}{(P+Q)(R+G)} \times (\text{slope}) \times \frac{L}{100} = \dots \dots \dots \text{A} / \text{mm}$$

3) Ballistic sensitivity of B.G = $(T / 2\pi) \times K = \dots \dots \dots \mu\text{C} / \text{mm}$

4) Volt Sensitivity of B.G

(i) Potential difference required for 1mm deflection = $K \times G = \dots \dots \dots \mu\text{V} / \text{mm}$

(ii) Deflection in mm for $1\mu\text{V}$ potential difference = $(1 / (KG)) = \dots \dots \dots \text{mm} / \mu\text{V}$

Result:

- Figure of merit of B.G = $K = \dots \dots \dots \text{A} / \text{mm}$
- Ballistic sensitivity of B.G = $\dots \dots \dots \mu\text{C} / \text{mm}$
- Volt Sensitivity of B.G = $\dots \dots \dots \mu\text{V} / \text{mm}$

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Department of Physics
B.Sc III Semester

CALIBRATION OF SPECTROMETER

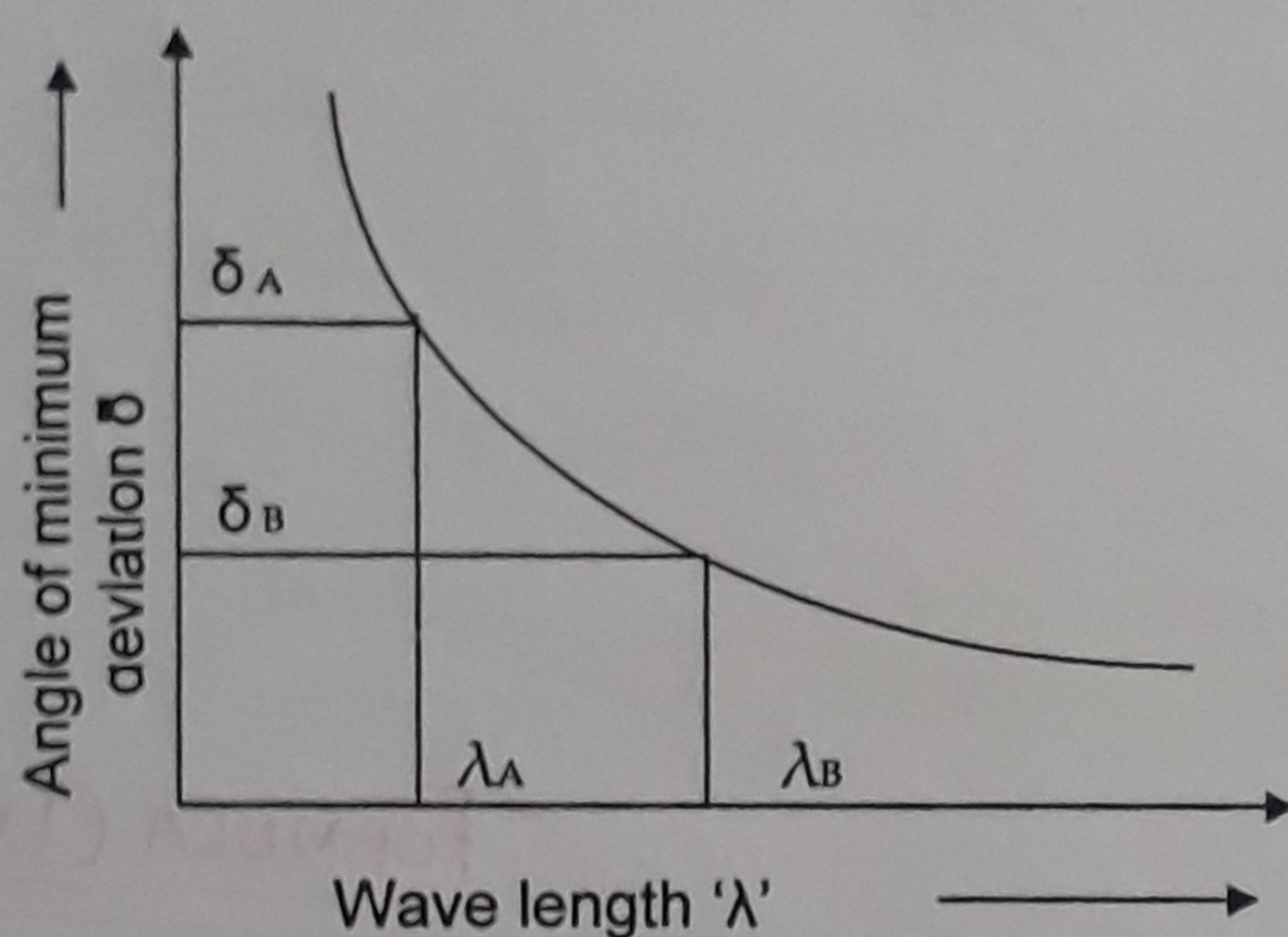
Aim: Obtain the calibration curve for given prism using mercury source & spectrometer. Using calibration curve determine the wave length of the other source.

Apparatus: Spectrometer, Prism, Mercury source, Spirit level, Magnifying lens, Hand lamp, etc.,

Observations:

1) Least Count of the Spectrometer, L.C = _____ minute

Nature of the Graph:



Tabular Column:

1) To determine the angle of minimum deviation for unknown source.

Colour of the Spectral line	Spectrometer reading for minimum deviation.		Angle of minimum deviation		Mean angle of minimum deviation $\delta = \frac{\delta_1 + \delta_2}{2}$
	Vernier A X_1	Vernier B Y_1	$\delta_1 = X \sim X_1$	$\delta_2 = Y \sim Y_1$	
Direct rays reacing	$X =$	$Y =$	-	-	-

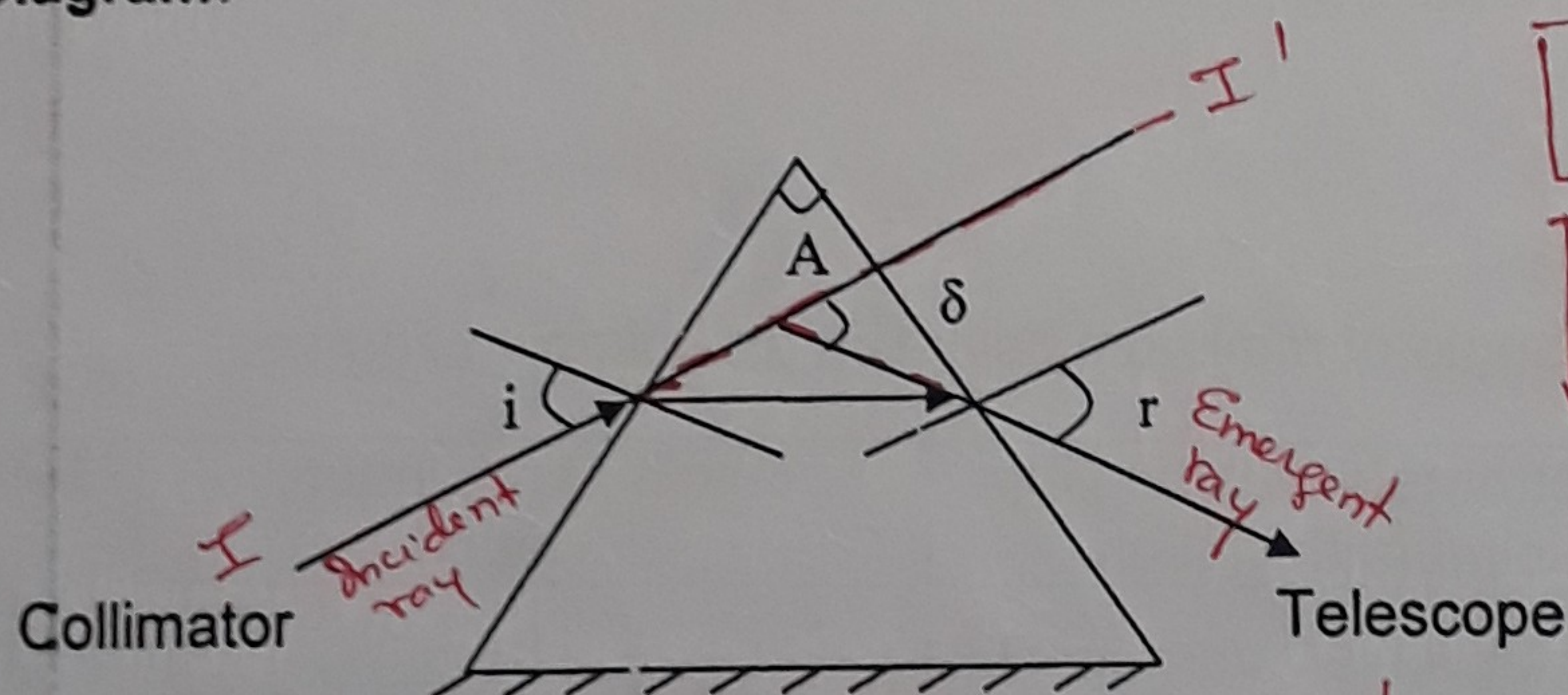
2) To determine the angle of minimum deviation for known source.

Wavelength & Colour of the Spectral line (in AU)	Spectrometer reading for minimum deviation.		Angle of minimum deviation		Mean angle of minimum deviation $\delta = \frac{\delta_1 + \delta_2}{2}$
	Vernier A X_1	Vernier B Y_1	$\delta_1 = X \sim X_1$	$\delta_2 = Y \sim Y_1$	
5791 Yellow - 1					
5770 Yellow - 2					
5461 Green					
4358 Blue					
4078 Violet - 1					
4047 Violet - 2					
Direct rays reading	$X =$	$Y =$	-	-	-

Result:

- 1) Wavelength of one unknown spectrum line = $\lambda_A = \dots\dots\dots$ AU
- 2) Wavelength of another unknown spectrum line = $\lambda_B = \dots\dots\dots$ AU

Ray Diagram:



FORMULA (1) :-

$$\delta_1 = |X - X_1|$$

$$\delta_2 = |Y - Y_1|$$

Where $(X, Y) \equiv$ Readings of particular wavelength line at minimum deviation

$(X_1, Y_1) =$ Direct reading

FORMULA:-(2)

$$\delta_x = \frac{\delta_1 + \delta_2}{2} \quad \text{Mean value of min. deviation}$$

Refractive index of the material of the prism μ_λ for

wavelength λ of light is
$$\mu_\lambda = \frac{\sin\left(\frac{A + \delta_x}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where $\delta_x =$ Angle of minimum deviation for wavelength λ of light (spectrum line of wavelength λ)

$A =$ Angle of the prism

B.Sc. III Semester
NEWTON'S RINGS

AIM: Obtain distinct Newton's rings using monochromatic source and determine the radius of curvature of the given Plano-convex lens by Newton's rings method.
Given: Wavelength of sodium source of light = 589.3 nm

APPARATUS: Sodium lamp, Microscope, Plano convex lens, Thin and thick glass plates, Condensing lens, Hand lamp, Magnifying lens etc.

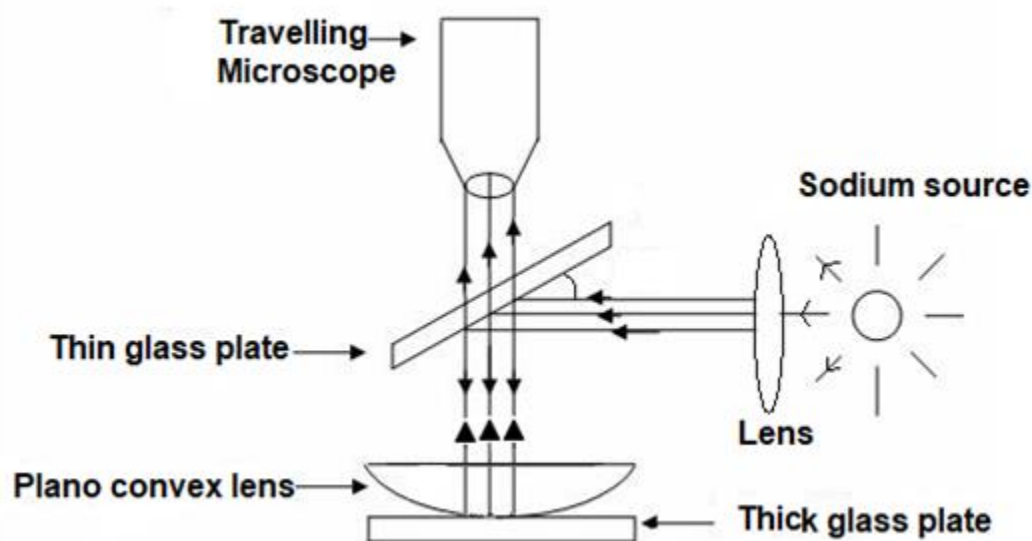
FORMULA:

Radius of curvature of convex lens surface is given by,

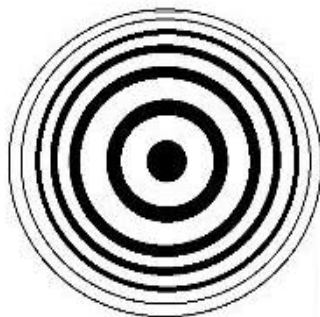
$$R = \frac{D_N^2 - D_M^2}{4\lambda (N - M)}$$

where N and M is some n^{th} and m^{th} ring and, D_N and D_M there corresponding diameter. λ is the wavelength of sodium source

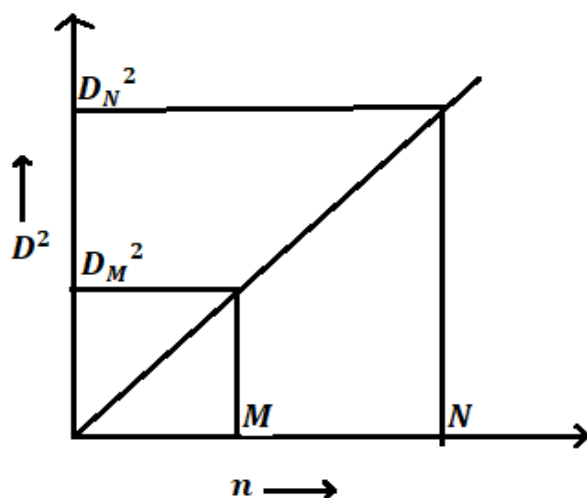
RAY DIAGRAM:



NATURE OF THE RINGS:



NATURE OF GRAPH:



$N = \dots\dots\dots$ $M = \dots\dots\dots$ $D_N^2 = \dots\dots\dots$ $D_M^2 = \dots\dots\dots$

B.Sc. III Semester
NEWTON'S RINGS

PRINCIPLE: The experiment is based on circular interference fringes produced by enclosing a thin air film of varying thickness between the surface of a convex lens of large radius of curvature and a plane glass plate. The thickness of air film is zero at the point of contact and increases as we go outwards.

If monochromatic light is incident on such an air film normally from above, it undergoes partial reflection from its two faces. The two systems of reflected beams are in a position to interfere, whenever the effective path difference between them is an odd multiple of $\lambda/2$. We obtain a number of concentric rings which are alternately bright and dark.

OBSERVATIONS:

- 1. Mean wavelength of the monochromatic light used= λ = 5893 Å
- 2. Least count of travelling microscope scale= LC = cm

TABULAR COLUMN:

Number of Ring 'n'	Microscope reading to measure diameter						Diameter of the ring (cm) D= a~b	D² (cm²)
	Left 'a'			Right 'b'				
	PSR	HSR	TR	PSR	HSR	TR		
20								
18								
16								
14								
12								
10								
8								
6								

RESULT:

Radius of curvature of convex lens surface R =..... cm

VIVA QUESTIONS:

- 1. What is interference of light?
- 2. How are Newton's rings formed?
- 3. Why is central ring dark?
- 4. What do you understand by coherent sources?
- 5. Why do the rings get closer as we move away from the center?
- 6. What is the function of glass plate inclined at 45° ?
- 7. What happens if glass plate at the bottom is replaced by a plane mirror?
- 8. What if sodium light is replaced with white light?
- 9. What happens if few drops of liquid is introduced between the lens and the lens and the glass?
- 10. Why plano convex lens of larger aperture is used in this experiment?

REFERENCES:

- 1. F. Jenkins and H. White, Fundamentals of Optics, TATA-McGrawHill.
- 2. A. Ghatak, Optics, TATA-McGraw Hill.
- 3. R.K. Shukla and A. Srivatsava, Practical Physics, New Age International Ltd.

TURN TABLE

B.Sc. – IV sem

Aim: Find the equivalent focal length and cardinal points of the given optical system. Locate cardinal points on the graph sheet, and verify the relation $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

Apparatus: Turn table capable of rotating about vertical axis, Optical system, scale, plane mirror, vertical pins etc.

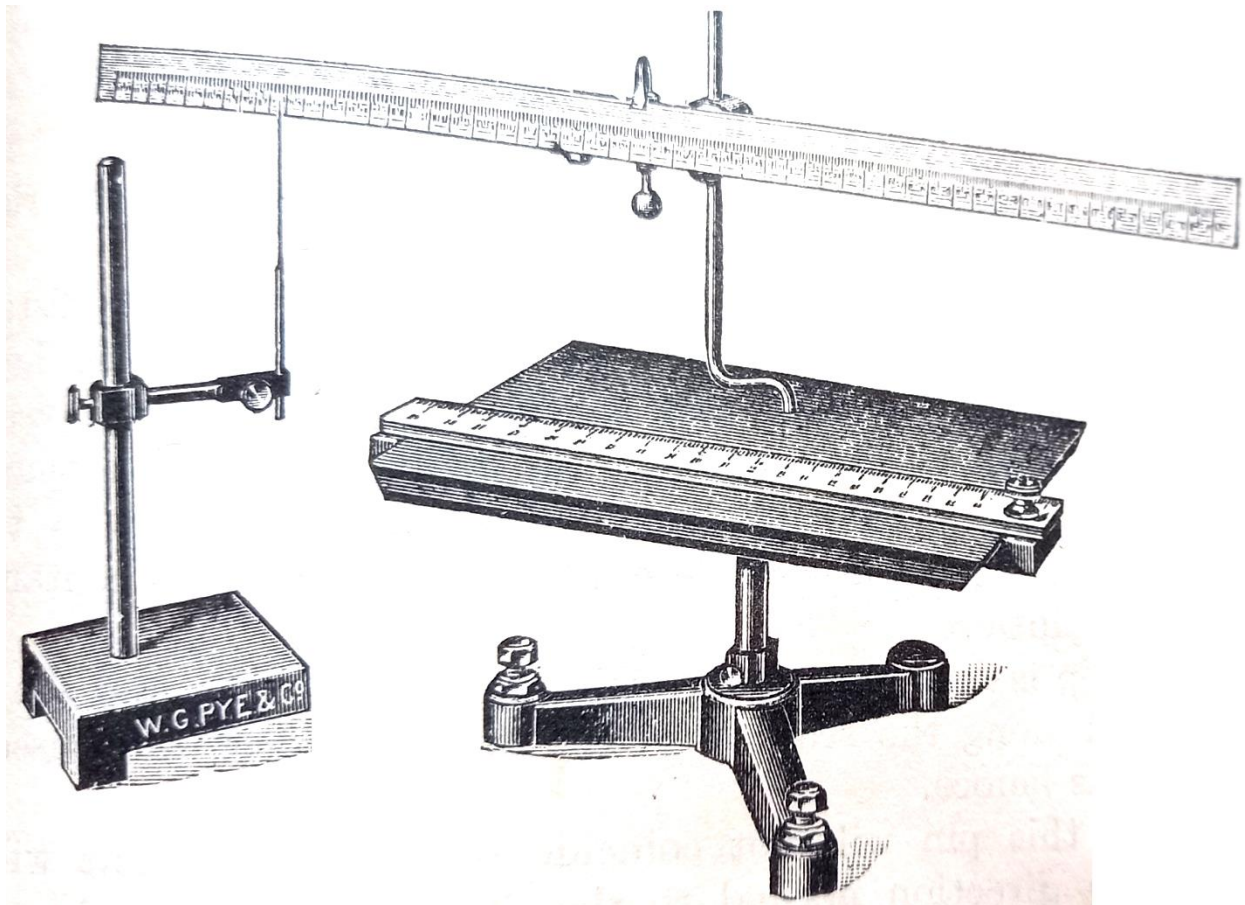
Theoretical Formula :

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

where F = Focal length of the system

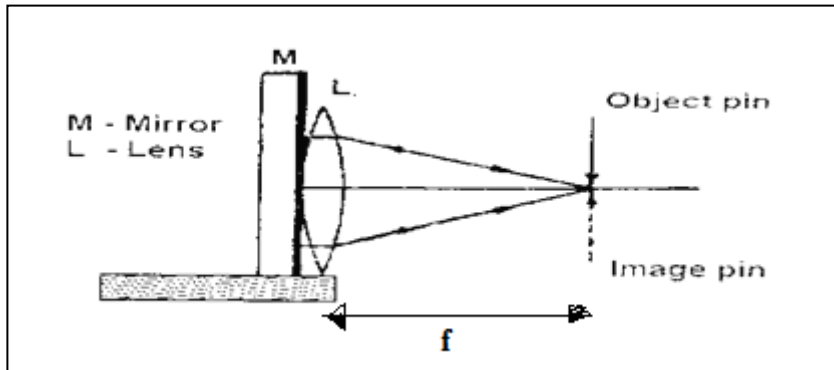
f_1, f_2 Focal lengths of individual lenses L_1 and L_2 ,

d = Separation between two lenses L_1 and L_2

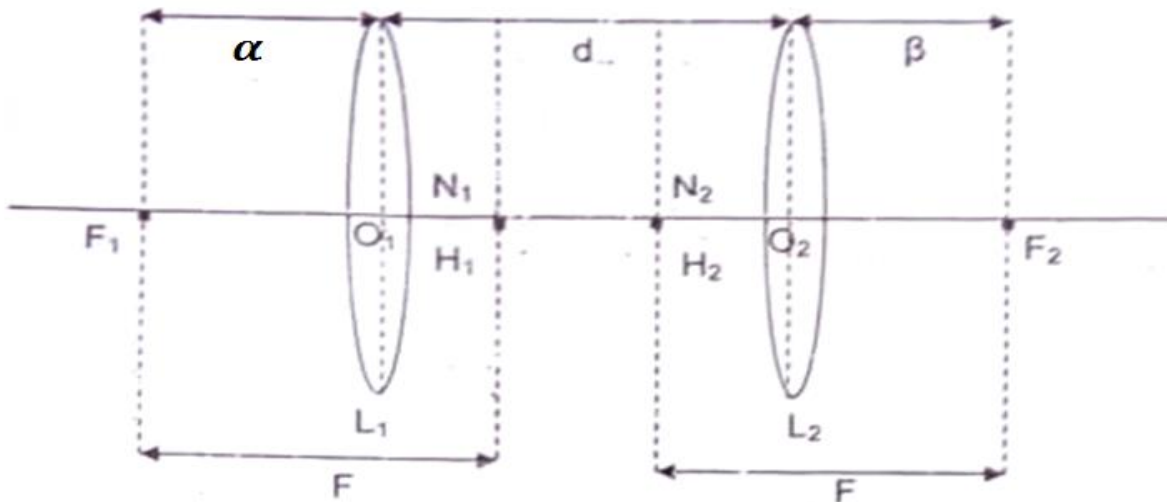


TURN TABLE
B.Sc. – IV sem

Ray diagram to find the focal length of individual lens



Representation of Cardinal Points



L_1 and L_2 = system of two convex lenses

$L_1L_2 = d$ = Distance between two lenses

N_1 and N_2 = Nodal Points

H_1 and H_2 = Principal Points

F_1 and F_2 = Focal Points

$F_1 N_1 = F_1 H_1 = F$

$F_2 N_2 = F_2 H_2 = F$

$F_1 O_1 = \alpha$

$F_2 O_2 = \beta$

TURN TABLE
B.Sc. – IV sem

Note : To locate the Cardinal points use the experimental value of focal length

Observations:

- 1) Focal length of the lens L_1 , $f_1 = \underline{\hspace{2cm}}$ cm.
- 2) Focal length of the lens L_2 , $f_2 = \underline{\hspace{2cm}}$ cm.
- 3) Perpendicular distance between two pins for the adjustment of the axis of the system, $x = \underline{\hspace{2cm}}$ cm.
- 4) Distance through which the lens system is to be shifted so that two axis will intersect, $x/2 = \underline{\hspace{2cm}}$ cm.

Result:

Trial No.	Distance between L_1 and L_2 d (cm)	Theoretical value of focal length $F = \frac{f_1 f_2}{f_1 + f_2 - d}$ (cm)	Experimental value of focal length determined using turn table F (cm)

[illegible]

B.Sc. III Semester

HIGH RESISTANCE BY LEAKAGE METHOD

Aim: To determine high resistance by leakage method.

Apparatus: Resistor having high resistance, Electrolytic Capacitor, Ballistic Galvanometer (B.G), Decade Resistance boxes, plug keys, Tap keys, Battery.

Formula:

$$\text{Value of Resistance} = R = \frac{t}{2.303 \times C \times \log_{10}\left(\frac{\theta_1}{\theta_2}\right)} = \text{_____} \Omega$$

where

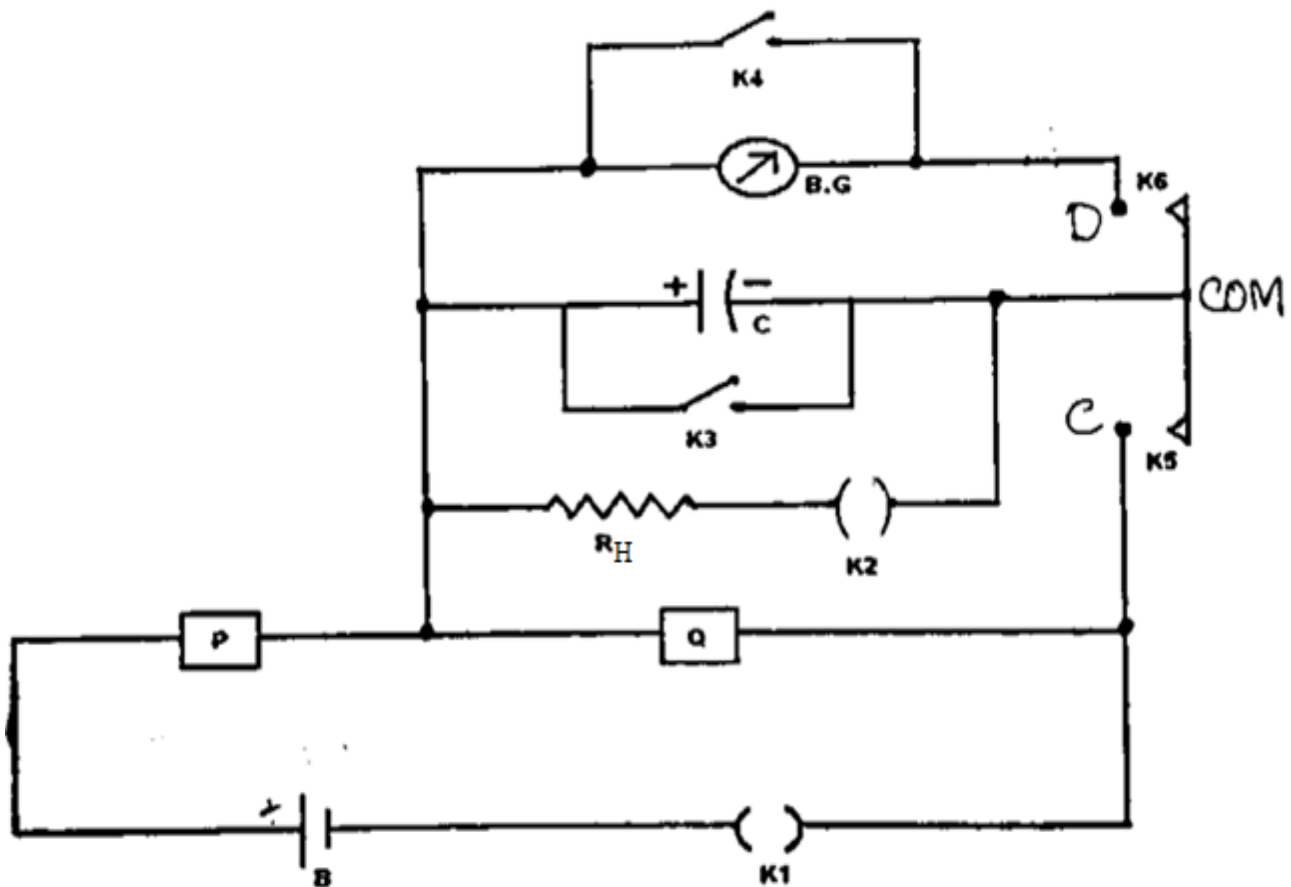
C = Capacity of the Capacitor

θ_1 = Corrected throw obtained by discharging charged capacitor through B.G immediately after charging it.

θ_2 = Corrected throw obtained by discharging the charged capacitor through B.G after leakage through high resistance for time t.

t = Time in seconds for which the charged capacitor is allowed to leak through the given high resistance.

Circuit Diagram:



B-Battery (Emf, E = 6 V)

P & Q - Decade Resistance boxes (P= 15000 Ω & Q= 100 Ω)

K1, K2 - Plug key

B.Sc. III Semester

HIGH RESISTANCE BY LEAKAGE METHOD

K3, K4, -Tap keys
K5 & K6 - Charging Discharging key
 R_H - High Resistance
C- Capacitor (C= 47 μ F)
B.G- Ballistic galvanometer

Observation:

- 1) Battery B = 5 V
- 2) P & Q - Decade Resistance boxes P = 3500 Ω and Q = 500 Ω
- 3) Capacitance of the capacitor C = _____ μ F

Tabulation of the results and Error determination by residual analysis:

T R I A L N O	Throw obtained by discharging fully charged capacitor through B.G immediately after charging θ_1 (in cm)			Leak age time t (s)	Throw obtained by the discharging of the capacitor through B.G immediately after it was allowed to leak for time T=300 s, through high resistance (in cm).			R = $\frac{t}{2.303 \times C \times \log(\frac{\theta_1}{\theta_2})}$ (Ω)
	First throw θ'_1	Third throw θ'_3	Corected throw $\theta_1 =$ $\left[\theta'_1 \cdot \left(\frac{\theta'_1}{\theta'_3} \right)^{\frac{1}{4}} \right]$		First throw θ''_1	Third throw θ''_3	Corrected throw $\theta_2 =$ $\left[\theta''_1 \cdot \left(\frac{\theta''_1}{\theta''_3} \right)^{\frac{1}{4}} \right]$	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Mean R = _____ Ω

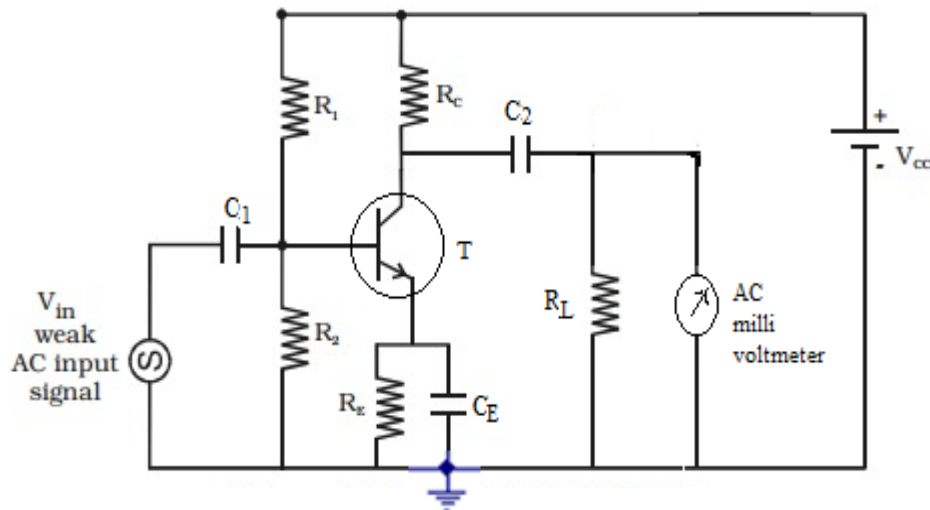
Result: Determined Value of High resistance is R = _____ Ω

B.Sc. IV – SEMESTER (NEP)
CE AMPLIFIER

AIM: Set up R.C. coupled CE Transistor amplifier. Draw the Frequency response curve and obtain band width.

APPARATUS: working board, Transistor (BC-547), capacitors, resistors, power supply, signal generator, AC millivoltmeter etc.

CIRCUIT DIAGRAM:



V_{in} -Signal generator

T - Transistor BC547

$C_E = 22 \mu F$

V_{out} = AC millivoltmeter

$V_{cc} = 9V$ Power supply $R_1 = 47 K\Omega$ pot

$R_C = 2.2 K\Omega$

$C_1 = C_2 = 22 \mu F$

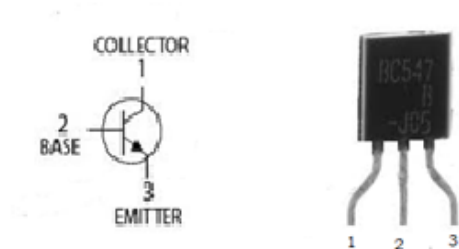
$R_e = 1 K\Omega$

$R_2 = 5.6 K\Omega$

$R_L = 12 K\Omega$

Pin Configuration

BC 547 NPN Transistor



OBSERVATIONS:

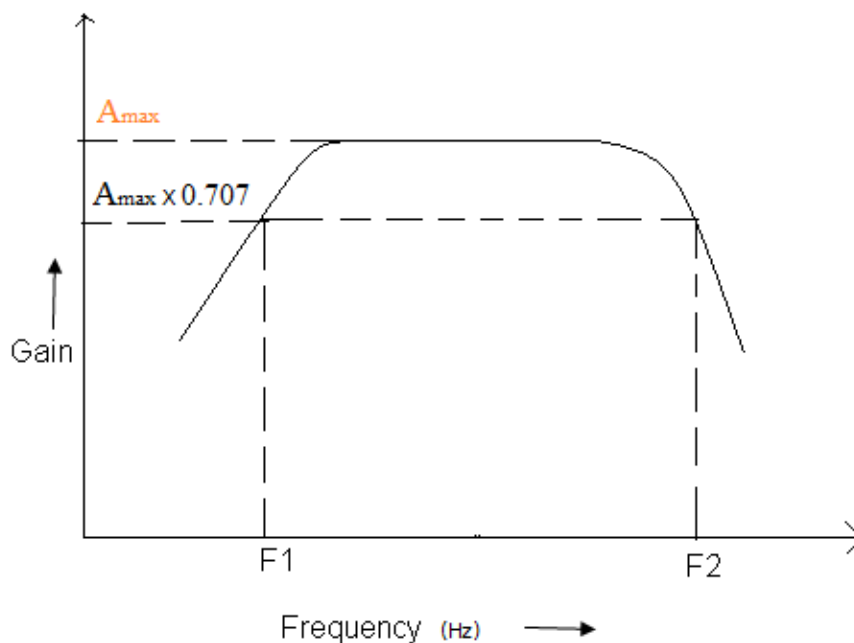
1. DC condition: Adjust $V_{CE} = \frac{V_{cc}}{2}$

2. Input voltage (V) = 20 mV kept constant for all frequencies of input signal.

B.Sc. IV – SEMESTER (NEP)
C E AMPLIFIER

Sl.NO	Frequency (Hz)	Output voltage V_o volts	Gain = V_o/V_{in}
1	50		
2	100		
3	200		
4	-		
-	-		

NATURE OF GRAPH:



RESULT:

- 1) Mid band gain $A_{max} =$ _____
- 2) Lower half Frequency $F1 =$ _____ Hz
- 3) Upper half frequency $F2 =$ _____ Hz
- 4) Band width = $F2 - F1 =$ _____ Hz

B.Sc. IV – SEMESTER (NEP)
C E AMPLIFIER

Theory:

An amplifier is an electronic device that increases the voltage, current, or power of a signal. Amplifiers are used in wireless communications and broadcasting, and in audio equipment of all kinds. For any amplifier, the transistor is an essential part of the circuit. Transistor used can be a BJT or a FET. These are classified into various configurations based on their characteristics. Based on desired operating point transistors must be biased. Then the signal is applied as the input to the amplifier and achieved gain at the output.

A transistor in which the emitter terminal is made common for both the input and the output circuit connections is known as common emitter configuration. When this configuration is provided with the supply of the alternating current (AC) and operated in between the both positive and the negative halves of the cycle in order to generate the specific output signal is known as common emitter amplifier.

In this type of configuration the input is applied at the terminal base and the considered output is to be collected across the terminal collector. By keeping emitter terminal is common in both the cases of input as well as output. It should be noted that for using transistor as amplifier, emitter base junction should be forward biased and collector base junction should be reversed biased. These two conditions are to be achieved simultaneously using single power supply only. Hence universal voltage divider bias (VDB) method is used.

Other than this there are various electronic components are to be included in this circuit. One is the resistor R_1 that is the one to make the transistor to function in the forward biasing mode. The R_2 is responsible to make the biasing possible. There is the load resistor and the resistor that is connected at the emitter so that it controls the stability related to thermal issue. The resistors R_1 and R_2 connected across the terminal base as it is the input side. The load resistor is connected at the output side that is across the collector terminal.

C_1 and C_2 are the capacitors placed in the input and output of an amplifier they are used to couple one circuit with another hence they are called as coupling capacitors. The capacitor C_1 is at the input side and the capacitor C_2 is connected across the emitter resistor. The C_1 capacitor is responsible to separate the value of the AC signals from that of DC signals. There exists the inverse relation between the R_1 resistor and the biasing. As R_2 tends to increase the biasing tends to increase and vice-versa. Hence to the smaller or the weaker signals that are applied to the base gets

B.Sc. IV – SEMESTER (NEP)
CE AMPLIFIER

amplified at the obtained output signals. Hence this is the reason it is known as CE amplifier.

The capacitor C_E is known as bypass capacitor which is used to bypass the AC signal to ground. It is very helpful because any noise signal that may be present in AC signal will be passed out from bypass capacitor.

The resistances R_1 and R_2 are placed to control base current I_B and hence provide required collector current I_C and collector to emitter voltage V_{CE} as per the Quiescent point Q (operating point) that provides the required biasing to the transistor hence they are known as biasing resistors.

The resistance R_C is a collector load placed in the collector terminal in order produce faithful amplification. The resistance R_E resistor is placed in the emitter terminal of a transistor, and it is useful to control the gain of an amplifier.

Voltage Gain

The ratio of the output voltage generated when the input voltage is applied decides the voltage gain of the common emitter amplifier. Here the load resistance is the resistor connected across the collector. The ratio in between the output current to the applied input current gives the current gain. This is denoted as beta. In this way the values of the voltage gain and the current gain are calculated for this amplifier configuration.

Characteristics

The characteristics of the common emitter configuration amplifier configuration are as follows

1. The voltage gain value obtained for the common emitter amplifier is medium.
2. It also consists of the current gain in the medium range.
3. Because of both the voltage and the current gains the power gain value of this configuration is referred to be high.
4. There is some resistance value at the inputs as well as the output but in this configuration it is maintained at the medium value.
5. Amplifier in this mode of operation introduces 180 degree shift of the phase difference between input signal and output signal.
6. In this mode there is large bandwidth.

B.Sc. IV – SEMESTER (NEP)
CE AMPLIFIER

All these characteristics of the common emitter configuration make it most widely used amplifier among all the three configurations. As the applied input signal V_i increases, base current I_B increases above the biased value thereby increasing collector current I_C by beta (β) times above the operating value which increases the voltage at the collector resulting in decreasing the output voltage. This output is mathematically represented by the equation

$$V_o = V_{cc} - I_C R_c$$

This explains the 180° phase difference between input and output signals

Applications

The applications of this CE amplifier are as follows

1. These amplifiers are preferably used as the current amplifier than a voltage amplifier as it has more current gain than the voltage gain.
2. In the radio frequency circuitry this configuration is preferred.
3. For the lower values of noise and its amplification this configuration is preferred.
4. In order to construct the sinusoidal oscillators (such as Hartley, Colpitts, Phase shift oscillator) CE amplifier is used.

Relevant Viva Questions:

- 1) What is an amplifier used for?
- 2) What is a Common Emitter Amplifier?
- 3) What kind of bias is preferable in designing Common Emitter Amplifiers?
- 4) What is phase relation between the input and output?
- 5) How do you bias the BJT for amplifier application?
- 6) What is voltage gain, Current gain and power gain?
- 7) What is band width?
- 8) What is meant by gain band width?
- 9) What are applications of CE amplifier?
- 10) Describe the working of CE amplifier in brief.

B.Sc III – SEM

VOLTAGE-REGULATOR (USING ZENER DIODE)

AIM: Set up voltage regulator using zener diode of break down voltage $V_z = \text{---V}$ and Power rating $P_z = \text{--- watt}$ Plot the Variation of the output voltage versus load current. Determine Percentage of regulation and internal resistance

APPARATUS USED: Zener diode, step down transformer, capacitors, resistors, ammeter, voltmeter, plug key, rheostat (1000 Ω or more).

FORMULAE:

1. Max current from zener diode = $I_{\max} = \frac{P_z}{V_z}$ (mA)

2. Protective resistance $R_s = \frac{V_{in} - V_z}{I_L}$ Ω

where I_L is chosen such that $I_L < I_{\max}$

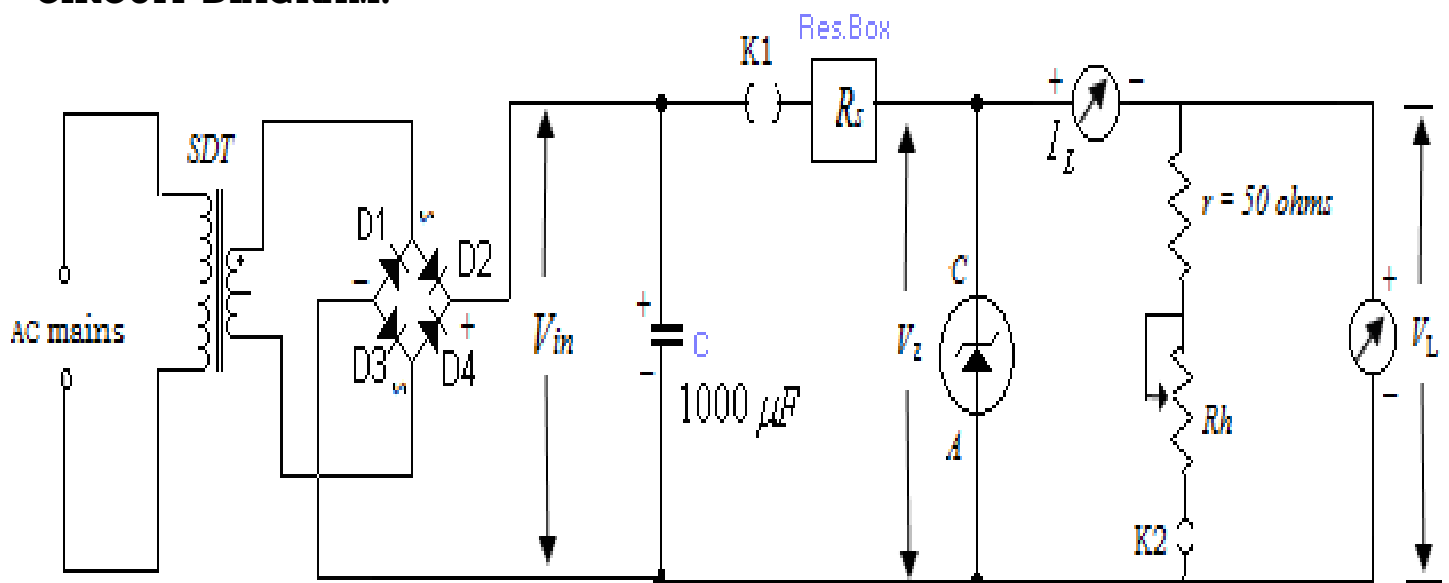
3. Percentage regulation is given by

$$\frac{V_{NL} - V_{FL}}{V_{NL}} \times 100 \%$$

4. Internal resistance

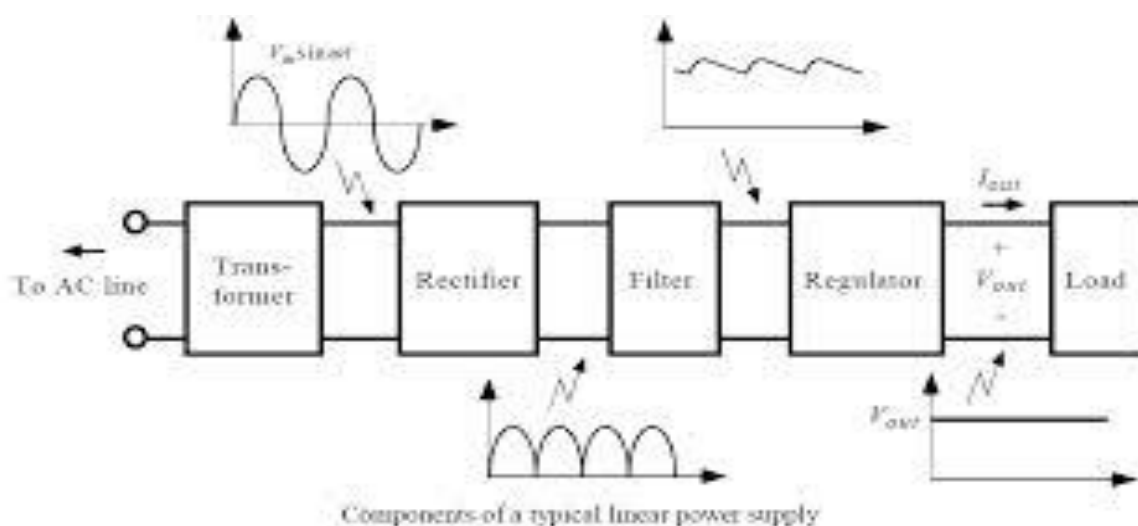
$$R_i = \frac{V_{NL} - V_{FL}}{I_{FL}} \Omega$$

CIRCUIT DIAGRAM:

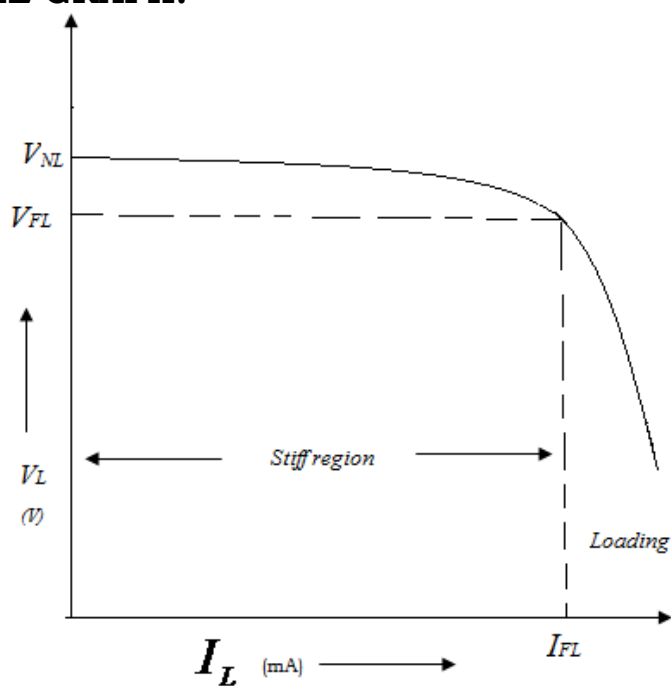


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VOLTAGE-REGULATOR (USING ZENER DIODE)



NATURE OF THE GRAPH:



OBSERVATIONS:

V_L in volts	I_L in mA

RESULT: The variation of load voltage with current is studied

Percentage regulation = _____%

Internal resistance R_i = _____ Ω

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VOLTAGE-REGULATOR (USING ZENER DIODE)