

# **PHYSICS LABORATORY MANUAL**

**UNDER**

**DBT-STAR COLLEGE SCHEME**

**Sponsored by**



**Department of Biotechnology**

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**DEPARTMENT OF PHYSICS**

**G.T.N. ARTS COLLEGE (AUTONOMOUS)**

**(Re-Accredited with A++ Grade by NAAC)**

**DINDIGUL-624 005**

## Preface

Department of Physics, G.T.N. Arts College, Dindigul, is prepared the lab manual for the Academic Year 2022-2023. This Manual enrich the practical knowledge of the students. This manual contains the latest syllabi of experiments on Elasticity, Heat, Optics, Electricity and Electronics according to Outcome Based Education of our Institution. The main objective of this work is to give hands - on - training to the students in order to use their theoretical concepts and apply the concepts into practice. This manual encourage the students to do the practicals within the given stipulated time. During Practicals, the students gained the practical knowledge and able to apply the knowledge while designing the circuits. This manual is prepared as per the Outcome based Education syllabus and thus it can help the students to follow the methods and learn to make the circuits and use various formulae for constructive design, calculation to get appropriate results. This manual will provide the right mixture of confidence and diffidence required of the student unleashed alone in the arena of expensive instrumentation. Finally we would like to thank the staff members who have helped us in preparing this manual. Our sincere thanks to the Management, DBT, Star College Scheme, for giving us this opportunity to formulate the Physics Lab manual for the boon of our students. Any suggestion towards further improvement will be thankfully acknowledged and incorporated in the next edition.

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## DETERMINATION OF RIGIDITY MODULUS- TORSIONAL PENDULUM

### Aim:

To determine the moment of inertia of the disc and the rigidity modulus of the wire by torsional oscillations.

### Apparatus:

Uniform circular disc, wire, two equal cylindrical masses, stop-clock, screw gauge and metre scale.

### Formula:

- i) Moment of Inertia of the disc

$$I = \frac{2m(d_2^2 - d_1^2)T_o^2}{T_2^2 - T_1^2} \text{ kg.m}^2$$

- ii) Rigidity modulus of the material of the wire

$$n = \frac{16\pi lm (d_2^2 - d_1^2)}{a^4(T_2^2 - T_1^2)} \text{ N/m}^2$$

Where,

$n$  = Rigidity modulus of the given wire ( $\text{N/m}^2$ )

$I$  = Moment of Inertia of the disc ( $\text{Kg m}^2$ )

$m_1, m_2$  = Mass of the symmetrical weights placed on the disc (Kg)

$d_1$  = Closest distance between suspension wire and the centre of mass of the cylinder (m)

$d_2$  = Farthest distance between suspension wire and the centre of mass of the cylinder (m)

$T_0$  = Time period without any mass placed on disc (sec)

$T_1$  = Time period when equal masses are placed at a minimum distance  $d_1$ (sec)

$T_2$  = Time period when equal masses are placed at a maximum distance  $d_2$ (sec)

$L$  = Length of the suspension wire (m)

$a$  = Radius of the wire (m)

### Procedure:

- The length of the suspension wire is fixed (50 cm to 80 cm)
- Disc is slightly twisted, so that executes torsional oscillations. (Wobbling and zigzag motions should be avoided)
- Without masses on the disc [Refer Fig.] the time taken for 10 oscillations are noted. Two trials were taken. By using this value Time period  $T_0$  (time for one oscillation) is calculated.
- With masses at a distance  $d_1$  [Refer Fig.], the time taken for 10 oscillations are noted. Two trials are taken from that the Time period  $T_1$  is calculated.
- With masses at a distance ' $d_2$ ' [Refer Fig.], the time taken for 10 oscillations are noted. Two trials are taken from that the time period  $T_2$  is calculated.
- After removing the disc, Diameter of the wire ( $d$ ) is measured by using screw gauge at various places and the radius ( $r$ ) of the wire is calculated.
- The moment of Inertia ( $I$ ) of the disc and the Rigidity modulus ( $n$ ) of the wire calculated by using the given formula.

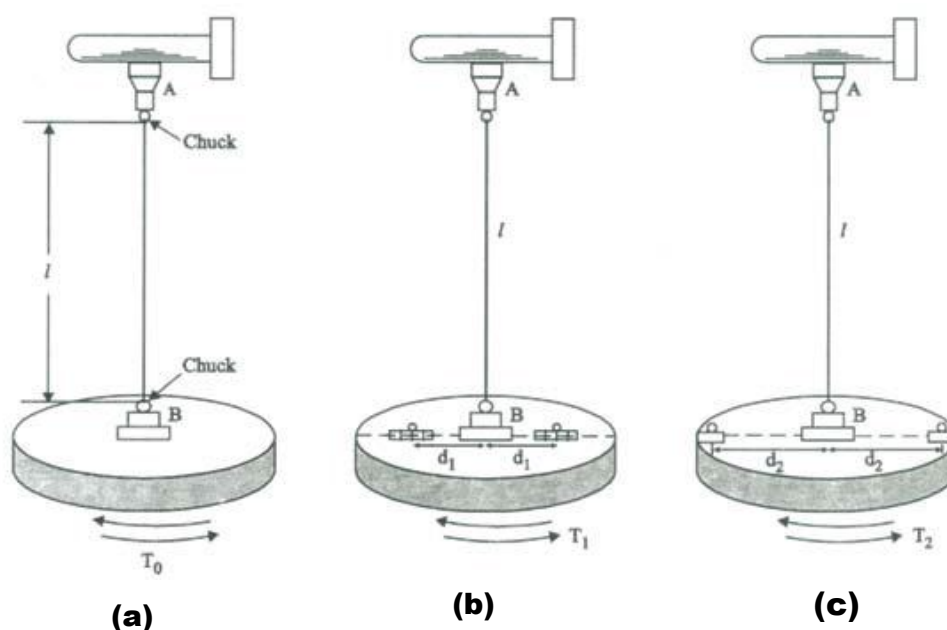


**Fig. Torsional pendulum**

**OBSERVATION:****TABLE.1.1 TO DETERMINES THE ‘T’ AND ‘n’ :**Length of the suspension wire (l) = ..... X 10<sup>-2</sup> m

| Position of masses                                                        | Time period for 10 oscillations |         |      | Time period for one oscillation (T/10) |
|---------------------------------------------------------------------------|---------------------------------|---------|------|----------------------------------------|
|                                                                           | Trial 1                         | Trial 2 | Mean |                                        |
| Unit                                                                      | sec                             | sec     | sec  | sec                                    |
| Without masses                                                            |                                 |         |      | T <sub>0</sub> =                       |
| Masses at closest distance<br>d <sub>1</sub> = ..... x10 <sup>-2</sup> m  |                                 |         |      | T <sub>1</sub> =                       |
| Masses at farthest distance<br>d <sub>2</sub> = ..... x10 <sup>-2</sup> m |                                 |         |      | T <sub>2</sub> =                       |

**TABLE.1. 2 TO FIND THE DIAMETER (D) OF THE SUSPENSION WIRE – SCREW GAUGE**

Zero Error (Z.E) = ..... div

Least Count = 0.01 mm

Zero Correction (Z.C) = ..... mm

| S. No. | Pitch Scale Reading (PSR)<br>× 10 <sup>-3</sup> m | Head Scale Coincidence (HSC)<br>div | CHSC = (HSC ± ZC)<br>× 10 <sup>-3</sup> m | HSR = (CHSC × LC)<br>× 10 <sup>-3</sup> m | Corrected Reading CR= (PSR + HSR)<br>× 10 <sup>-3</sup> m |
|--------|---------------------------------------------------|-------------------------------------|-------------------------------------------|-------------------------------------------|-----------------------------------------------------------|
| 1.     |                                                   |                                     |                                           |                                           |                                                           |
| 2.     |                                                   |                                     |                                           |                                           |                                                           |
| 3.     |                                                   |                                     |                                           |                                           |                                                           |
| 4.     |                                                   |                                     |                                           |                                           |                                                           |
| 5.     |                                                   |                                     |                                           |                                           |                                                           |

Mean diameter of the wire (d) = ..... X 10<sup>-3</sup>mMean radius of the wire (r) =  $\frac{d}{2}$  = ..... X 10<sup>-3</sup>m

**Calculation:**

Mass of one of the cylinder  $m = \dots\dots\dots \text{kg}$

Closest distance between suspension wire and  
The centre of mass of the cylinder  $d_1 = \dots\dots\dots \text{m}$

Farthest distance between suspension wire and  
The centre of mass of the cylinder  $d_2 = \dots\dots\dots \text{m}$

Time period without masses  $T_0 = \dots\dots\dots \text{sec}$

Time period with masses is at a distance ' $d_1$ '  $T_1 = \dots\dots\dots \text{sec}$

Time period with masses is at a distance ' $d_2$ '  $T_2 = \dots\dots\dots \text{sec}$

Length of the suspension wire  $l = \dots\dots\dots \text{m}$

Mean diameter of the wire  $d = \dots\dots\dots \text{m}$

Mean radius of the wire  $r = \dots\dots\dots \text{m}$

Moment of Inertia of the disc 
$$I = \frac{2m(d_2^2 - d_1^2)T_0^2}{(T_2^2 - T_1^2)} \text{kgm}^2$$

$$I =$$

$$I = \dots\dots\dots \text{Kg m}^2$$

Rigidity modulus of the material of the wire

$$n = \frac{16\pi lm (d_2^2 - d_1^2)}{a^4(T_2^2 - T_1^2)} \text{N/m}^2$$

$$n =$$

$$n = \dots\dots\dots \text{N/m}^2$$

**Result:**

i. The moment of inertia of the disc ( $I$ ) =  $\dots\dots\dots \text{kg m}^2$

ii. Rigidity modulus of the wire ( $n$ ) =  $\dots\dots\dots \text{N/m}^2$

## DETERMINATION OF YOUNG'S MODULUS – NON-UNIFORM BENDING

### Aim

To determine Young's modulus of the material of the beam by non-uniform bending method.

### Apparatus Required

The given beam (metre scale), Weight hangers with slotted weights and two knife edges, Pin and traveling microscope, Vernier caliper and Screw gauge.

### Formula

Young's Modulus of the material of the beam (metre scale) by non-uniform bending method:

$$E = \frac{Mgl^3}{4bd^3y} \text{ Nm}^{-2}$$

### Where,

- y – Mean depression for a load M kg in (meters)
- g – Acceleration due to gravity ( $9.8 \text{ m/s}^2$ )
- l – Distance between the two knife edges in (metres)
- b – Breadth of the beam (metre scale) in (metres)
- d – Thickness of the beam (metre scale) in (meters)
- a – Distance between knife edge and weight hanger in (meters)
- m- load applied (kg)
- E- Youngs modulus ( $\text{N/m}^2$ )

### Diagram:

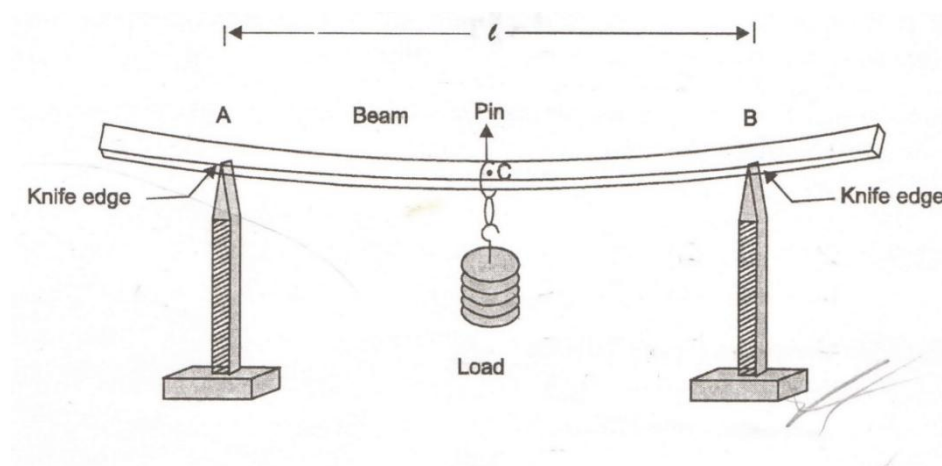


Fig. Non-Uniform bending

## Procedure

- The given wooden scale is placed on the knife edge by leaving equal distance on either end of the scale.
- A weight hanger is suspended at the centre of the beam and a pin fixed vertically on the frame of the hanger (Fig.)
- Taking the weight hanger as the dead load, the microscope is adjusted until the tip of pin just touches the horizontal cross wire.
- The reading of the microscope in the vertical scale is noted and then add weights to the hangers each time.
- The experiment is performed by unloading the weights in step of (50 grams).
- The readings for each load is obtained and measure the distance between the knife edges( $l$ ).
- The breadth and thickness of the beam are determined with a vernier caliper and a screw gauge respectively.
- From the observations, Young's modulus of the material of the beam is calculated by using the given formula.

## Observations:

TABLE.1.1 TO FIND THE DEPRESSION OF THE BEAM USING TRAVELLING MICROSCOPE

Total Reading (T.R.) = MSR + VSR ; VSR = (VSC  $\times$  L.C.) ; L.C. = .....cm

$M = 50 \times 10^{-3}$  kg

| S<br>·<br>N<br>o. | Load<br><br>× 10 <sup>-3</sup><br>kg | Microscope Readings × 10 <sup>-2</sup> m |                |                                 |                                |                                 |                |                                 |                                | Depression<br>‘y’ for M kg.<br><br>× 10 <sup>-2</sup> m |                |
|-------------------|--------------------------------------|------------------------------------------|----------------|---------------------------------|--------------------------------|---------------------------------|----------------|---------------------------------|--------------------------------|---------------------------------------------------------|----------------|
|                   |                                      | Loading                                  |                |                                 |                                | Unloading                       |                |                                 |                                |                                                         | Mean<br><br>TR |
|                   |                                      | MSR<br><br>X 10 <sup>-2</sup> m          | VSC<br><br>div | VSR<br><br>X 10 <sup>-2</sup> m | TR<br><br>X 10 <sup>-2</sup> m | MSR<br><br>X 10 <sup>-2</sup> m | VSC<br><br>div | VSR<br><br>X 10 <sup>-2</sup> m | TR<br><br>X 10 <sup>-2</sup> m |                                                         |                |
| 1                 | W                                    |                                          |                |                                 |                                |                                 |                |                                 |                                |                                                         |                |

|   |         |  |  |  |  |  |  |  |  |  |  |
|---|---------|--|--|--|--|--|--|--|--|--|--|
| 2 | W + 50  |  |  |  |  |  |  |  |  |  |  |
| 3 | W + 100 |  |  |  |  |  |  |  |  |  |  |
| 4 | W + 150 |  |  |  |  |  |  |  |  |  |  |
| 5 | W + 200 |  |  |  |  |  |  |  |  |  |  |

Mean y = ..... X  $10^{-2}$  m

(ii) To find the breadth of the beam (b) using Vernier Caliper:

L.C. = .....cm

Zero Error (Z.E) = .....div

Zero correction (Z.C) = .....cm

| S. No. | Main Scale Reading (MSR)<br>$\times 10^{-2}$ m | Vernier Scale Coincidence (VSC)<br>div | VSR= (VSC $\times$ LC)<br>$\times 10^{-2}$ m | Corrected Reading<br>CR = MSR + VSR<br>$\times 10^{-2}$ m |
|--------|------------------------------------------------|----------------------------------------|----------------------------------------------|-----------------------------------------------------------|
| 1      |                                                |                                        |                                              |                                                           |
| 2      |                                                |                                        |                                              |                                                           |
| 3      |                                                |                                        |                                              |                                                           |
| 4      |                                                |                                        |                                              |                                                           |
| 5      |                                                |                                        |                                              |                                                           |

Mean (b) = .....X  $10^{-2}$  m

(ii) To find the Thickness of the beam using Screw Gauge:

L.C. = .....mm Zero Error (Z.E) : .....div Zero Correction (Z.C):.....mm

| S. No. | Pitch Scale Reading (PSR)<br>$\times 10^{-3}\text{m}$ | Head Scale Coincidence (HSC)<br>div | CHSC =<br>(HSC $\pm$ ZC)<br>$\times 10^{-3}\text{m}$ | HSR =<br>(CHSC $\times$ LC)<br>$\times 10^{-3}\text{m}$ | Corrected Reading<br>CR= (PSR + HSR)<br>$\times 10^{-3}\text{m}$ |
|--------|-------------------------------------------------------|-------------------------------------|------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------|
| 1.     |                                                       |                                     |                                                      |                                                         |                                                                  |
| 2.     |                                                       |                                     |                                                      |                                                         |                                                                  |
| 3.     |                                                       |                                     |                                                      |                                                         |                                                                  |
| 4.     |                                                       |                                     |                                                      |                                                         |                                                                  |
| 5.     |                                                       |                                     |                                                      |                                                         |                                                                  |

Mean (d) =..... $\times 10^{-3}\text{m}$

### Calculation

Mean depression 'y' at the centre of the beam for  $M = 50 \times 10^{-3}\text{kg}$

Acceleration due to gravity  $g = 9.8\text{m/s}^2$

Distance between the two knife edges  $l = \dots \times 10^{-2}\text{m}$

Breadth of the beam  $b = \dots \times 10^{-2}\text{m}$

Thickness of the beam  $d = \dots \times 10^{-3}\text{m}$

Young's Modulus of the material of the beam (metre scale) by non-uniform bending method:

$$E = \frac{Mgl^3}{4bd^3y} \text{ Nm}^{-2}$$

### Result:

Young's modulus of the material of the beam (wooden scale) by non-uniform bending method

$E = \dots \text{ N/m}^2$ .

## YOUNG'S MODULUS – NON-UNIFORM BENDING SINGLE OPTIC LEVER

### Aim:

To determine the Young's modulus of elasticity of the material of a beam, subjecting it to non-uniform bending using single optic lever.

### Apparatus Required:

Rectangular bar, knife edges, optic lever, scale and telescope etc.

### Formula:

Young's modulus

$$E = \frac{gl^3D}{2bd^3p} \left( \frac{m}{x} \right) \text{ Nm}^{-2}$$

### Expansion of the formula:

$l$  - Distance between the knife edges (m)

$b$  - Breadth of the beam (m)

$d$  - Thickness of the beam (m)

$g$  - Acceleration due to gravity ( $9.8\text{ms}^{-2}$ )

$d$  - Distance between the mirror and scale (m)

$p$  - Perpendicular distance between front leg and line joining hind legs (m)

### Diagram:

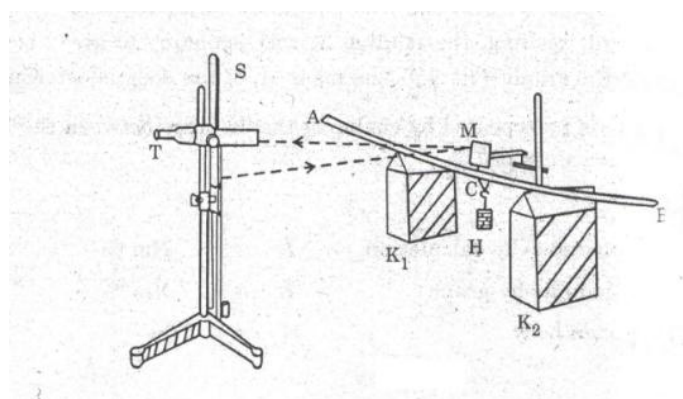


Fig.1.1–Non – Uniform Bending- Single Optic Lever

### Procedure:

The depression at the mid point of a beam subjected to non-uniform bending can be measured accurately using single optic lever with scale and telescope arrangement. The given beam is placed symmetrically on knife edges. The front leg of single optic lever is resting on the mid point  $C$  of the beam (Fig.1.1). The other two hind legs are resting on a suitable support kept at the same level behind the beam. The scale and telescope are kept at a distance of about one metre in front of optic lever. The weight hanger  $H$  with a dead weight  $W$  is suspended at the mid point  $C$  of the bar.

The telescope is properly focused to see the image of the vertical scale reading formed by the plane mirror of the optic lever. The telescope is adjusted to make the horizontal cross wire of the eye piece to coincide with certain scale reading. This is the first reading with the initial dead weight  $W$ . Then, weights are added to the hanger in steps of  $m$ , say, 50g. Each time, the scale reading viewed through the telescope is taken. For convenience, including the reading for the dead weight  $W$ , eight or ten readings can be taken while loading.

The procedure is repeated by unloading the weights in steps of  $m$ . The readings are tabulated as in Table 1.1. The distance  $D$  of the scale from the mirror and the length  $l$  of the beam between the knife edges are measured accurately. With Vernier calipers and Screw gauge, the breadth  $b$  (Table 1.2) and thickness  $d$  (Table 1.3) are measured, respectively.

Experiment is repeated for different length of the beam between the knife edges.

### Observation:

**Table 1.1 To find the depression of the beam**

| Load<br>(Kg) | Telescope Reading |                | Mean<br>cm | Shift for $4m$<br>cm |
|--------------|-------------------|----------------|------------|----------------------|
|              | Loading (cm)      | Unloading (cm) |            |                      |
| $W$          |                   |                | $x_0$      |                      |
| $W+m$        |                   |                | $x_1$      |                      |
| $W+2m$       |                   |                | $x_2$      |                      |
| $W+3m$       |                   |                | $x_3$      |                      |

Mean shift for  $4m =$  cm

Shift for  $m = x =$  cm

**Table 1.2 Breadth of the beam using Vernier Calliper**

L.C. = .....cm

Zero Error (Z.E) = .....div

Zero correction (Z.C) = .....cm

| S.No. | Main Scale Reading (MSR)<br>$\times 10^{-2}$ m | Vernier Scale Coincidence (VSC)<br>div | VSR = (VSC $\times$ LC)<br>$\times 10^{-2}$ m | Corrected Reading<br>CR = MSR + VSR<br>$\times 10^{-2}$ m |
|-------|------------------------------------------------|----------------------------------------|-----------------------------------------------|-----------------------------------------------------------|
| 1     |                                                |                                        |                                               |                                                           |
| 2     |                                                |                                        |                                               |                                                           |
| 3     |                                                |                                        |                                               |                                                           |
| 4     |                                                |                                        |                                               |                                                           |
| 5     |                                                |                                        |                                               |                                                           |

Mean (b) = .....  $\times 10^{-2}$  m

**Table 1.3: Thickness of the beam using Screw guage**

L.C. = .....mm Zero Error (Z.E) : .....div Zero Correction (Z.C): .....mm

| S. No. | Pitch Scale Reading (PSR)<br>$\times 10^{-3}$ m | Head Scale Coincidence (HSC)<br>div | CHSC = (HSC $\pm$ ZC)<br>$\times 10^{-3}$ m | HSR = (CHSC $\times$ LC)<br>$\times 10^{-3}$ m | Corrected Reading<br>CR = (PSR + HSR)<br>$\times 10^{-3}$ m |
|--------|-------------------------------------------------|-------------------------------------|---------------------------------------------|------------------------------------------------|-------------------------------------------------------------|
| 1.     |                                                 |                                     |                                             |                                                |                                                             |
| 2.     |                                                 |                                     |                                             |                                                |                                                             |
| 3.     |                                                 |                                     |                                             |                                                |                                                             |
| 4.     |                                                 |                                     |                                             |                                                |                                                             |
| 5.     |                                                 |                                     |                                             |                                                |                                                             |

Mean (d) = .....  $\times 10^{-3}$  m

**Calculations:**

|                                                                    |                                                       |   |                  |
|--------------------------------------------------------------------|-------------------------------------------------------|---|------------------|
| Distance between the knife edges                                   | $l$                                                   | = | m                |
| Breadth of the beam                                                | $b$                                                   | = | m                |
| Thickness of the beam                                              | $d$                                                   | = | m                |
| Acceleration due to gravity                                        | $g$                                                   | = | $\text{ms}^{-2}$ |
| Distance between the mirror and scale                              | $D$                                                   | = | m                |
| Perpendicular distance between front leg and line joining hindlegs | $p$                                                   | = | m                |
|                                                                    | Mean $m/x$                                            | = | Kg/m             |
|                                                                    | By graph, $m/x = \Delta M / \Delta X$                 | = | Kg/m             |
| Young's modulus                                                    | $E = \frac{gl^3D}{2bd^3p} \left( \frac{m}{x} \right)$ | = | $\text{Nm}^{-2}$ |

**Result:**

- |      |                                            |   |                  |
|------|--------------------------------------------|---|------------------|
| (i)  | Young's modulus of the beam by calculation | = | $\text{Nm}^{-2}$ |
| (ii) | Young's modulus of the beam by graph       | = | $\text{Nm}^{-2}$ |

## YOUNG'S MODULUS – UNIFORM BENDING SINGLE OPTIC LEVER

### Aim:

To determine the Young's modulus of elasticity of the material of a beam, subjecting it to uniform bending using single optic lever.

### Apparatus Required:

Rectangular bar, knife edges, optic lever, scale and telescope etc.

### Formula:

Young's modulus

$$E = \frac{3gl^2D}{bd^3p} \left( \frac{m}{x} \right) \text{ Nm}^{-2}$$

### Expansion of the formula:

$l$  - Distance between the knife edges (m)

$b$  - Breadth of the beam (m)

$d$  - Thickness of the beam (m)

$g$  - Acceleration due to gravity ( $9.8\text{ms}^{-2}$ )

$d$  - Distance between the mirror and scale (m)

$p$  - Perpendicular distance between front leg and line joining hind legs (m)

### Diagram:

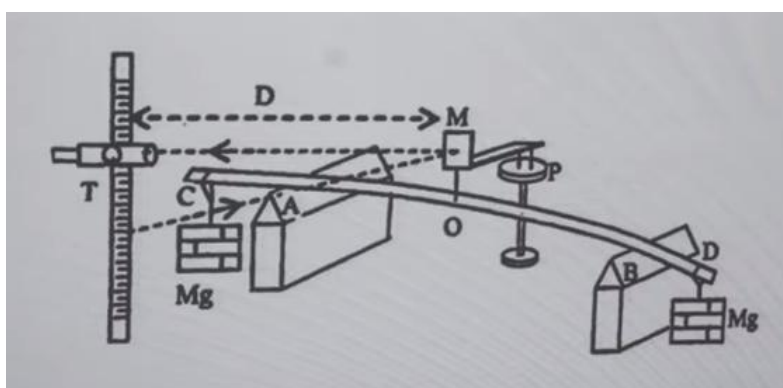


Fig.1.1 –Uniform Bending- Single Optic Lever

### Procedure:

The depression at the mid point of a beam subjected to uniform bending can be measured accurately using single optic lever with scale and telescope arrangement. The given beam is placed symmetrically on knife edges. The front leg of single optic lever is resting on the mid point  $C$  of the beam (Fig.1.1). The other two hind legs are resting on a suitable support kept at the same level behind the beam. The scale and telescope are kept at a distance of about one metre in front of optic lever. The weight hanger  $H$  with a dead weight  $W$  is suspended at the mid point  $C$  of the bar.

The telescope is properly focused to see the image of the vertical scale reading formed by the plane mirror of the optic lever. The telescope is adjusted to make the horizontal cross wire of the eye piece to coincide with certain scale reading. This is the first reading with the initial dead weight  $W$ . Then, weights are added to the hanger in steps of  $m$ , say, 50g. Each time, the scale reading viewed through the telescope is taken. For convenience, including the reading for the dead weight  $W$ , eight or ten readings can be taken while loading.

The procedure is repeated by unloading the weights in steps of  $m$ . The readings are tabulated as in Table 1.1. The distance  $D$  of the scale from the mirror and the length  $l$  of the beam between the knife edges are measured accurately. With Vernier calipers and Screw gauge, the breadth  $b$  (Table 1.2) and thickness  $d$  (Table 1.3) are measured, respectively.

Experiment is repeated for different length of the beam between the knife edges.

### Observation:

**Table 1.1 To find the depression of the beam**

| Load<br>(Kg) | Telescope Reading |                | Mean<br>Cm | Shift for $4m$<br>cm |
|--------------|-------------------|----------------|------------|----------------------|
|              | Loading (cm)      | Unloading (cm) |            |                      |
| $W$          |                   |                | $x_0$      |                      |
| $W+m$        |                   |                | $x_1$      |                      |
| $W+2m$       |                   |                | $x_2$      |                      |
| $W+3m$       |                   |                | $x_3$      |                      |
| $W+4m$       |                   |                | $x_4$      | $x_4 - x_0$          |

|        |  |  |       |             |
|--------|--|--|-------|-------------|
| $W+5m$ |  |  | $X_5$ | $X_5 - X_1$ |
| $W+6m$ |  |  | $X_6$ | $X_6 - X_2$ |
| $W+7m$ |  |  | $X_7$ | $X_7 - X_3$ |

Mean shift for  $4m =$  cm

Shift for  $m = x =$  cm

**Table 1.2 Breadth of the beam using Vernier Calliper**

L.C. = .....cm

Zero Error (Z.E) = .....div

Zero correction (Z.C) = .....cm

| S.No. | Main Scale Reading (MSR)<br>$\times 10^{-2}$ m | Vernier Scale Coincidence (VSC)<br>div | VSR= (VSC $\times$ LC)<br>$\times 10^{-2}$ m | Corrected Reading<br>CR = MSR + VSR<br>$\times 10^{-2}$ m |
|-------|------------------------------------------------|----------------------------------------|----------------------------------------------|-----------------------------------------------------------|
| 1     |                                                |                                        |                                              |                                                           |
| 2     |                                                |                                        |                                              |                                                           |
| 3     |                                                |                                        |                                              |                                                           |
| 4     |                                                |                                        |                                              |                                                           |
| 5     |                                                |                                        |                                              |                                                           |

Mean (b) = .....  $\times 10^{-2}$  m

**Table 1.3: Thickness of the beam using Screw guage**

L.C. = .....mm Zero Error (Z.E) : .....div Zero Correction (Z.C): .....mm

| S. No. | Pitch Scale Reading (PSR)<br>$\times 10^{-3}$ m | Head Scale Coincidence (HSC)<br>div | CHSC = (HSC $\pm$ ZC)<br>$\times 10^{-3}$ m | HSR = (CHSC $\times$ LC)<br>$\times 10^{-3}$ m | Corrected Reading<br>CR= (PSR + HSR)<br>$\times 10^{-3}$ m |
|--------|-------------------------------------------------|-------------------------------------|---------------------------------------------|------------------------------------------------|------------------------------------------------------------|
| 1.     |                                                 |                                     |                                             |                                                |                                                            |
| 2.     |                                                 |                                     |                                             |                                                |                                                            |
| 3.     |                                                 |                                     |                                             |                                                |                                                            |
| 4.     |                                                 |                                     |                                             |                                                |                                                            |

Mean (d) = .....  $\times 10^{-3}$  m

**Calculations:**

|                                                                    |                                       |   |                  |
|--------------------------------------------------------------------|---------------------------------------|---|------------------|
| Distance between the knife edges                                   | $l$                                   | = | m                |
| Breadth of the beam                                                | $b$                                   | = | m                |
| Thickness of the beam                                              | $d$                                   | = | m                |
| Acceleration due to gravity                                        | $g$                                   | = | $\text{ms}^{-2}$ |
| Distance between the mirror and scale                              | $D$                                   | = | m                |
| Perpendicular distance between front leg and line joining hindlegs | $p$                                   | = | m                |
|                                                                    | Mean $m/x$                            | = | $\text{Kg/m}$    |
|                                                                    | By graph, $m/x = \Delta M / \Delta X$ | = | $\text{Kg/m}$    |
| Young's modulus                                                    |                                       |   |                  |

$$E = \frac{3gl^2D}{bd^3p} \left( \frac{m}{x} \right) \text{ Nm}^{-2}$$

**Result:**

- (iii) Young's modulus of the beam by calculation = ..... $\text{Nm}^{-2}$
- (iv) Young's modulus of the beam by graph = ..... $\text{Nm}^{-2}$

## DETERMINE THE THICKNESS OF THE GIVEN WIRE USING AIR WEDGE EXPERIMENT

### Aim:

To find the thickness of the thin wire using Air-wedge experiment

### Apparatus Required:

Travelling microscope, sodium vapour lamp, optical glass plates, reading lens and thin wire.

### Formula:

$$d = \frac{\lambda l}{2\beta} \text{ (m)}$$

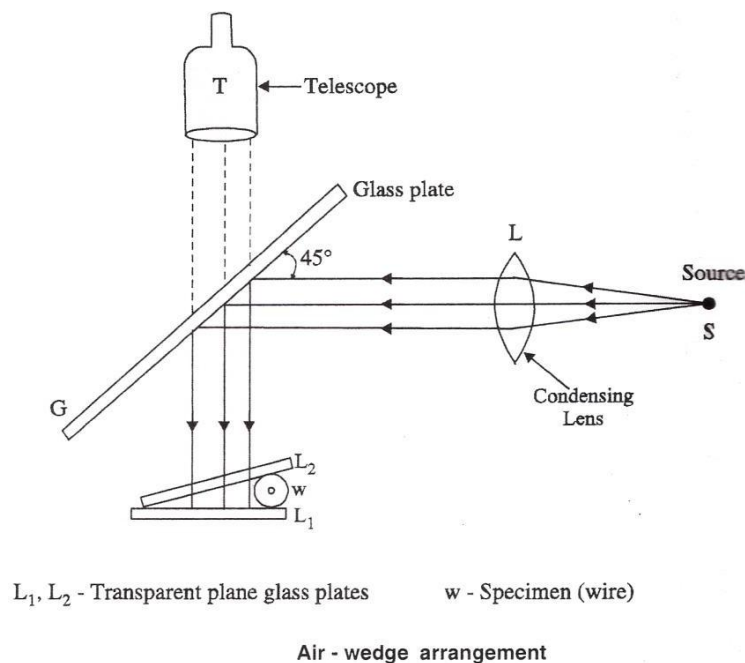
where,

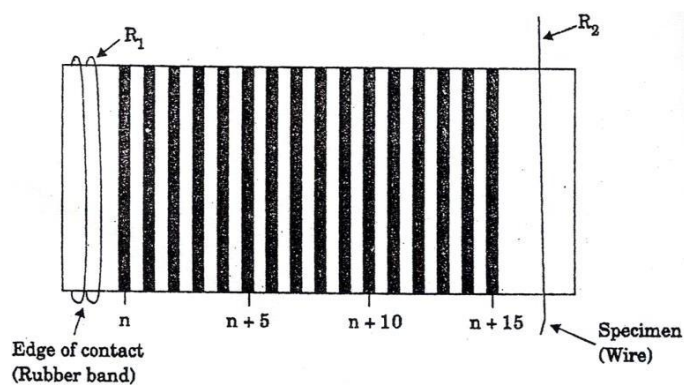
$\lambda$  – Wavelength of the Sodium vapour lamp ( $5893 \times 10^{-10}$  m)(m)

$l$  – Distance between the wire and the edge of the contact (m)

$\beta$  – Band width (m)

### DIAGRAM:





Interference - fringe pattern

### PROCEDURE:

1. Air wedge set up consists of two plane optical glass plates, one end tied with rubber band and in other end a thin wire is inserted whose thickness is to be measured, experimental set up are arranged as shown in figure.
2. Light from the source is made passing parallel on it.
3. The parallel beam is incident on glass plate at  $45^\circ$  and gets reflected towards air- wedge set up.
4. By adjusting Air wedge set up, focusing of travelling microscope, the interference fringes are viewed through traveling microscope.
5. The vertical cross wire of the microscope is adjusted using horizontal fine adjustment screw to coincide with anyone of the dark fringes, taken as  $n$ , the reading is noted from the horizontal scale.
6. The microscope is moved either left or right using fine- adjustment screw of horizontal scale and made to coincide with every successive  $5^{\text{th}}$  fringe. The readings are noted. The distance  $l$ , between the wire and one edge of contact is measured with the help of travelling microscope.
7. From the observed readings, the thickness of the given wire can be calculated by using the given formula.

**Observation:****(i) To determine the Bandwidth ( $\beta$ ):**

$$LC = 0.001 \times 10^{-2} \text{m}; \text{ VSR} = (\text{VSC} \times LC) \times 10^{-2} \text{m} ; \text{TR} = (\text{MSR} + \text{VSR}) \times 10^{-2} \text{m}$$

| Order of the band | Main Scale Reading (MSR)  | Microscope reading              |                                                        |                           | Width of 5 bands ( $5\beta$ ) | Width of one band ( $\beta$ ) |
|-------------------|---------------------------|---------------------------------|--------------------------------------------------------|---------------------------|-------------------------------|-------------------------------|
|                   |                           | Vernier Scale Coincidence (VSC) | Vernier Scale Reading (VSR) ( $\text{VSC} \times LC$ ) | TR = MSR + VSR            |                               |                               |
| Unit              | $\times 10^{-2} \text{m}$ | div                             | $\times 10^{-2} \text{m}$                              | $\times 10^{-2} \text{m}$ | $\times 10^{-2} \text{m}$     | $\times 10^{-2} \text{m}$     |
| n                 |                           |                                 |                                                        |                           |                               |                               |
| n+5               |                           |                                 |                                                        |                           |                               |                               |
| n+10              |                           |                                 |                                                        |                           |                               |                               |
| n+15              |                           |                                 |                                                        |                           |                               |                               |
| n+20              |                           |                                 |                                                        |                           |                               |                               |
| n+25              |                           |                                 |                                                        |                           |                               |                               |
| n+30              |                           |                                 |                                                        |                           |                               |                               |
| n+35              |                           |                                 |                                                        |                           |                               |                               |
| n+40              |                           |                                 |                                                        |                           |                               |                               |
| n+45              |                           |                                 |                                                        |                           |                               |                               |

Mean = \_\_\_\_\_  $\times 10^{-2} \text{m}$

(ii) To determine the distance between the edge of the contact and specimen wire:

$$LC = 0.001 \text{ cm} = 0.001 \times 10^{-2} \text{ m}$$

$$VSR = (VSC \times LC) \times 10^{-2} \text{ m} ; \quad TR = (MSR + VSR) \times 10^{-2} \text{ m}$$

| Position | Microscopic Reading        |     |                            |                            | Length                     |
|----------|----------------------------|-----|----------------------------|----------------------------|----------------------------|
|          | MSR                        | VSC | VSR                        | TR                         |                            |
|          | $\times 10^{-2} \text{ m}$ | div | $\times 10^{-2} \text{ m}$ | $\times 10^{-2} \text{ m}$ | $\times 10^{-2} \text{ m}$ |
| Tied End |                            |     |                            |                            |                            |
| Free End |                            |     |                            |                            |                            |

$$\text{Length (l)} = \underline{\hspace{2cm}} \times 10^{-2} \text{ m}$$

#### CALCULATION:

$$\text{The Thickness of the given wire (d)} = \frac{\lambda l}{2\beta} \text{ (m)}$$

#### Result:

$$\text{The Thickness of the given wire (d)} = \underline{\hspace{2cm}} \text{ (m)}.$$

## DETERMINE THE ACCELERATION DUE TO GRAVITY USING COMPOUND PENDULUM

### Aim:

To determine the acceleration due to gravity. To determine the radius of gyration and the moment of inertia of the bar pendulum about an axis through center of gravity perpendicular to the plane of the bar.

### Apparatus Required:

Bar pendulum, stop clock, pointer and metre scale.

### Formula:

$$\text{Acceleration due to gravity (g)} = 4\pi^2 \left( \frac{l}{T^2} \right) \text{ m/s}^2$$

where,

$g$  = acceleration due to gravity in ( $\text{m/s}^2$ ).

$l$  = length of the equivalent simple pendulum in (sec).

$T$  = period of simple pendulum in (sec).

### Diagram:

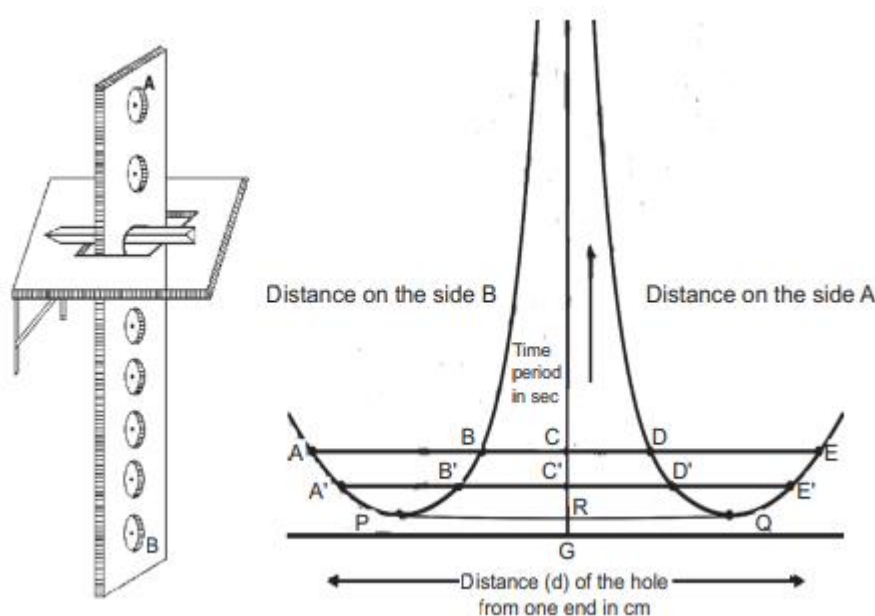


Figure: Compound Pendulum

**Procedure:**

A uniform bar AB of about one metre length in which holes are drilled along the length at regular intervals is taken, It can be suspended on a horizontal knife edge about each of the holes. It can be made to oscillate about the axis of suspension in the vertical plane. The bar pendulum is suspended from the first hole near the end A of the bar. It is allowed to oscillate with small amplitude. The time taken for twenty oscillations is noted using stop watch. From this, the time taken for one oscillation (T) is calculated. In a similar way, periods are found by suspending the pendulum from successive holes. The distance of each hole from the same end A of the bar is measured. The distance and time period readings are tabulated.

A graph is drawn taking the values of distance along the x- axis and the corresponding periods along the Y – axis. A graph as shown in the figure is obtained. The graph consists of two curves symmetrical about the line CG. The line CG is a line drawn perpendicular to the X – axis at the distance equal to the distance of centre of gravity from the same end A. The point P and Q correspond to the minimum period of oscillation. A line parallel to the x – axis is drawn corresponding to the known period T in the graph. The line intersects the curves at A, B, D and E. The points A and B (or B and D) are on either side of the centre of gravity not symmetrical with respect to it but having the same period T. Hence the distance AD (or BE) gives the length of the equivalent simple pendulum l corresponding to the period T. The distance AD and BE are measured. The value of  $l = \frac{(AD+BE)}{2}$  is calculated. Knowing the values of l and T the value of  $(l/T^2)$  is calculated.

The value of acceleration due to gravity (g) at the place can be calculated using the formula, gravity  $(g) = 4\pi^2(1/ T^2) \text{ m/s}^2$

**To find the radius of gyration and moment of inertia:**

From the graph, the point P and R corresponding to minimum period are calculated. The distance of the point P to the centre of gravity is equal to K, for the minimum period. Similarly, the distance of point T to the centre of gravity is K, the radius of gyration of the bar about the axis through centre of gravity.

**Hence  $PQ = K + K = 2K$**

Knowing the value of PQ from the graph, the radius of gyration of the pendulum can be found out using the relation.

$$K = \frac{PQ}{2}$$

The mass of the bar M is found using a paper balance. Hence the moment of inertia of the bar about an axis through the centre of gravity perpendicular to the plane of the bar can be calculated using the formula:

$$I = MK^2$$

**Observation:**

**To Find Period of Oscillation**

**Table 1.Determination of Period of Oscillation**

| Distance of knife edge (hole) from the end A<br>(cm) | Time taken for 20 oscillations |                    |                   | Time period for one oscillation<br>(T/20)<br>(Sec) |
|------------------------------------------------------|--------------------------------|--------------------|-------------------|----------------------------------------------------|
|                                                      | Trial (1)<br>(Sec)             | Trial (2)<br>(Sec) | Mean (T)<br>(Sec) |                                                    |
|                                                      |                                |                    |                   |                                                    |
|                                                      |                                |                    |                   |                                                    |
|                                                      |                                |                    |                   |                                                    |
|                                                      |                                |                    |                   |                                                    |
|                                                      |                                |                    |                   |                                                    |
|                                                      |                                |                    |                   |                                                    |

**To find ( $\frac{l}{T^2}$ ):**

**Table: 2 Determination of ( $\frac{l}{T^2}$ ):**

| S.No | T     | T <sup>2</sup>      | PR  | QS  | $l = \frac{PR+QS}{2}$ | $\left(\frac{l}{T^2}\right)$ |
|------|-------|---------------------|-----|-----|-----------------------|------------------------------|
|      | (sec) | (sec <sup>2</sup> ) | (m) | (m) | (m)                   | (m/s <sup>2</sup> )          |
|      |       |                     |     |     |                       |                              |
|      |       |                     |     |     |                       |                              |

Mean ( $\frac{l}{T^2}$ ) = \_\_\_\_\_ (m/s<sup>2</sup>)

**CALCULATIONS:**

Acceleration due to gravity:

$$g = 4\pi^2 \left( \frac{l}{T^2} \right) \text{ m/s}^2$$

**Result:**

Acceleration due to gravity at the place (g) = \_\_\_\_\_ (m/s<sup>2</sup>).

## SONOMETER – VERIFICATION OF LAWS

### Aim:

To verify the laws of transverse vibrations of stretched strings.

### Apparatus:

Sonometer, tuning fork with different frequencies cork hammer, Weighthanger with suitable hanging weights, physical balance

### Formula:

#### First Law:

$$n l = \text{constant}$$

Where T and m are constant

#### Second Law:

$$\sqrt{T/l} = \text{constant}$$

When n and m are constant

#### Third Law:

$$l \sqrt{m} = \text{constant}$$

Where n and T are constant

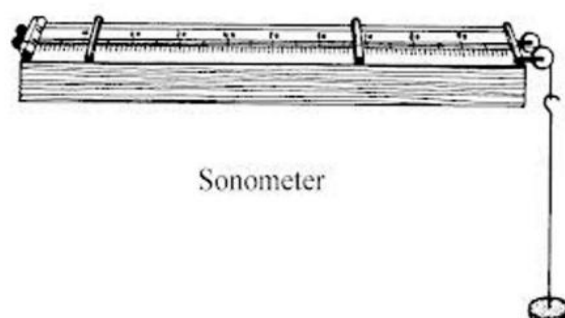
Where “n” is the fundamental frequency

“T” is the tension on the string

“m” is the linear density (or) mass per unit volume length of string

“l” is the length vibrating segment of the string

#### BLOCK DIAGRAM:



## Procedure:

### Verification of First Law:

To verify the first law, the string of the sonometer is kept under a suitable tension. A tuning fork of known frequency ( $n$ ) is excited and placed on the surface of the sonometer. A paper rider is placed on the string between the two bridges. The length of the wire is adjusted. So that the paper rider flutters vigorously and falls down. In this position the frequency of vibrating segment of the string is measured, keeping the tension as constant and using the same wire, the experiment is repeated with different tuning forks. The first law is verified by showing the  $nxl$  is constant.

**TABLE-1**

Tension=

Linear density=

| s.no | Frequency<br>n(Hz) | Resonating length of wire $10^{-2}$ m |         |      | n $xl$ |
|------|--------------------|---------------------------------------|---------|------|--------|
|      |                    | Trial-1                               | Trial-2 | Mean |        |
|      |                    |                                       |         |      |        |
|      |                    |                                       |         |      |        |
|      |                    |                                       |         |      |        |

### VERIFICATION OF SECOND LAW:

To verify the second law a tuning fork is taken and the string is kept under suitable tension ( $T$ ). the fork is excited and placed on sonometer. The length ( $l$ ) of the vibrating segment of the string is found as said above keeping the frequency of tuning fork as constant and using the same string, the experiment is repeated with different tensions. The second law is verified by showing the  $\sqrt{Tl}$  is constant.

Frequency=

Linear density=

| S.NO | Load<br>M(g) | Tension T=Mg<br>(g-wt) | Resonating length of wire |         |           | $\sqrt{T/l}$ |
|------|--------------|------------------------|---------------------------|---------|-----------|--------------|
|      |              |                        | Trail-1                   | Trail-2 | Mean l cm |              |
|      |              |                        |                           |         |           |              |
|      |              |                        |                           |         |           |              |
|      |              |                        |                           |         |           |              |

### THIRD VERIFICATION LAW:

To verify the third law a string is kept under suitable tension. A tuning fork is excited and placed on the sonometer. The length of (l) of the vibrating segment of the string is determined as said above. A known length of the wire is taken and its mass is found in a physical balance from which mass per unit length (m) of the wire determined used the same tuning fork and the same tension. The experiment is repeated with different metal wire. The third law is verified by showing that  $l\sqrt{m}$  is constant.

| S.No | Material of the wire | Mass per unit length | Resonating length of wire |         |         | $l\sqrt{m}$ |
|------|----------------------|----------------------|---------------------------|---------|---------|-------------|
|      |                      |                      | Trial-1                   | Trial-2 | Trial-3 |             |
| 1    | Steel                |                      |                           |         |         |             |
| 2    | Copper               |                      |                           |         |         |             |
| 3    | Brass                |                      |                           |         |         |             |

### RESULT:

The law of transverse vibration of stretched strings are verified

## YOUNG'S MODULUS – UNIFORM BENDING (PIN AND MICROSCOPE)

### Aim:

To determine the Young's modulus of the material of the given beam by Uniform-Bending method using pin and microscope.

### Apparatus Required:

Travelling Microscope, two knife edges for support, two weight hangers, slotted weights, pin, screw gauge and vernier caliper.

### Formula:

Young's Modulus of the material of the beam (metre scale) by Uniform Bending method:

$$E = \frac{Mgal^2}{2byd^3} Nm^{-2}$$

### Where,

E = Young's modulus of the material of the beam in Pascal or  $N/m^2$ .

y = Elevation produced for 'M' Kilogram of load in (metre).

M = Mass suspended on either side of the beam in (Kg).

g = Acceleration due to gravity ( $9.8 m/s^2$ ).

l = Distance between the two knife edges in (metre).

b = Breadth of the beam in (metre).

d = Thickness of the beam in (metre).

a = Distance between the weight hanger and the adjacent knife edge in (metre).

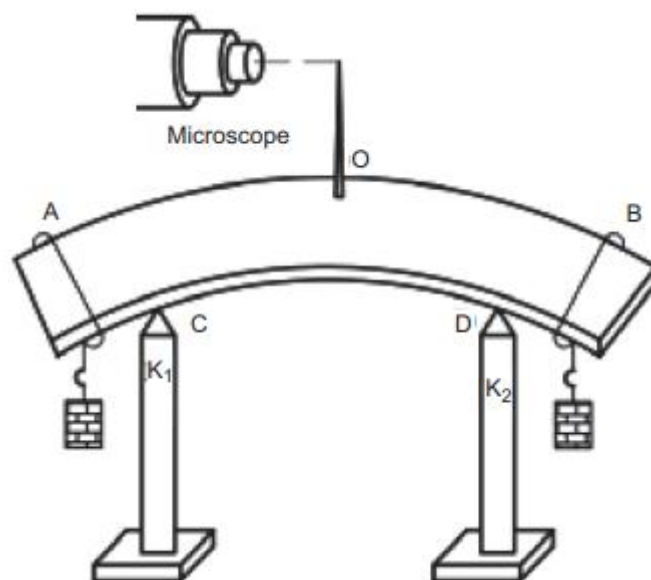
**DIAGRAM:**

**Figure: Uniform Bending**

**PROCEDURE:**

The given beam is placed over the two knife edges (C & D) at a distance of 70 cm or 80 cm. Two weight hangers are suspended, one each on either side of the knife edge at equal distance from the knife edge. Since the load is applied at both points of the beam, the bending is uniform throughout the beam and the bending of the beam is called uniform bending. A pin is fixed vertically exactly at the centre of the beam. Now the bar has to be brought to elastic mood as follows; Additional weights are loaded and unloaded. This is repeated four or five times. A travelling microscope is placed in front of this arrangement. Taking the weight hangers alone as the dead load, the tip of the pin is focused by the microscope and is adjusted in such a way that the tip of the pin just touches the horizontal cross wire. The reading on the vertical scale of the travelling microscope is noted. Now, equal weights are added on both the weight hangers, in steps of 50 gram. Each time the position of the pin is focused and the readings are noted from the microscope. The procedure is followed until the maximum load is reached.

**OBSERVATION:****TABLE.1.1 To Find the Elevation of the Beam Using Travelling Microscope:**

**Total Reading (T.R.) = MSR + VSR      VSR= (VSC × L.C.) L.C. = .....cm**

**M =  $50 \times 10^{-3}$  kg**

| S. No. | Load<br>$\times 10^{-3}$ kg | Microscope Readings $\times 10^{-2}$ m |            |                           |                          |                           |            |                           |                          |            | Depression<br>‘y’ for M kg.<br>$\times 10^{-2}$ m |
|--------|-----------------------------|----------------------------------------|------------|---------------------------|--------------------------|---------------------------|------------|---------------------------|--------------------------|------------|---------------------------------------------------|
|        |                             | Loading                                |            |                           |                          | Unloading                 |            |                           |                          | Mean<br>TR |                                                   |
|        |                             | MSR<br>$\times 10^{-2}$ m              | VSC<br>div | VSR<br>$\times 10^{-2}$ m | TR<br>$\times 10^{-2}$ m | MSR<br>$\times 10^{-2}$ m | VSC<br>div | VSR<br>$\times 10^{-2}$ m | TR<br>$\times 10^{-2}$ m |            |                                                   |
| 1      | W                           |                                        |            |                           |                          |                           |            |                           |                          |            |                                                   |
| 2      | W + 50                      |                                        |            |                           |                          |                           |            |                           |                          |            |                                                   |
| 3      | W + 100                     |                                        |            |                           |                          |                           |            |                           |                          |            |                                                   |
| 4      | W + 150                     |                                        |            |                           |                          |                           |            |                           |                          |            |                                                   |
| 5      | W + 200                     |                                        |            |                           |                          |                           |            |                           |                          |            |                                                   |

**Mean y = .....  $\times 10^{-2}$  m**

(ii) To find the breadth of the beam (b) using Vernier Caliper:

L.C. = .....cm

Zero Error (Z.E) = .....div

Zero correction (Z.C) = .....cm

| S. No. | Main Scale Reading (MSR)<br>$\times 10^{-2}$ m | Vernier Scale Coincidence (VSC)<br>Div | VSR = (VSC $\times$ LC)<br>$\times 10^{-2}$ m | Corrected Reading<br>CR = MSR + VSR<br>$\times 10^{-2}$ m |
|--------|------------------------------------------------|----------------------------------------|-----------------------------------------------|-----------------------------------------------------------|
| 1      |                                                |                                        |                                               |                                                           |
| 2      |                                                |                                        |                                               |                                                           |
| 3      |                                                |                                        |                                               |                                                           |
| 4      |                                                |                                        |                                               |                                                           |
| 5      |                                                |                                        |                                               |                                                           |

Mean (b) = .....  $\times 10^{-2}$  m

(ii) To find the Thickness of the beam using Screw Gauge:

L.C. = \_\_\_\_mm ; Zero Error (Z.E) : \_\_\_\_div ; Zero Correction (Z.C): \_\_\_\_mm

| S. No. | Pitch Scale Reading (PSR)<br>$\times 10^{-3}$ m | Head Scale Coincidence (HSC)<br>Div | CHSC = (HSC $\pm$ ZC)<br>$\times 10^{-3}$ m | HSR = (CHSC $\times$ LC)<br>$\times 10^{-3}$ m | Corrected Reading<br>CR = (PSR + HSR)<br>$\times 10^{-3}$ m |
|--------|-------------------------------------------------|-------------------------------------|---------------------------------------------|------------------------------------------------|-------------------------------------------------------------|
| 1.     |                                                 |                                     |                                             |                                                |                                                             |
| 2.     |                                                 |                                     |                                             |                                                |                                                             |
| 3.     |                                                 |                                     |                                             |                                                |                                                             |
| 4.     |                                                 |                                     |                                             |                                                |                                                             |
| 5.     |                                                 |                                     |                                             |                                                |                                                             |

Mean (d) = .....  $\times 10^{-3}$  m

**CALCULATION:**

Mean depression 'y' at the centre of the beam for  $M = 50 \times 10^{-3} \text{ kg}$

Acceleration due to gravity  $g = 9.8 \text{ m/s}^2$

Distance between the two knife edges  $l = \dots \times 10^{-2} \text{ m}$

Breadth of the beam  $b = \dots \times 10^{-2} \text{ m}$

Thickness of the beam  $d = \dots \times 10^{-3} \text{ m}$

Distance between the weight hanger and the adjacent knife edge  $a = \dots \times 10^{-2} \text{ m}$

Young's Modulus of the material of the beam (metre scale) by uniform bending method:

$$E = \frac{Mga l^2}{2byd^3} \text{ Nm}^{-2}$$

**RESULT:**

Young's modulus of the material of the beam (wooden scale) by uniform bending method

$E = \dots \text{ N/m}^2$ .

## DETERMINE THE RADIUS OF CURVATURE USING NEWTON'S RINGS EXPERIMENT

### Aim:

1. To study the interference of light by observing the formation of Newton's rings.
2. To determine the radius of curvature of a plano-convex lens for a particular monochromatic light.

### Apparatus Required:

Traveling microscope, sodium vapour lamp, plano-convex lens, plane glass plate, magnifying lens.

### Formula:

The radius of curvature of the plano-convex lens is,

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

### Where,

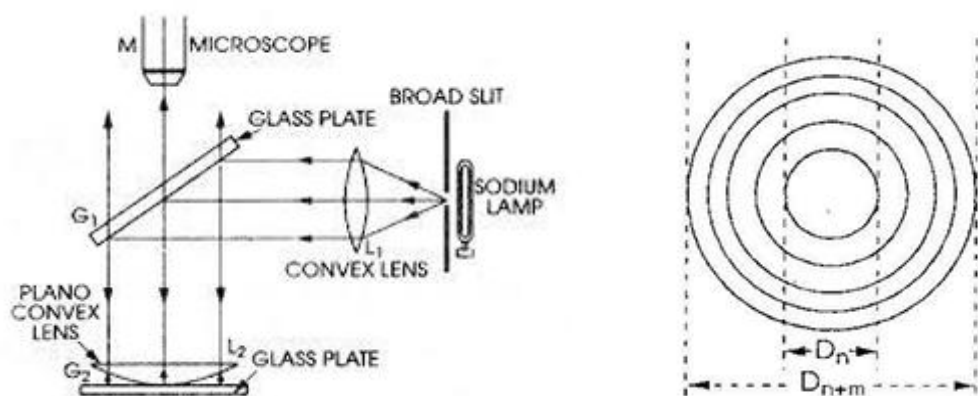
$D_{n+m}$  = diameter of  $(n+m)^{\text{th}}$  ring,

$D_n$  = diameter of  $n^{\text{th}}$  ring,

$m$  = an integer number (of the rings)

$R$  = radius of curvature of the curved face of the plano-convex lens.

### Diagram:



## PROCEDURE:

1. Find the least count of micrometer scale.
2. Clean the surface of glass plate 'G', glass plate 'P' and the Plano-convex lens L, Put them in position as shown in Fig.1 in front of the sodium lamp.
3. Switch on the sodium lamp and see that only parallel beam of light coming from the convex lens on the glass plate 'G'.
4. Adjust the position of microscope so that it lies vertically above the center of lens  $L_2$ . Focus the microscope so that alternate dark and bright rings are clearly visible.
5. Adjust the position of the microscope till the point of intersection of the cross-wires coincides with the center of the ring system and one of the vertical cross-wires is perpendicular to the horizontal scale.
6. Move the microscope to the left with the help of micrometer screw so that the vertical cross wire lies tangentially at one of the extreme ends of the 20<sup>th</sup> dark ring.
7. Note the reading of the micrometer scale 'a' of the microscope.
8. Slide the microscope backward with the help of micrometer screw and go on noting the readings when the cross wire lies tangentially at the extreme ends of horizontal diameter of 16th, 12th, 8th and 4th dark rings in column 'Left (a)' respectively.
9. Continue sliding the microscope to the right and note down the readings in column 'Right (b)' when the vertical cross wires lies tangentially at the other extreme end of the diameter of 4th, 8th, 16th and 20th dark rings respectively.
10. Now slide the microscope backwards and again note down the readings corresponding to the same rings on the right and then on the left to the center of the ring system in column 'Right(c)' and 'Left(d)'.
11. Remove the Plano-convex lens  $L_2$  and find the radius of curvature of its convex surface by using a spherometer. The radius of curvature may also be determined by plotting a graph between  $D_n^2$  along Y-axis and then number of the ring(n) along X-axis as explained in part-2 of the experiment.

**OBSERVATION :**

Least count of the microscope = \_\_\_\_\_ cm.

| Order of the Ring | Microscopic Reading (cm) |       | Diameter D (cm) | D <sup>2</sup> (cm <sup>2</sup> ) | $D_{n+m}^2 - D_n^2$ (cm <sup>2</sup> ) |
|-------------------|--------------------------|-------|-----------------|-----------------------------------|----------------------------------------|
|                   | LEFT                     | RIGHT |                 |                                   |                                        |
|                   |                          |       |                 |                                   |                                        |
|                   |                          |       |                 |                                   |                                        |
|                   |                          |       |                 |                                   |                                        |
|                   |                          |       |                 |                                   |                                        |
|                   |                          |       |                 |                                   |                                        |
|                   |                          |       |                 |                                   |                                        |

**Calculation:**

The radius of curvature of the plano-convex lens is,

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

**Result:**

The radius of curvature of the plano-convex lens is, \_\_\_\_\_ (m).

## COMPARISON OF CAPACITANCE USING DESAUTY'S BRIDGE

### Aim:

To compare the capacitance of the two given capacitors by the Desauty's method.

### Apparatus Required:

De-Sauty bridge- Two Capacitors, Two resistance boxes, AFO, connecting wires, Head phone.

### Formula:

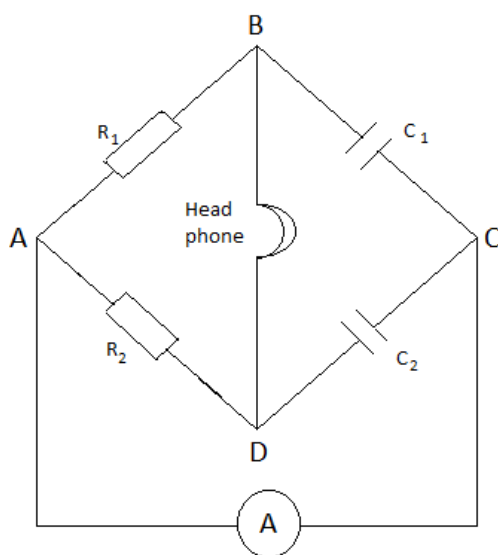
$$\frac{C_1}{C_2} = \frac{R_2}{R_1}$$

Where,

$C_1, C_2$  = Capacitances of known values ( $\mu\text{F}$ )

$R_1, R_2$  = Resistance of unknown values ( $\Omega$ )

### Diagram:



De-sauty Bridge

**Procedure:**

- 1) Connect the resistors and capacitors as shown in figure. Connect the headphone across B and D and audio-frequency oscillator across A and C.
- 2) Increase the frequency of audio-frequency oscillator so that the sound is hearable in the headphone.
- 3) Now balance the bridge by the values of  $R_1$  and  $R_2$ , in the balance state the sound through the headphone will be minimum.

**Observation:** $C_1 = \dots\dots\dots \mu\text{F}$  $C_2 = \dots\dots\dots \mu\text{F}$  $C_1 / C_2 = \dots\dots\dots$ 

| S.No | Resistance for Minimum Sound |               | $\frac{C_1}{C_2} = \frac{R_2}{R_1}$ |
|------|------------------------------|---------------|-------------------------------------|
|      | $R_1(\Omega)$                | $R_2(\Omega)$ |                                     |
|      |                              |               |                                     |
|      |                              |               |                                     |
|      |                              |               |                                     |
|      |                              |               |                                     |
|      |                              |               |                                     |
|      |                              |               |                                     |

**Mean = .....****Result:**

The ratio of the Capacitance of the two given values,

Theoretical Value = .....

Practical Value = .....

## COEFFICIENT OF VISCOSITY - STOKE'S METHOD

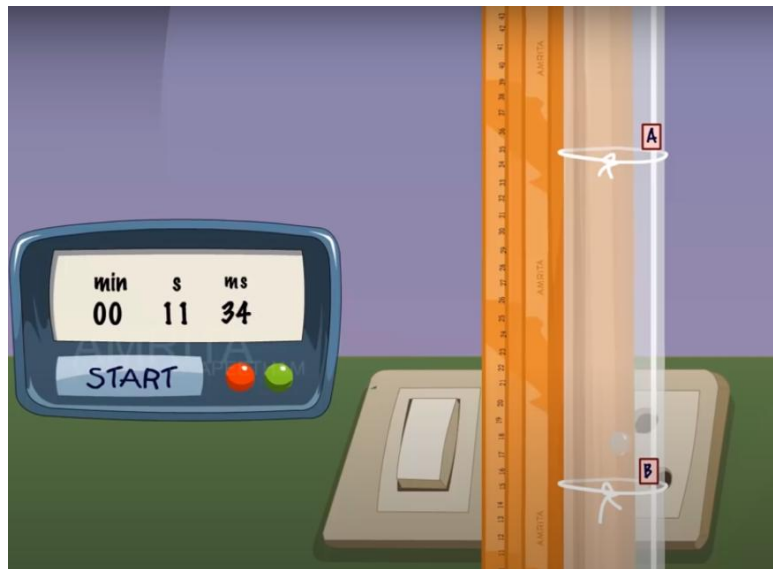
### Aim:

To determine the coefficient of viscosity of a highly viscous liquid (such as castor oil) by stoke's method.

### Apparatus Required:

A tall cylindrical jar, experimental liquid, thread, steel balls of different diameters, stop watch and Hare's apparatus.

### Diagram:



### Formula:

$$\text{Coefficient of viscosity of oil } \eta = \frac{2}{9} \frac{r^2}{v} (\rho - \sigma) g \text{ } Nsm^{-2}$$

where,

$g$  - the acceleration due to gravity ( $9.8 \text{ ms}^{-2}$ )

$\rho$  - the density of the ball ( $7450 \text{ Kg m}^{-3}$  for steel).

$\sigma$  - the density of the liquid in the vertical column ( $970 \text{ Kg m}^{-3}$ ).

$r$  - radius of the ball in m.

$v$  - terminal velocity of the steel ball

**Observation:****To find the terminal velocity of the steel ball:**

| S. No | Distance<br>(cm) | Time<br>(s) | Velocity<br>(ms <sup>-1</sup> ) | $\eta$<br>(Nsm <sup>-2</sup> ) |
|-------|------------------|-------------|---------------------------------|--------------------------------|
|       |                  |             |                                 |                                |
|       |                  |             |                                 |                                |
|       |                  |             |                                 |                                |

**To find the radius of the steel ball:**

$$\begin{aligned} \text{Least count} &= \frac{\text{Value of 1 PSD}}{\text{Total Number of HSD}} \\ &= \frac{1\text{mm}}{100} \\ &= 0.01\text{mm} \end{aligned}$$

$$\text{Zero error} =$$

$$\text{Zero correction} =$$

| S.No | PSR<br>(mm) | HSR<br>(div) | CHSR<br>(div) | CR= (PSR+CHSR×L.C)<br>(mm) |
|------|-------------|--------------|---------------|----------------------------|
|      |             |              |               |                            |
|      |             |              |               |                            |
|      |             |              |               |                            |

**Procedure:**

- ❖ The experimentally highly viscous liquid such as castor oil is taken in a tall jar.
- ❖ Two thread marks A and B are made over the surface of the jar, separated by a distance of AB = 30 cm.
- ❖ A spherical steel ball is taken and its mean diameter is measured using a screw gauge. Its radius (r) is found.
- ❖ The ball is gently dropped from the surface of the liquid into the jar.
- ❖ The ball soon attains terminal velocity (uniform velocity) as it moves down.

- ❖ When it crosses the mark A, the stop clock is started. When the ball crosses the mark B, the stop clock is stopped. The time taken to travel the distance (AB) is found as (t) second.
- ❖ The distance (AB) is measured. The value of terminal velocity is calculated.
- ❖ The experiment is repeated by using steel balls of different radii.
- ❖ In each case, the value of r, t and hence terminal velocity is found out.
- ❖ The coefficient of viscosity of oil can be calculated using the formula

**Result :** The coefficient of viscosity of the highly viscous liquid = \_\_\_\_\_ ( $\text{Nsm}^{-2}$ )

## THERMAL CONDUCTIVITY OF A BAD CONDUCTOR – LEE'S DISC

### Aim:

To determine the thermal conductivity of a bad conductor like card board using Lee's disc apparatus.

### Apparatus Required:

Lee's disc apparatus, two thermometers, bad conductor, stop watch, steam boiler, Vernier calliper, screw gauge and biscuit balance

### Formula:

Thermal conductivity of the given bad conductor

$$K = \frac{MSx\left(\frac{d\theta}{dt}\right)(r + 2t)}{\pi r^2(\theta_1 - \theta_2)2(r + 2t)} \text{ Wm}^{-1}\text{K}^{-1}$$

where,

M = mass of the metal disc in Kg.

S = specific heat capacity of the metal disc in J/Kg/K.

$(d\theta/dt)$  = Rate of cooling at steady temperature in °C/s.

$\theta_1$  = Steady temperature of the steam chamber in °C.

$\theta_2$  = Steady temperature of the metal disc in °C.

$r$  = radius of the metallic disc in metre.

$t$  = thickness of the metallic disc in metre.

$x$  = thickness of the bad conductor in metre.

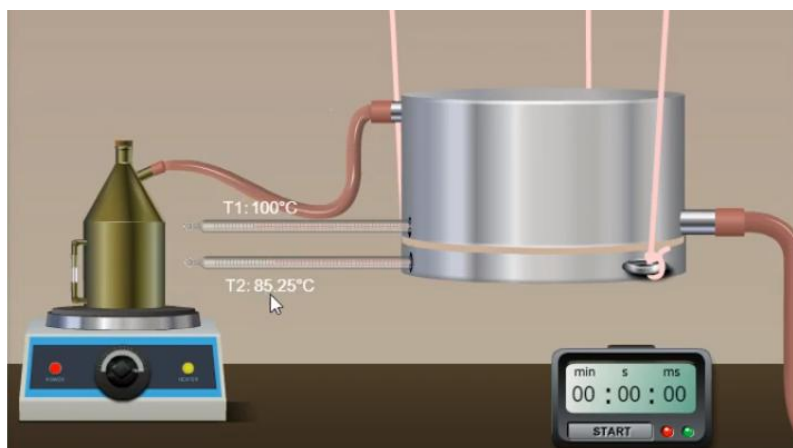
### To Find the Thickness of the Metallic Disc using Vernier Caliper

Least count : 0.01 cm

| S.No | MSR<br>(mm) | VSR<br>(div) | CVSR<br>(div) | CR= (MSR+CVSR×L.C)<br>(mm) |
|------|-------------|--------------|---------------|----------------------------|
|      |             |              |               |                            |
|      |             |              |               |                            |
|      |             |              |               |                            |

### Description:

Lee's disc apparatus consists of a brass metal disc (B) suspended horizontally by three strings from a stand. A hollow steam chamber (A) with inlet and outlet for steam is placed above. The given bad conductor is placed between them. Two thermometers T1 and T2 are inserted to measure the temperatures of A and B respectively.



### Procedure:

The experimental arrangement is as shown in Figure 2. Steam is allowed to pass through the steam chamber. The temperature indicated by two thermometers starts rising. After 30 minutes a steady state is reached (i.e) the temperature of the lower disc will no longer rise. At this stage, steady temperatures  $\theta_1$  and  $\theta_2$  are recorded from the thermometers T1 and T2. Now the cardboard is removed and the lower disc is heated directly by keeping it in contact with the steam chamber. When the temperature of the lower disc attains a value of about  $10^\circ\text{C}$  more than its steady state temperature, the chamber is removed and the lower disc is allowed to cool down on its own accord. When the temperature of the disc reaches  $5^\circ\text{C}$  above the steady temperature of the disc. i.e.,  $(\theta_2 + 5)^\circ\text{C}$ , a stop watch is started and the time is noted for every  $1^\circ\text{C}$  fall of temperature until the metallic disc attains temperature  $(\theta_2 - 5)^\circ\text{C}$ .

### To Find Thickness of the Card Board using Screw Gauge

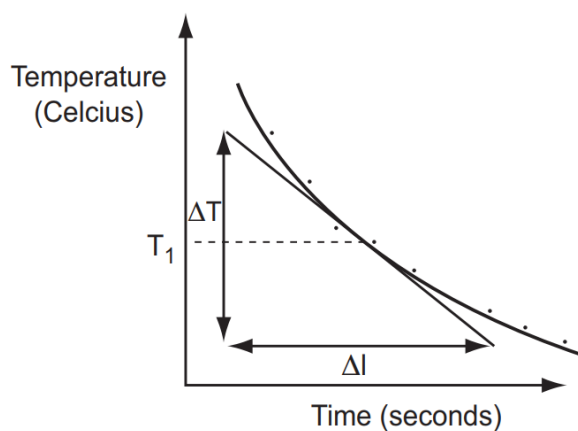
$$\begin{aligned}\text{Least count} &= \frac{\text{Value of 1 PSD}}{\text{Total Number of HSD}} \\ &= \frac{1\text{mm}}{100} \\ &= 0.01\text{mm}\end{aligned}$$

$$\text{Zero error} =$$

Zero correction =

| S.No | PSR<br>(mm) | HSR<br>(div) | CHSR<br>(div) | CR= (PSR+CHSR×L.C)<br>(mm) |
|------|-------------|--------------|---------------|----------------------------|
|      |             |              |               |                            |
|      |             |              |               |                            |
|      |             |              |               |                            |

### Model graph



A graph is drawn by taking time along the x-axis and the temperature along y-axis. Cooling curve is drawn. From the cooling curve  $d\theta/dt$  is calculated by drawing a triangle by taking  $0.5^\circ\text{C}$  above and  $0.5^\circ\text{C}$  below the steady temperature  $\theta_2$ . Substituting this  $d\theta/dt$  in the given formula, thermal conductivity of the cardboard can be calculated

### Calculations:

Thermal conductivity of the given bad conductor

$$K = \frac{MSx\left(\frac{d\theta}{dt}\right)(r + 2t)}{\pi r^2(\theta_1 - \theta_2)2(r + 2t)} \text{ Wm}^{-1}\text{k}^{-1}$$

### Result:

Thermal conductivity of the given bad conductor = \_\_\_\_\_  $\text{Wm}^{-1}\text{k}^{-1}$

## CALIBRATION OF AMMETER USING POTENTIOMETER

### Aim:

To find the corrections of various readings of given ammeter using potentiometer.

### Apparatus Required:

Potentiometer, Battery, Daniel cell, Rheostat, Galvanometer, high resistance, Ammeter, Jockey, Standard resistance etc.,

### Formula:

From the theory of potentiometer

$$\frac{E_2}{E_1} = \frac{l_2}{l_1} \quad (E_2 = IR)$$

$$I = \frac{E_1}{R} \times \frac{l_2}{l_1} \text{ (A)}$$

where,

$E_1$  = E.M.F of Daniel cell (V)

$I$  = Calculated value of electric current in the secondary circuit (A)

$l_1$  = Balancing length of Daniel cell (m)

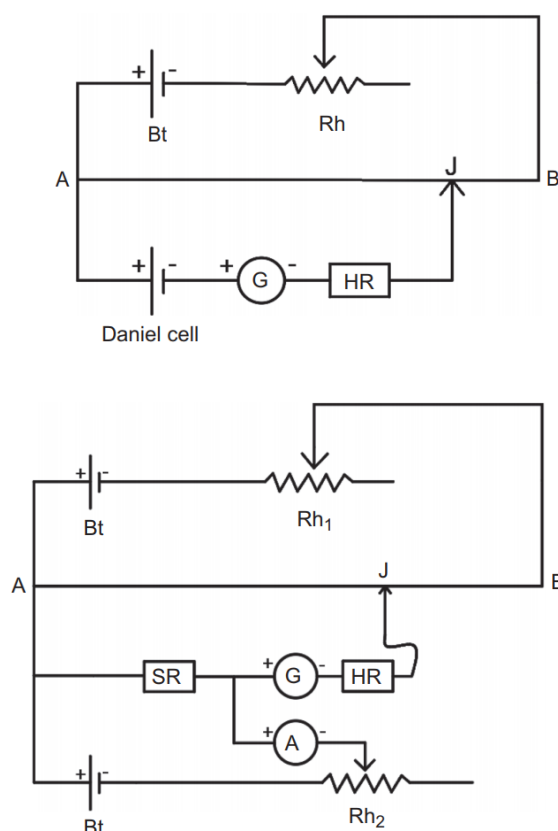
$l_2$  = Balancing length for potential difference across  $R$  (m)

**Table 2.3.1 Determination of  $l_2$**

| S. No | Ammeter Reading (A) | Balancing length<br>$l_2 \times 10^{-2}$ (m) | Calculated current<br>$I = \frac{E_1}{R} \times \frac{l_2}{l_1}$ (A) | Correction (I-A)<br>(A) |
|-------|---------------------|----------------------------------------------|----------------------------------------------------------------------|-------------------------|
|       |                     |                                              |                                                                      |                         |
|       |                     |                                              |                                                                      |                         |

$R = (\Omega)$ ;  $E_1 = (\text{V})$ ;  $l_1 = 10^{-2}$  (m).

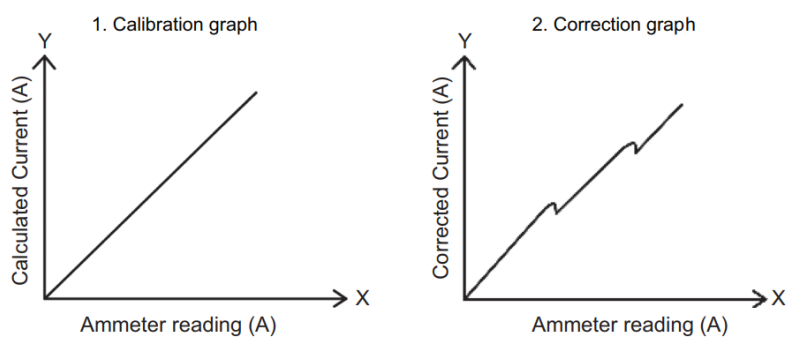
### Circuit Diagram:



### Procedure:

- ❖ Electrical connections are made as shown in the Figure 2.3.1. Using Daniel cell of EMF of 1.08 V, galvanometer and high resistance in the primary circuit, the balancing length  $l_1$  is found
- ❖ The secondary circuit is made as in Figure 2.3.2.  $R_{h2}$  is adjusted so that the ammeter reads 0.2 ampere. The balancing length  $l_2$  for potential difference across the standard resistance SR is found.
- ❖ Knowing  $l_1$  and  $l_2$ , the current in the secondary circuit is calculated from the formula given. The correction to the ammeter reading ( $I - A$ ) is found out.
- ❖ The experiment is repeated by adjusting the rheostat for reading 0.4, 0.6, 0.8, 1, 1.2 ampere in the ammeter. In each case, the balancing length is found and correction is calculated.
- ❖ The calibration graph is drawn by taking ammeter reading along the positive x axis and calculated current along the y axis. The correction graph is drawn by taking ammeter reading along the positive x axis and correction along the y axis.

### Model Graphs:



### Result:

The corrections to various readings of the ammeter are found out and their correction and calibration graphs are drawn

## LCR SERIES RESONANCE CIRCUIT

### Aim:

1. To set up a series resonance circuit and to study the frequency response of the circuit.
2. To determine its resonant frequency and Q factor of the circuit.
3. To determine the self-inductance of the coil.
4. To determine the bandwidth of the response curve.

### Apparatus Required:

Audio Frequency Oscillator(AFO), Milliammeter, Voltmeter, Resistance box, Decade condenser box etc.,

### Formula:

$$f_0 = \frac{1}{2\pi \sqrt{LC}} \text{ (Hz)}$$

$$L = \frac{1}{4 C f_0^2 \pi^2} \text{ (H)}$$

$$Q = \frac{f_0}{f_1 - f_2}$$

$$\text{Bandwidth} = f_1 - f_2 \text{ (Hz)}$$

Where

$f_0$  = Resonant frequency (Hz)

$L$  = Self inductance of the coil (H)

$C$  = Capacity of the capacitor (F)

$Q$  = Q-factor of the circuit

$f_1$  = Lower cut off frequency (Hz)

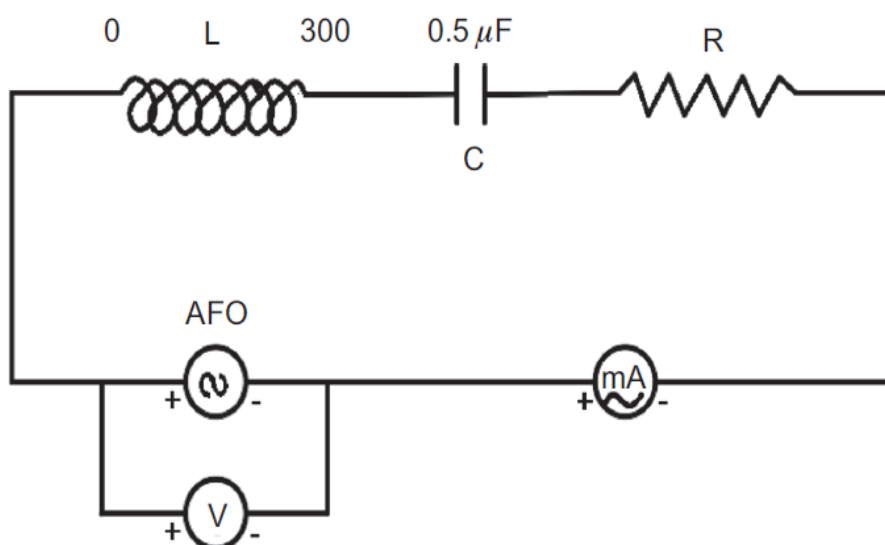
**Table- 1: Determination of the current for different values of R**

| S. No | Frequency<br>(Hz) | log(f) | Current in mA   |                 |
|-------|-------------------|--------|-----------------|-----------------|
|       |                   |        | $R_1=100\Omega$ | $R_2=300\Omega$ |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |
|       |                   |        |                 |                 |

$f_2$  = Upper cut off frequency (Hz)

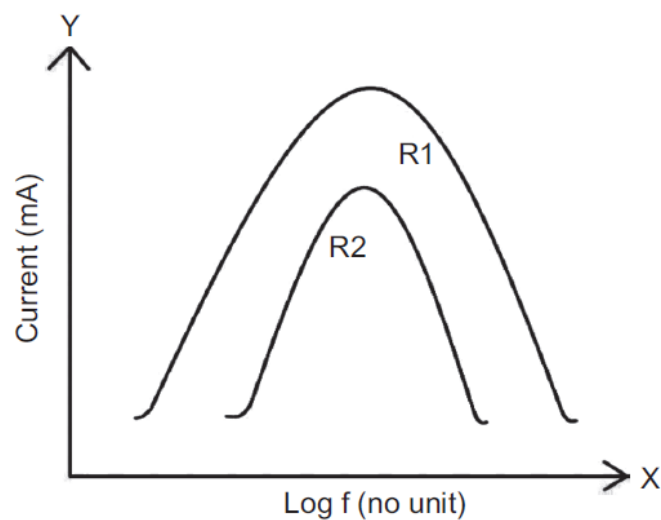
R = Resistance of the circuit ( $\Omega$ )

**Circuit Diagram:**



**Procedure:**

- i. Connections are made as shown in the Figure1
- ii. Introduce 100 ohms in R and 0.5mF in C.
- iii. Measure the current in mA for various values of the frequency.
- iv. Plot a graph between log f and current.
- v. Repeat the experiment by varying the value of R.

**Model Graph:****Result:**

- |   |                                    |   |
|---|------------------------------------|---|
| 1 | Resonant frequency $f_0$           | = |
| 2 | Self inductance of the coil<br>$L$ | = |
| 3 | Q-factor of the circuit            |   |
| · | (i) for ( $R = 100\Omega$ )        | = |
|   | (ii) for ( $R = 300\Omega$ )       | = |
| 4 | Bandwidth                          |   |
| · | (i) for( $R=100\Omega$ )           | = |
|   | (ii) for( $R=300\Omega$ )          | = |

## LCR PARALLEL RESONANCE CIRCUIT

### Aim:

1. To study the frequency response of the circuit.
2. To determine its resonant frequency.
3. To determine the self inductance of the coil.
4. To determine the Q factor and impedance of the circuit.

### Apparatus Required:

Audio Frequency Oscillator (AFO), Milliammeter, Resistance box, Decade condenser box, Inductance coil, etc.,

### Formula:

$$L = \frac{1}{4 C f_0^2 \pi^2} \text{ (H)}$$

$$Z = \frac{L}{C R} \text{ (ohm)}$$

$$\omega = 2 \pi f_0$$

$$Q = \frac{Z}{L \omega}$$

where,

$f_0$  = Resonant frequency (Hz)

$L$  = Self inductance of the coil (H)

$C$  = Capacity of the capacitor (F)

$Q$  = Q-factor of the circuit

$R$  = Resistance of the circuit ( $\Omega$ )

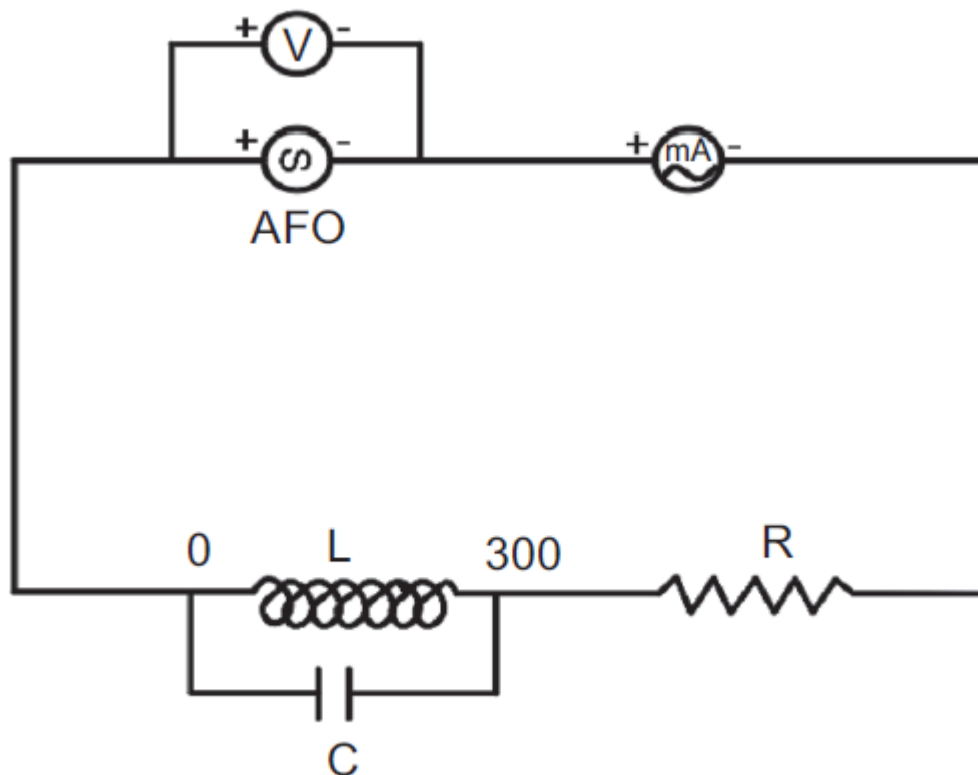
$Z$  = Impedance of the circuit ( $\Omega$ )

$\omega$  = Angular resonance frequency

**Table – Determination of current for different values of R**

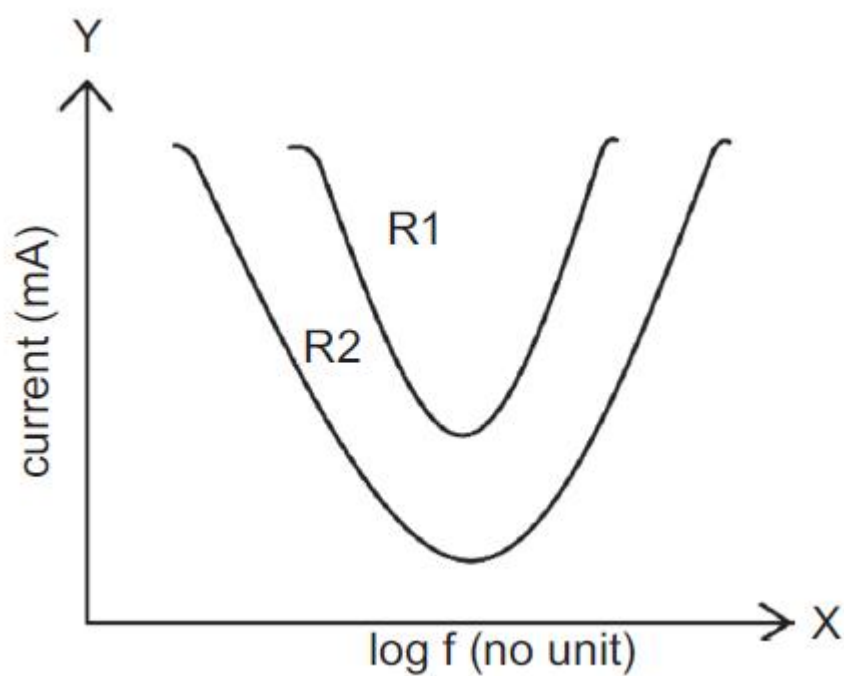
| S. No | Frequency<br>(Hz) | log(f) | Current in mA     |                   |
|-------|-------------------|--------|-------------------|-------------------|
|       |                   |        | $R_1=100\ \Omega$ | $R_2=300\ \Omega$ |
|       |                   |        |                   |                   |

**Circuit diagram:**



**Procedure:**

- i. Connections are made as shown in the Figure
- ii. Introduce 100 ohms in R and 0.05 mF in C.
- iii. Measure the current in mA for various values of the frequency.
- iv. Plot a graph between  $\log f$  and current.
- v. Repeat the experiment by varying the value of R.

**Model Graph:**

**Result:**

- 1 Resonant frequency  $f_o$  =
- 2 Self inductance of the coil =  
 $L$
- 3 Q-factor of the circuit  
· (i) for( $R=100\Omega$ ) =  
(ii) for( $R=300\Omega$ ) =
- 4 Bandwidth  
· (i) for( $R=100\Omega$ ) =  
(ii) for( $R=300\Omega$ ) =

## SPECTROMETER – GRATING – NORMAL INCIDENCE METHOD

### Aim:

1. To determine the number of lines per metre of the grating (to standardize the grating)
2. To find the wavelength of prominent lines of the mercury light spectrum.

### Apparatus Required:

Spectrometer, Grating, Mercury vapour lamp, Reading lens etc.,

### Formula:

- (i) Number of lines per metre of grating

$$\sin \theta = Nm \lambda$$

$$N = \frac{\sin \theta}{m \lambda} \quad \text{lines / metre}$$

- (ii) Wavelength of prominent lines of the mercury light spectrum

$$\lambda = \frac{\sin \theta}{mN} \quad \text{\AA}$$

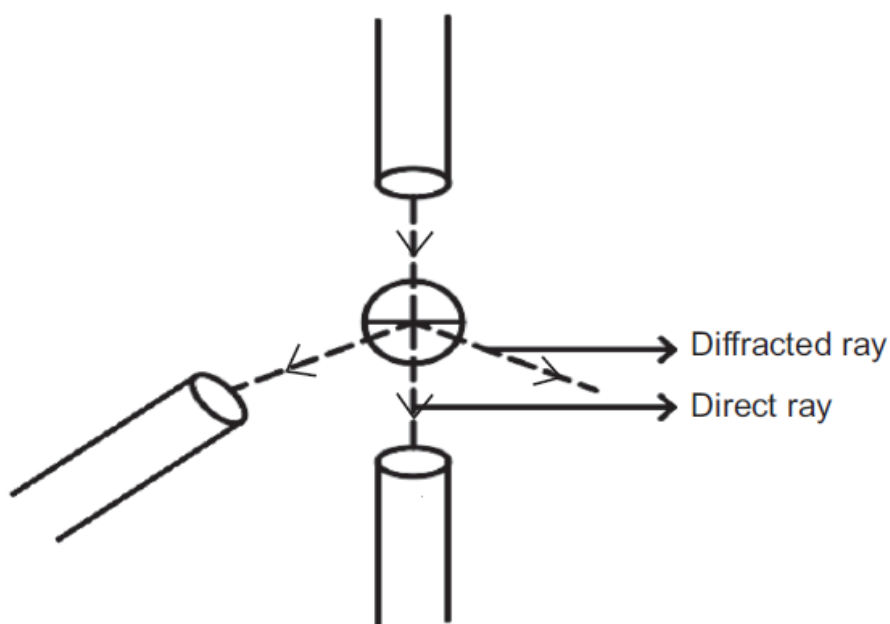
where,

$\theta$  = Angle of diffraction in degree

$m$  = Order of the diffraction

( $m = 1$  for 1<sup>st</sup> order,  $m = 2$  for 2<sup>nd</sup> order )

### Diagram



**Let's Continue**

[illegible]

**Procedure:**

- i. Do the initial adjustments. Illuminate the slit with mercury vapour lamp. Adjust the telescope  
to be in line with the collimator so as to observe the image of the slit. Make the image of the  
slit as narrow as possible.
- ii. By adjusting the tangential screw of the telescope, make the crosswire to coincide with the  
image. Release the vernier and set the direct reading  $0^\circ$ -  $180^\circ$  and then fix the vernier.
- iii. Move the telescope through an angle  $90^\circ$  and fix it.
- iv. Mount the grating on the grating table and rotate the grating table so that the reflected  
image  
coincides with the cross-wire of the telescope and fix the grating table.
- v. Now release the vernier table and rotate it through an angle  $45^\circ$  such that the grating plane  
becomes normal to the incident beam.
- vi. Release the telescope to observe the direct image and spectrum on either side.
- vii. Make the crosswire to coincide with the first order violet, blue, bluish green, green,  
yellow  
and yellow 2 lines respectively. In each case, note the readings in vernier A and vernier  
B.
- viii. Move the telescope to the right and repeat the previous step.
- ix. With green colour wavelength as standard and with its diffracted value  $q$ ,  $N$  is calculated  
using the formula.
- x. Using the value of  $N$ , wavelength of different spectral lines are calculated.

# Determination of Wavelength of Various Colours

## Least Count:

[illegible]

**Result:**

1. Number of lines per metre of the grating =
2. Wavelength of the prominent lines of the mercury spectrum are determined and the values are tabulated.

| Colour | Wavelength |
|--------|------------|
|        |            |

# SPECTROMETER - i-d CURVE USING PRISM

## Aim:

1. To determine the angle of deviation (d) corresponding to known angles of incidence and to determine the angle of the prism from the i-d curve.
2. To determine the refractive index of the material of the prism.

## Apparatus Required:

Spectrometer, Solid prism, Sodium vapour lamp etc.,

## Formula:

$$A = i_1 + i_2 - d(\text{degree})$$

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

where,

$i_1, i_2$  = angles of incidence for deviation (d) in degree.

A = Angle of the prism in degree.

D = Angle of minimum deviation in degree.

m = Refractive index of the material of the prism.

## Procedure:

- i. All the preliminary adjustments of the spectrometer are made.
- ii. The prism is mounted on the prism table.

## To find the Angle of Deviation

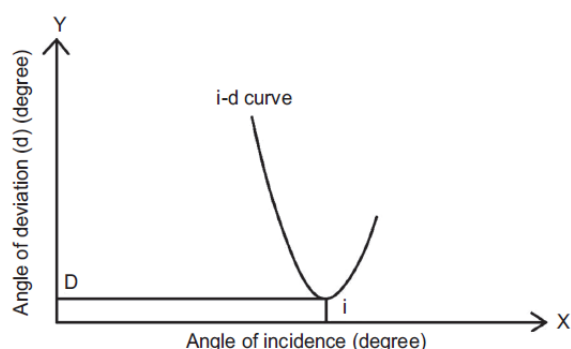
| S. No. | $2i$<br>(degree) | $i$<br>(degree) | Telescope Reading |     |    |           |     |    | Angle of deviation |              |
|--------|------------------|-----------------|-------------------|-----|----|-----------|-----|----|--------------------|--------------|
|        |                  |                 | Vernier A         |     |    | Vernier B |     |    | Vernier<br>A       | Vernier<br>B |
|        |                  |                 | MSR               | VSR | TR | MSR       | VSR | TR |                    |              |
|        |                  |                 |                   |     |    |           |     |    |                    |              |

Direct ray reading:

Vernier A: \_\_\_\_\_ ; Vernier B: \_\_\_\_\_

### Adjustment to set the prism for a particular angle of incidence, ' $i$ ':

- i. Now the telescope is brought parallel to the collimator and the direct image of the slit is obtained at the vertical crosswire.
- ii. The readings on both the verniers are set to be  $0^\circ - 180^\circ$ .
- iii. Now the telescope is released and turned through an angle  $90^\circ$  and clamped there.
- iv. Place the prism on the prism table with one of its faces facing the collimator. Then the vernier table (or prism table) is rotated to and fro so that the image of the slit reflected from the face is made to coincide with the vertical crosswire of the telescope.
- v. The vernier table is clamped there.
- vi. Now the prism is set for the angle of incidence  $i$ .
- vii. The telescope is then released, turned towards the refracted ray and the refracted image of the slit is obtained at the vertical crosswire.
- viii. The readings (a) on both the verniers are noted.
- ix. Again the telescope is brought in line with the collimator and the direct image of the slit is obtained at the cross wire.
- x. The readings (b) on both the verniers are taken.
- xi. The difference between ' $a$ ' and ' $b$ ' gives the angle of deviation.
- xii. The angles of deviation for different angles of incidence, say  $i = 40^\circ, 45^\circ, 50^\circ$  etc., are noted.
- xiii. A graph is plotted with ' $i$ ' along the X- axis and ' $d$ ' along the Y-axis.
- xiv. The angle of incidence corresponding to the angle of minimum deviation can be determined from the graph. Then the angle of the prism and the refractive index can be calculated.



### Result:

1. Refractive index of the prism  $\mu =$
2. Angle of the prism  $A =$

## SPECTROMETER – I – I' CURVE

### Aim:

To draw the  $i$ - $i'$  curve for a prism by measuring the angles of emergence  $i'$  for different values of angles of incidence  $i$  and hence calculate the refractive index

### Apparatus Required:

Spectrometer, prism and sodium vapor lamp.

### Formula:

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

Angle of the prism  $A = i + i' - d$

At minimum deviation position,  $d = D$ ,  $i = i'$ ,

$$A + D = 2i$$

$$\frac{A+D}{2} = i$$

$$\text{Hence } \mu = \frac{\sin i}{\sin\frac{A}{2}}$$

where,

$\mu$  is the refractive index of the material of the given prism

$A$  is the angle of the prism in degree

$D$  is the angle of minimum deviation in degree

## Determination of the Angle of the Prism

| $i^\circ$ | $\theta = 180 - 2i$ | Reflected ray |      | Refracted ray |      | Angle of deviation |      | Mean deviation | $\theta^\circ$ | $i' = 90 - \frac{\theta'}{2}$ | $A = i + i' - d$ |
|-----------|---------------------|---------------|------|---------------|------|--------------------|------|----------------|----------------|-------------------------------|------------------|
|           |                     | V-I           | V-II | V-I           | V-II | V-I                | V-II |                |                |                               |                  |
|           |                     |               |      |               |      |                    |      |                |                |                               |                  |
|           |                     |               |      |               |      |                    |      |                |                |                               |                  |

Direct Ray Reading: V-I:

V-II :

Mean A =

$i$  is the angle of incidence in degree

$d$  is the angle of deviation in degree

## Procedure:

The initial adjustments of the spectrometer are to be done. Illuminate the slit with sodium

vapor lamp and make the vertical crosswire of the telescope coincide with the image. Fix the telescope at the position. Release and rotate the Vernier table to read  $0 - 180^\circ$  and fix it. Now release the telescope. If  $i$  is chosen as the angle of incidence, turn it through an angle  $\theta = 180 - 2i$  and fix it there. For example, if  $i = 40^\circ$ ,  $2i = 80^\circ$   $\theta = 180 - 80^\circ = 100^\circ$ . So turn the telescope through  $100^\circ$  and fix it there.

Mount the prism on the prism table and rotate it so as to get the reflected image to coincide with the vertical crosswire. Release the telescope and get the refracted image and fix it note the reading for the refracted image. Turn the prism table such that the refracted ray moves to the minimum deviation position. Continue rotation until it comes back to its original position. Now the angle of incidence at the incident surface is  $i'$ .

Release the telescope and make the vertical crosswire to coincide with the reflected ray

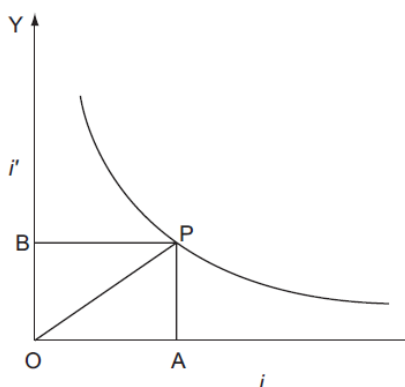
from the incident surface. The difference between this reading and the direct reading is

$\theta' = 180 - 2i'$ . Therefore,  $i = 90 - \frac{\theta'}{2}$ . Repeat this procedure for different angles of incidence.

Direct Ray Reading: V-I:

V- II:

## Model Graph:



Plot a graph with  $i \times i$ . The bisector intersects the graph at  $i = i$  where  $d = D$

$$\text{So, } A = 2i - D$$

$$A + D = 2i$$

$$\frac{A + D}{2} = i$$

$$\mu = \frac{\sin i}{\sin \frac{A}{2}}$$

**Result:**

The refractive index of the material of the prism is \_\_\_\_\_.

## CONVERSION OF GALVANOMETER INTO VOLTMETER AND AMMETER

### Aim:

To convert the given table galvanometer into (i) a milli voltmeter and (ii) a milli ammeter, and to draw the calibration curves.

### Formula:

$$S_v = \left( \frac{E}{P+Q} \right) \times \left( \frac{P}{\theta} \right) \times 10^3 \text{ m volt / div}$$

$$S_c = \left( \frac{E}{P+Q} \right) \times \left( \frac{P}{\theta} \right) \times \left( \frac{1}{R_g} \right) \times 10^3 \text{ m amp / div}$$

$$I_g = S_c * N$$

$$I_s = I - I_g$$

$$R = \left( \frac{V}{I_g} \right) - R_g$$

$$R_s = \frac{I_g R_g}{I_s}$$

Where,

- $S_v$  – Voltage sensitiveness of the galvanometer
- $S_c$  – Current sensitiveness of the galvanometer
- P – Resistance in box P
- Q – Resistance in box Q
- E – EMF of the power supply
- $\theta$  - Mean deflection in the galvanometer
- $R_g$  – Resistance of the galvanometer
- N – Number of divisions in the galvanometer
- $I_g$  – Total current through the galvanometer
- I – Maximum range of the milli ammeter
- $I_s$  – Remainder current through  $R_s$

$V$  – Maximum range of the milli voltmeter

$R_S$  – Shunt resistance for the milli-ammeter

$R$  – Series resistance for the milli-voltmeter

### Procedure:

The circuit connections are made as shown in Fig. 1. The Power supply is switched on. Suitable resistances are added in boxes P and Q. The commutator key is thrown to one side. The deflection in the galvanometer is noted. Now, suitable resistance is added in box R, so that the deflection in the galvanometer reduces to one-half. Now, the resistance in box R is noted. It is  $R_g$ .

Then, the resistance in box R is made zero. Now, the commutator key is thrown to the other side, and the deflection in the galvanometer is noted. Resistance in R for the half deflection is found as like in the previous case. The experiment is repeated for different values of P and Q, keeping  $(P+Q)$  constant. The readings are tabulated. From the tabular column, the values of  $P/\theta$  and  $R_g$  as calculated.

Substituting the values of  $P/\theta$  and  $R_g$ , the voltage sensitiveness ( $S_V$ ) and current sensitiveness ( $S_C$ ) of the galvanometer are determined.

### Circuit diagram:

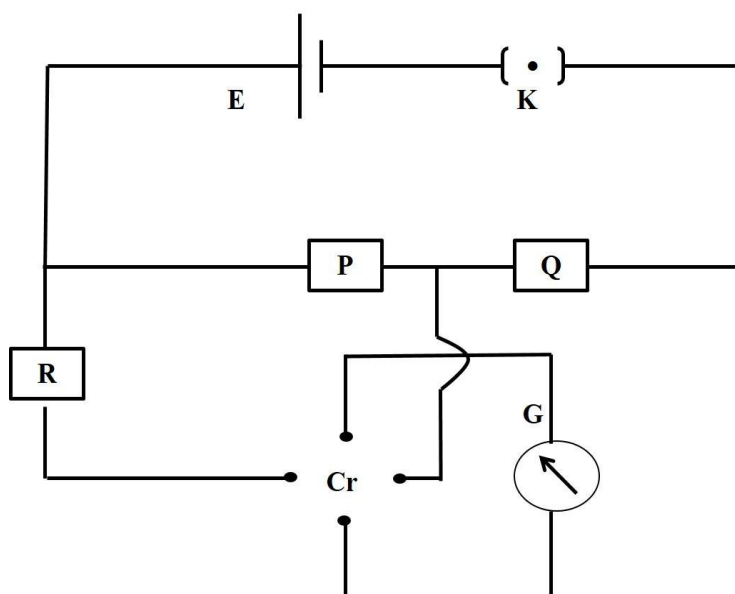


Fig. 1

**Observations:**

$$E = 2 \text{ V}$$

$$P + Q = 500 \, \Omega$$

| P<br>(ohms) | Deflection ( $\theta$ ) |       |      | Resistance $R_g$ (ohms)<br>for half deflection |       |      | P/ $\theta$ |
|-------------|-------------------------|-------|------|------------------------------------------------|-------|------|-------------|
|             | Left                    | Right | Mean | Left                                           | Right | Mean |             |
|             |                         |       |      |                                                |       |      |             |

**Milli voltmeter:**

The series resistance  $R$  for the milli-voltmeter is calculated using the given equation, where  $V$  is the maximum range of the milli-voltmeter. Now, circuit connections are made as shown in Fig. 2. Suitable resistances are added in boxes  $P$  and  $Q$ . The commutator key is thrown to the left side, and the deflection is noted. Then, the commutator key is thrown to the other side. Now, the galvanometer deflection is also noted. Mean deflection  $d$  is found. The experiment is repeated for different values of  $P+Q$ , keeping  $(P+Q)$  constant. The voltmeter readings  $V_m$  and the calculated voltage  $V_c$  are determined from the suitable equations. The calibration graph is drawn taking  $V_m$  on the x-axis and the correction  $(V_c - V_m)$  on the y-axis.

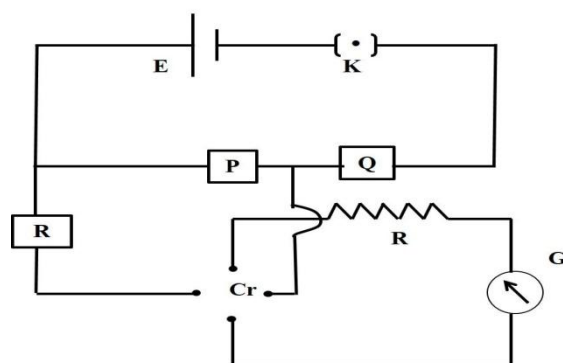
**Circuit diagram:**

Fig. 2

**Observations:**

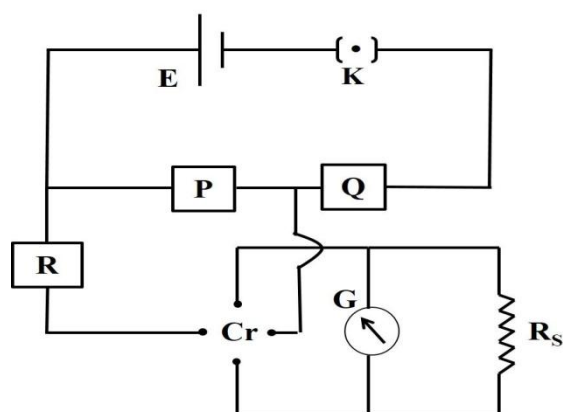
$$E = 2 \text{ V}$$

$$P + Q = 500 \, \Omega$$

| P<br>(ohms) | Deflection (d) |       |      | Voltmeter<br>reading<br>$V_m = \left( \frac{V}{N} \right) \times d$<br>milli volt | Calculated current<br>$V_c = \left( \frac{E \times P}{(P + Q)} \right) \times 10^3$<br>milli volt | Correction<br>( $V_c - V_m$ )<br>milli. volt |
|-------------|----------------|-------|------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|----------------------------------------------|
|             | Left           | Right | Mean |                                                                                   |                                                                                                   |                                              |
|             |                |       |      |                                                                                   |                                                                                                   |                                              |

**Milli ammeter:**

The shunt resistance  $R_s$  for the milli-ammeter is determined by the given equation. The circuit connections are made for the milli ammeter as shown in Fig. 3. Suitable resistances are added in boxes P and Q. The commutator key is thrown on one side, and deflection in the galvanometer is noted. Similarly, the deflection is noted in the galvanometer on the other side. The ammeter readings  $I_m$  and the calculated current  $I_c$  are determined using the given equations. The calibration graph is drawn taking  $I_m$  on the x-axis and the correction ( $I_c - I_m$ ) on the y-axis.

**Circuit diagram:****Fig. 3**

**Observations:**

$$E = 2 \text{ V}$$

$$P + Q = 500 \, \Omega$$

| P<br>(ohms) | Deflection (d) |       |      | Ammeter<br>reading<br><br>$I_m = \left( \frac{I}{N} \right) \times d$<br>milli amps | Calculated current<br><br>$I_c = \left( \frac{E \times P}{(P + Q) \times R} \right) \times 10^3$<br>milli amps | Correction<br>(I <sub>c</sub> -I <sub>m</sub> )<br>milli amps |
|-------------|----------------|-------|------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
|             | Left           | Right | Mean |                                                                                     |                                                                                                                |                                                               |
|             |                |       |      |                                                                                     |                                                                                                                |                                                               |

**Result:**

The given table galvanometer was converted into a milli-voltmeter and a milli-ammeter, and the calibration curves were drawn.

- (i) Voltage sensitiveness of the galvanometer  $S_V =$  Volt/div
- (ii) Current sensitiveness of the galvanometer  $S_C =$  mA/div
- (iii) Resistance of the galvanometer  $R_g =$  Ohm
- (iv) Series resistance for milli voltmeter  $R =$  Ohm
- (v) Shunt resistance for milli ammeter  $R_s =$  Ohm

## BRIDGE RECTIFIER

### Aim:

To construct the bridge rectifier using diodes and to measure the DC output voltage.

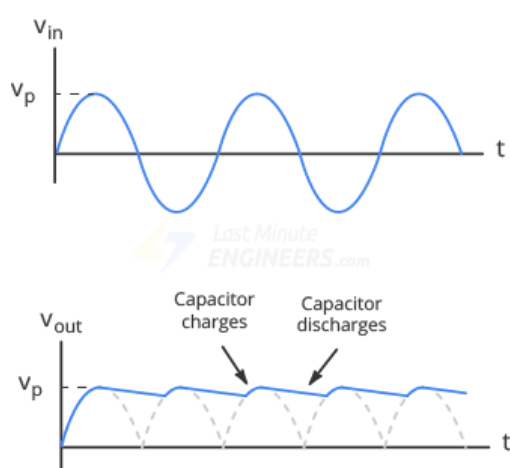
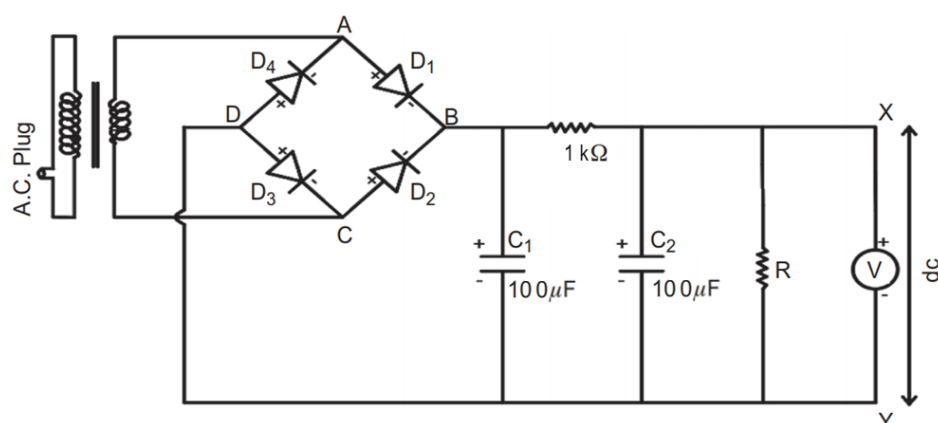
### Apparatus Required:

Diodes, Step down transformer, Electrolytic capacitors 10  $\mu$ F and 470  $\mu$ F, Resistors, Voltmeter etc.,

### Formula

$$\text{Percentage of regulation} = \frac{DC \text{ without load} - DC \text{ with Load}}{DC \text{ with Load}} \times 100 \%$$

### Circuit diagram:



### Procedure:

- ❖ Electrical connections are made as shown in the Figure 2.9.1
- ❖ C1 and C2 are electrolytic capacitors, the longer leg in each being positive.

- ❖ After the connections are made, the multimeter which is set for resistance is used to
- ❖ test the continuity between the output terminals X and Y. There will be continuity shown in the multimeter, when the positive probe of the multimeter is touched with end Y and the negative probe with the end X.
- ❖ If the probes are interchanged, there should not be any continuity between X and Y.
- ❖ Now the primary power line is switched on. The AC voltage across the secondary is
- ❖ measured with the multimeter.
- ❖ This is rectified by the bridge circuit and the rectified DC voltage appears across X and Y.
- ❖ The DC voltage is measured using the multimeter.
- ❖ In this circuit, the combination of two capacitors C1 and C2 that are parallel to each
- ❖ other and the resistance R works as the smoothening circuit.
- ❖ This removes the ripple present in the output of the bridge rectifier.
- ❖ Output DC voltage is measured for different values of R.

### Observation

AC Voltage across primary Cell :

AC Voltage across Secondary Cell :

DC Output Voltage without load Resistance :

DC Output Voltage with load Resistance :

| S.No | Resistance (ohm) | Output voltage (V) |
|------|------------------|--------------------|
|      |                  |                    |
|      |                  |                    |
|      |                  |                    |

### Result:

The bridge rectifier circuit is constructed and DC outputs are measured.

## BASIC LOGIC GATES - AND, OR AND NOT USING DISCRETE COMPONENTS

### Aim:

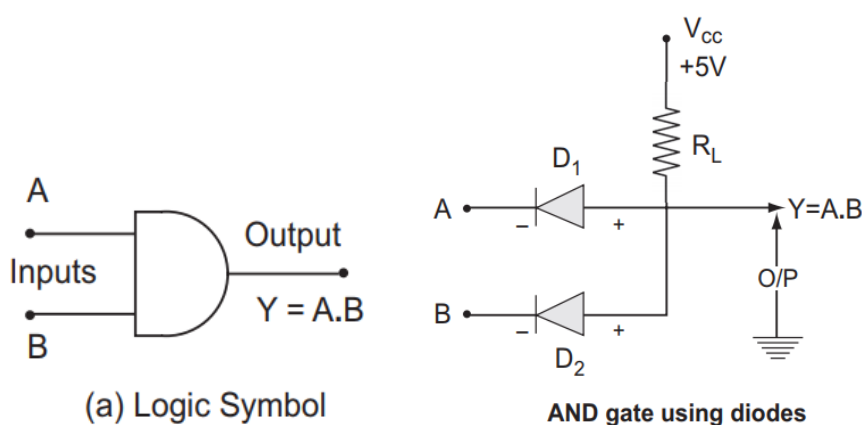
To construct the basic logic gates, namely AND, OR and NOT gates using diode and discrete components and to verify their truth tables.

### Apparatus Required:

Two diodes, 10 Kohm resistor, 2.2 Kohm resistor, multimeter (voltmeter), two 6V batteries, breadboard, connecting leads and BC 107 transistor (npn).

### Circuit diagram:

#### The AND logic gate



### Procedure:

The circuit is connected as shown in the figure 3.11.1. A and B are the terminals to give inputs. All the ground points (G) are connected together at a single point (0 volt). Now, 0V is taken as 0 state. i.e;  $V(0) = 0$  Volt and 5V is taken as 1 state i.e;  $V(1) = 5$  Volt. That is positive logic system is followed.

#### Case 1: A = 0; B = 0; Y = ?

The input terminal A and B are connected to the ground terminal so as to have 0 input. The output voltage at Y is measured with respect to ground using a voltmeter. The observation is recorded.

#### Case 2: A = 1; B = 0; Y = ?

The input terminal A is connected to (+5) volt and B is connected to the ground. The output voltage Y is measured with respect to ground using a voltmeter. The observation is recorded.

**Case 3: A = 0; B = 1; Y = ?**

The input terminal B is connected to (+5) volt and A is connected to the ground. The output voltage Y is measured with respect to ground using a voltmeter. The observation is recorded.

**Case 4: A = 1; B = 1; Y = ?**

The input terminal A is connected to (+5) volt. The input terminal B is also connected to (+5) volt. The output voltage Y is measured with respect to ground using a voltmeter. The observation is recorded. The truth table is formed from the observations recorded.

**Observations:**

The AND logic gate

$$Y = A.B$$

$$V(0) = 0V; V(1) = 5V$$

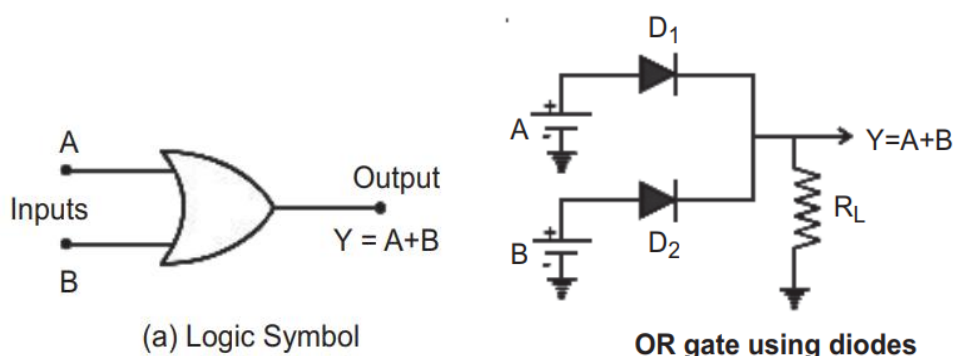
Truth table

| Input A | Input B | Output<br>Y=A.B |
|---------|---------|-----------------|
| 0       | 0       | 0               |
| 1       | 0       | 0               |
| 0       | 1       | 0               |
| 1       | 1       | 1               |

Verification table

| Input A<br>(V) | Input B<br>(V) | Output<br>Y=A.B (V) |
|----------------|----------------|---------------------|
|                |                |                     |
|                |                |                     |
|                |                |                     |
|                |                |                     |

## The OR logic gate



### Procedure:

The circuit is connected as shown in the figure 3.11.2. The reference voltage  $V_R = 0$ ; The logic level  $V(1) = 5V$ ; The logic level  $V(0) = 0V$ . The diodes are IN 4001 or by 127.

Case 1:  $A = 0$ ;  $B = 0$ ;  $Y = ?$

The input terminals A and B are connected to the ground(0V). The output voltage Y is measured with respect to ground using volt meter. The reading are recorded.

Case 2:  $A = 1$ ;  $B = 0$ ;  $Y = ?$

The input A is connected to +5 V. The terminal B is grounded. The output voltage Y is measured with respect to ground using a voltmeter. The readings are recorded.

Case 3:  $A = 0$ ;  $B = 1$ ;  $Y = ?$

The input terminal B is connected to (+5) volt and A is connected to the ground. The output voltage Y is measured with respect to ground using a voltmeter. The observation is recorded

Case 4:  $A = 1$ ;  $B = 1$ ;  $Y = ?$

Now both the inputs are raised to  $V(1)$  state by connecting them together at +5V. The output voltage Y is measured with respect to ground using a voltmeter. The readings are recorded.

Observations:

The OR logic gate:  $Y = A + B$

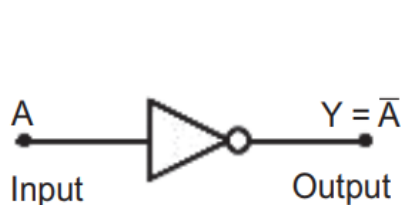
$V(0) = 0V$ ;  $V(1) = 5V$

**Truth table**

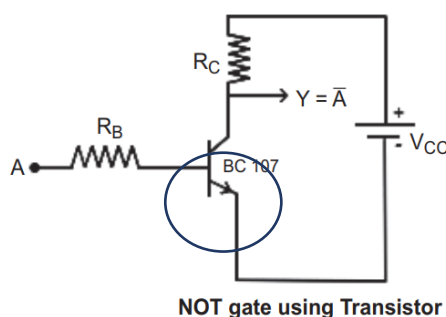
| Input A | Input B | Output<br>$Y=A+B$ |  | Input A<br>(V) | Input B<br>(V) | Output<br>$Y=A+B$ (V) |
|---------|---------|-------------------|--|----------------|----------------|-----------------------|
| 0       | 0       | 0                 |  |                |                |                       |
| 1       | 0       | 1                 |  |                |                |                       |
| 0       | 1       | 1                 |  |                |                |                       |
| 1       | 1       | 1                 |  |                |                |                       |

**Verification table**

**The NOT logic gate using Transistor**



(a) Logic Symbol



NOT gate using Transistor

**Procedure:**

The NOT logic gate circuit is connected as shown in the figure 3.12.3. BC 107 (npn) transistor is used. The logic gate V (1) corresponds to +5 volt and the state V(0) corresponds to 0 volt in the positive logic system. All the ground points are connected together G (0 volt) and voltage are measured with respect to this point G. The input terminal A is given +5 volt and it is in the V (1) state. The output voltage at Y is measured with respect to ground using a voltmeter and recorded.

**Observations:**

V (1) = +5V; V(0) = 0V;

NOT logic gate:  $Y = \bar{A}$

**Truth table**

| Input A | Output<br>$Y=\bar{A}$ |  | Input A<br>(V) | Output<br>$Y = Y=\bar{A}$ (V) |
|---------|-----------------------|--|----------------|-------------------------------|
| 0       | 1                     |  |                |                               |
| 1       | 0                     |  |                |                               |

**Verification table**

**Result:**

The AND, OR and NOT gates are constructed using diode and discrete components and their truth tables are verified.

## CALIBRATION OF HIGH RANGE VOLTMETER –POTENTIOMETER

### Aim:

To calibrate the high range voltmeter using a potentiometer and a standard cell.

### Apparatus Required:

Potentiometer, rheostat, voltmeter, galvanometer, high resistance, d.c. power source, connecting wires and standard cell (Daniel cell).

### Formula:

Voltage measured using potentiometer,

$$V = 1.08 \left( \frac{l}{l_0} \right) \frac{P+Q}{P} \text{ (V)}$$

where,

$l_0$  is the balancing length of the potentiometer wire (m)

$P, Q$  are resistances included in the resistance boxes ( $\Omega$ )

$l$  is the balancing length against the different ratio of  $[P + Q]$  (m).

### Procedure:

#### (1) To standardize the potentiometer

For standardizing the potentiometer, firstly we apply a constant DC voltage across the two ends of the potentiometer. For this we can use a 2V accumulator or a 2V stabilized power supply. If a stabilized power supply of 6V is available, we have to use a potential divider arrangement with a rheostat and voltmeter to tap 2V. With this, we drop 2V across the 10m length of potentiometer wire. Further, for standardization, we use a standard cell of constant emf (here, Daniel cell of 1.08V). Make the circuit as shown in Figure 4.8.1, wherein care must be taken to connect the positive end of potentiometer wire to the positive of the Daniel cell. Remove the plug in the high resistance (H.R.) and press the jockey J on the potentiometer wire near the end A and note the direction of the deflection in the galvanometer G. Press the jockey near the other end B, and now the deflection in G must be opposite to the earlier deflection. If so the connections are correct, otherwise connections need to be checked. Now find the approximate balancing length (for which the deflection in G is zero) keeping the jockey near the approximate balancing length. H.R. can now be bypassed by putting its key. This results to more deflection in G, and now by adjusting the position of J, more accurate balancing length  $l_0$  can be found. In other words, the potential across A and J is equal to the potential of Daniel

cell (i.e., 1.08V). Then, the potential corresponding to 1m length of potentiometer wire is  $\frac{1.08}{10} \text{ Vm}^{-1}$

## 2) To calibrate the voltmeter

Without disturbing the primary (earlier) circuit, disconnect the Daniel cell and make the new circuit as shown in Figure 4.8.2. Make sure that the polarities are maintained correctly at each point. Adjust the rheostat in the secondary circuit so that the voltmeter reads 1 V. The resistances P and Q must be such that the potential difference across P is less than 2V, since the voltage between A and B is 2V. Now find the balancing length  $l$ , which corresponds to the potential across P. If  $V_P$  is the voltage across, then  $V_P = l \left( \frac{1.08}{10} \right)$

With this we shall now find the voltage across (P + Q), as shown below, and can be compared with the voltmeter reading. If  $V'$  is the voltage across (P + Q), then from Fig. 4.8.3 we have

$$I = \frac{V_P}{P} = \frac{V}{(P + Q)}$$

In other words,

$$V_P = \frac{VP}{(P+Q)} = 1.08 \left( \frac{l}{10} \right) \text{ or } V = 1.08 \left( \frac{l}{10} \right) \frac{(P+Q)}{P}$$

Repeat the experiment for different voltmeter readings (e.g. 1V-5V in steps of 0.5V), by either keeping the resistances P and Q the same or varying them each time suitably, if necessary. Tabulate the observations as follows and draw the calibration graph and correction graph.

### Result:

The given high range potentiometer is calibrated and calibration and correction graphs are drawn.

## PN JUNCTION DIODE CHARACTERISTICS

### Aim:

To draw the characteristics of a PN junction diode in forward and reverse bias

### Apparatus used:

PN Junction diode, voltmeter (0-2volt), voltmeter (0-30 volt), mili-ammeter, micro-ammeter, variable source (0-2 volt and 0-30 volt).

### Formula

$$\text{Forward Resistance } R_F = \left( \frac{\Delta V_F}{\Delta I_F} \right)_{\text{Ohm}}$$

$$\text{Reverse Resistance } R_R = \left( \frac{\Delta V_R}{\Delta I_R} \right)_{\text{Ohm}}$$

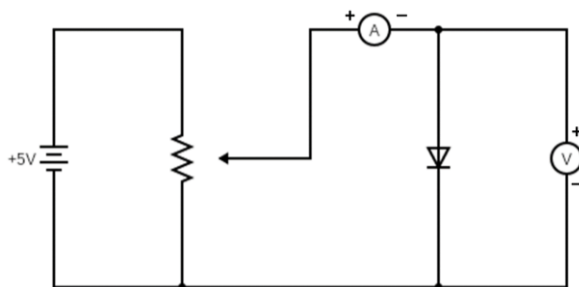
$\Delta V_F$  – Forward Voltage (V)

$\Delta I_F$  – Forward Current (mA)

$\Delta V_R$  – Reverse Voltage (V)

$\Delta I_R$  – Reverse Current ( $\mu A$ )

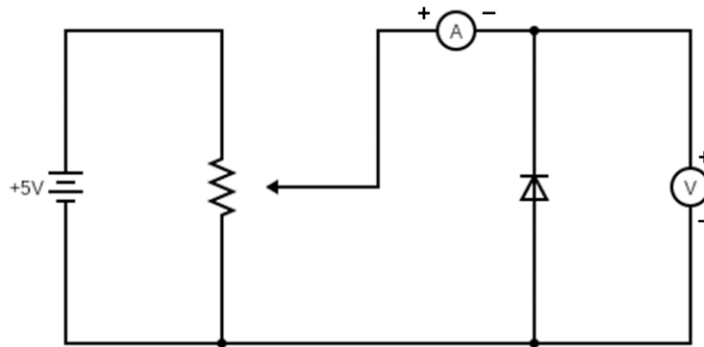
### Forward V-I Characteristics:



- Connections are made as per the connection diagram.
- Insert the key. Arrange the sliding contact of the rheostat to minimum.
- Now, gently move the rheostat contact to provide a positive bias voltage.
- Note the voltmeter and milli ammeter readings.
- Repeat the process by increasing the forward current in equal steps by changing the rheostat slider.

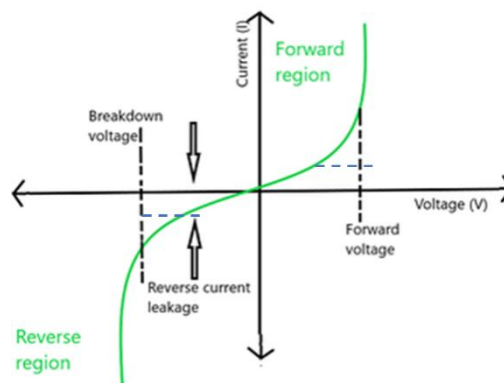
- It can be noted that, initially the current increase very slowly. For a certain value of voltage, it shows a sharp increase. The corresponding voltage represents the knee voltage of that diode.
- Plot a graph with forward voltage along X axis and forward current along Y axis. The graph shows the forward V-I characteristics of the given p-n junction diode.

### Reverse V-I Characteristics:



- Make the circuit diagram as shown in the figure.
- Insert the key. Arrange the sliding contact of the rheostat to maximum.
- Move the sliding contact of the rheostat to provide a reverse bias voltage. Note the voltmeter and micro ammeter readings.
- Note the voltmeter and micro ammeter readings.
- Repeat the process by changing the reverse voltage in equal steps.
- The current increases slowly in the beginning and then rapidly when the reverse voltage becomes a certain value. This voltage is known as the reverse breakdown voltage.
- Plot a graph with reverse voltage along X axis and reverse current along Y axis. The graph shows the reverse V-I characteristics of the given p-n junction diode.

### Model Graph



## Observation

### Forward Bias

| S.No | $V_F(V)$ | $I_F(mA)$ |
|------|----------|-----------|
|      |          |           |
|      |          |           |

### Reverse Bias

| S.No | $V_R(V)$ | $I_R(mA)$ |
|------|----------|-----------|
|      |          |           |

## Result:

Forward Resistance  $R_F =$

Reverse Resistance  $R_R =$

The forward and reverse characteristics of the given p-n junction diode is drawn.

## ZENER DIODE CHARACTERISTICS

### Aim :

1. To observe and draw the V-I characteristics and Regulation characteristics of a Zener diode.
2. To find the Zener Break down voltage in reverse biased condition.

### Apparatus used:

Zener diode, voltmeter (0-2volt), voltmeter (0-30 volt), mili-ammeter, micro-ammeter, variable source (0-2 volt and 0-30 volt).

### Formula

$$\text{Forward Resistance } R_F = \left( \frac{\Delta V_F}{\Delta I_F} \right)_{\text{Ohm}}$$

$$\text{Reverse Resistance } R_R = \left( \frac{\Delta V_R}{\Delta I_R} \right)_{\text{Ohm}}$$

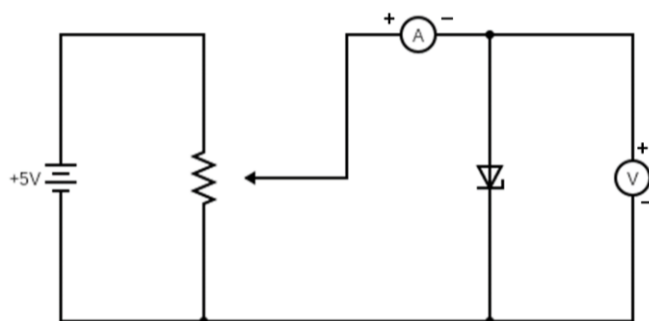
$\Delta V_F$  – Forward Volatge (V)

$\Delta I_F$  – Forward Current (mA)

$\Delta V_R$  – Reverse Volatge (V)

$\Delta I_R$  – Reverse Current ( $\mu A$ )

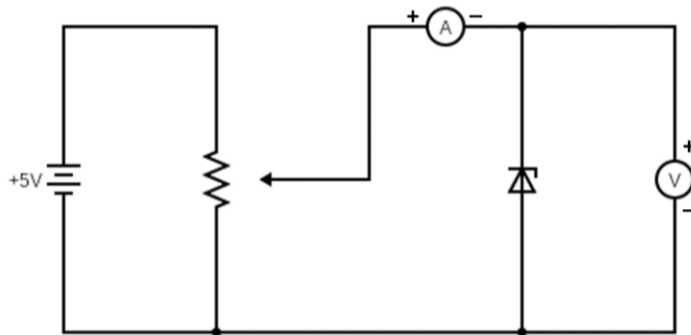
### Forward V-I Characteristics:



- Connections are made as per the connection diagram.
- Insert the key. Arrange the sliding contact of the rheostat to minimum.
- Now, gently move the rheostat contact to provide a positive bias voltage.
- Note the voltmeter and milli ammeter readings.

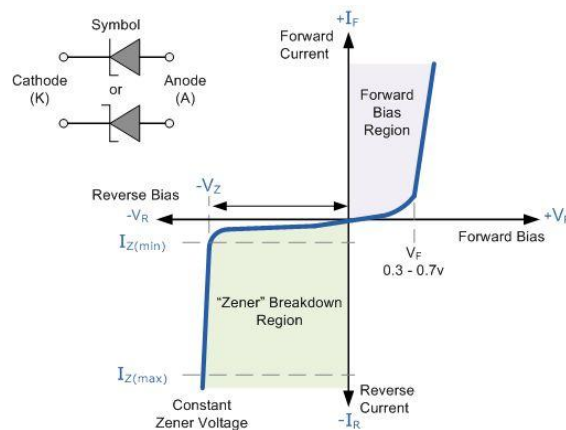
- Repeat the process by increasing the forward current in equal steps by changing the rheostat slider.
- It can be noted that, initially the current increase very slowly. For a certain value of voltage, it shows a sharp increase. The corresponding voltage represents the knee voltage of that diode.
- Plot a graph with forward voltage along X axis and forward current along Y axis. The graph shows the forward V-I characteristics of the given p-n junction diode.

### Reverse V-I Characteristics:



- Make the circuit diagram as shown in the figure.
- Insert the key. Arrange the sliding contact of the rheostat to maximum.
- Move the sliding contact of the rheostat to provide a reverse bias voltage.
- Note the voltmeter and micro ammeter readings.
- Repeat the process by changing the reverse voltage in equal steps.
- The current increases slowly in the beginning and then rapidly when the reverse voltage becomes a certain value. This voltage is known as the reverse breakdown voltage.
- Plot a graph with reverse voltage along X axis and reverse current along Y axis. The graph shows the reverse V-I characteristics of the given p-n junction diode.

### Model Graph



## Result

The forward and reverse characteristics of the given Zener junction diode are drawn and its parameters are determined

1. Forward Resistance  $R_F =$
2. Reverse Resistance  $R_R =$
3. Knee Voltage =
4. Breakdown Voltage =

## UNIVERSAL NAND GATE

### Aim:

To verify the truth table for NAND gate and to verify as universal building block.

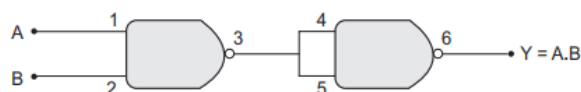
### Apparatus required:

NAND gate – IC 7400, IC trainer kit, voltmeter and connecting wires.

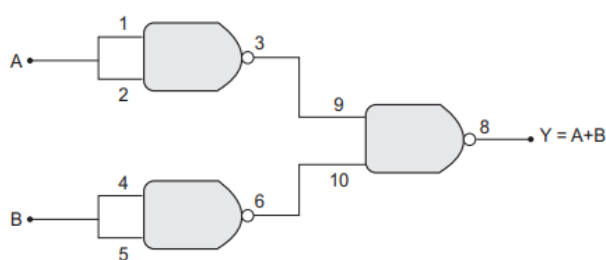
### Procedure:

1. Make the connections as given in the circuit separately for each gate.
2. For various input combinations, measure the output value by connecting the voltmeter between the output pin and ground terminal.
3. Compare it with the truth table to check the voltage levels match with the high and low level in the truth table.

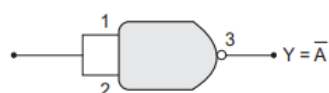
### Circuit Diagram:



AND gate using NAND gates



OR gate using NAND gates



NOT gate using NAND gate

### AND gate using NAND gates

Table 5.12.11 Truth Table

| A | B | $y = A \cdot B$ |
|---|---|-----------------|
| 0 | 0 | 0               |
| 0 | 1 | 0               |
| 1 | 0 | 0               |
| 1 | 1 | 1               |

Table 5.11.12 Verification Table

| $A_v$ | $B_v$ | $y = A_v \cdot B_v$ |
|-------|-------|---------------------|
|       |       |                     |
|       |       |                     |
|       |       |                     |
|       |       |                     |

### OR gate using NAND gates

Table 5.12.13 Truth Table

| A | B | $y = A + B$ |
|---|---|-------------|
| 0 | 0 | 0           |
| 0 | 1 | 1           |
| 1 | 0 | 1           |
| 1 | 1 | 1           |

Table 5.11.14 Verification Table

| $A_v$ | $B_v$ | $y = A_v + B_v$ |
|-------|-------|-----------------|
|       |       |                 |
|       |       |                 |
|       |       |                 |
|       |       |                 |

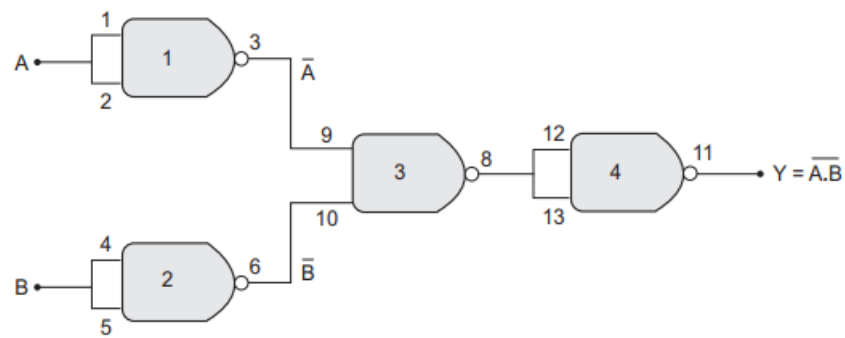
### NOT gate using NAND gate

Table 5.12.15 Truth Table

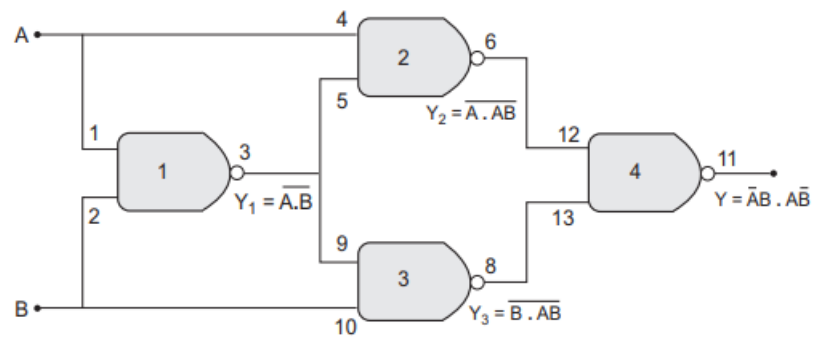
| A | $y = \overline{A}$ |
|---|--------------------|
| 0 | 1                  |
| 1 | 0                  |

Table 5.11.16 Verification Table

| $A_v$ | $y = \overline{A_v}$ |
|-------|----------------------|
|       |                      |
|       |                      |



**NOR gate using NAND gates**



**EX-OR gate using NAND gates**

### NOR gate using NAND gates

Table 5.12.17 Truth Table

| A | B | $y = \overline{A + B}$ |
|---|---|------------------------|
| 0 | 0 | 1                      |
| 0 | 1 | 0                      |
| 1 | 0 | 0                      |
| 1 | 1 | 0                      |

Table 5.11.18 Verification Table

| $A_v$ | $B_v$ | $y = \overline{A_v + B_v}$ |
|-------|-------|----------------------------|
|       |       |                            |
|       |       |                            |
|       |       |                            |
|       |       |                            |

### EX-OR gate using NAND gates

Table 5.12.19 Truth Table

| A | B | $y = A \oplus B$ |
|---|---|------------------|
| 0 | 0 | 0                |
| 0 | 1 | 1                |
| 1 | 0 | 1                |
| 1 | 1 | 0                |

Table 5.11.20 Verification Table

| $A_v$ | $B_v$ | $y = A_v \oplus B_v$ |
|-------|-------|----------------------|
|       |       |                      |
|       |       |                      |
|       |       |                      |
|       |       |                      |

### Result:

Thus the NAND gate is justified as universal building blocks and their truth tables are verified using corresponding IC.

## UNIVERSAL NOR GATE

### Aim:

To verify the truth table for NORgate and to verify as universal building block.

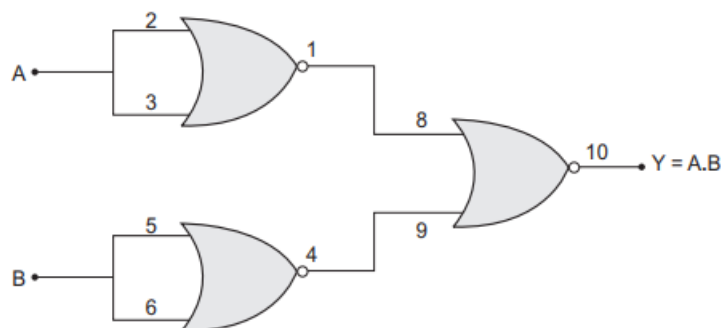
### Apparatus required:

NAND gate – IC 7402, IC trainer kit, voltmeter and connecting wires.

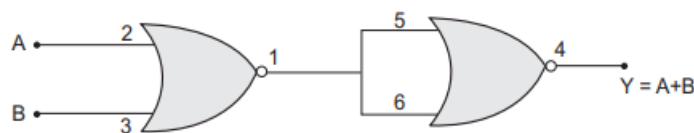
### Procedure:

1. Make the connections as given in the circuit separately for each gate.
2. For various input combinations, measure the output value by connecting the voltmeter between the output pin and ground terminal.
3. Compare it with the truth table to check the voltage levels match with the high and low level in the truth table.

### Circuit Diagram:



AND gate using NOR gates



OR gate using NOR gates

### AND gate using NAND gates

Table 5.12.11 Truth Table

| A | B | $y = A \cdot B$ |
|---|---|-----------------|
| 0 | 0 | 0               |
| 0 | 1 | 0               |
| 1 | 0 | 0               |
| 1 | 1 | 1               |

Table 5.11.12 Verification Table

| $A_v$ | $B_v$ | $y = A_v \cdot B_v$ |
|-------|-------|---------------------|
|       |       |                     |
|       |       |                     |
|       |       |                     |
|       |       |                     |

### OR gate using NAND gates

Table 5.12.13 Truth Table

| A | B | $y = A + B$ |
|---|---|-------------|
| 0 | 0 | 0           |
| 0 | 1 | 1           |
| 1 | 0 | 1           |
| 1 | 1 | 1           |

Table 5.11.14 Verification Table

| $A_v$ | $B_v$ | $y = A_v + B_v$ |
|-------|-------|-----------------|
|       |       |                 |
|       |       |                 |
|       |       |                 |
|       |       |                 |

### NOT gate using NAND gate

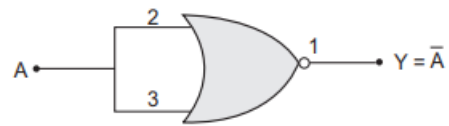
Table 5.12.15 Truth Table

| A | $y = \overline{A}$ |
|---|--------------------|
| 0 | 1                  |
| 1 | 0                  |

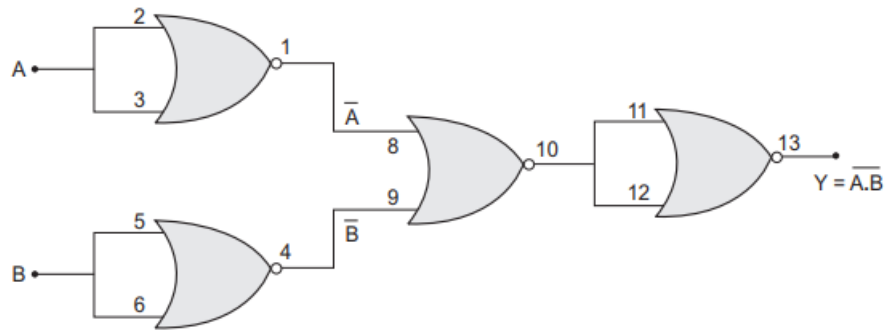
Table 5.11.16 Verification Table

| $A_v$ | $y = \overline{A_v}$ |
|-------|----------------------|
|       |                      |
|       |                      |

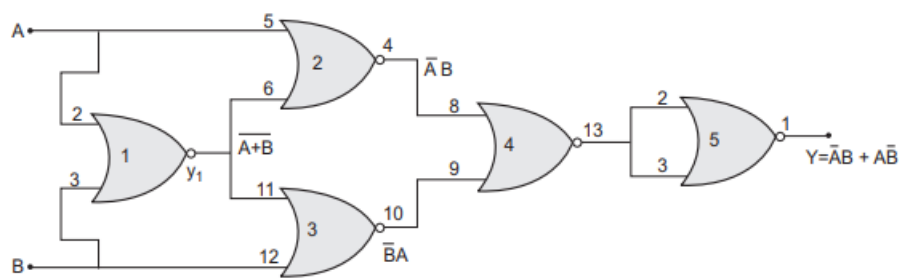
|



**NOT gate using NOR gates**



**NAND gate using NOR gates**



**EX-OR gate using NOR gates**

### NOT gate using NOR gates

Table 5.12.5 Truth Table

| A | $y = \bar{A}$ |
|---|---------------|
| 0 | 1             |
| 1 | 0             |

Table 5.12.6 Verification Table

| $A_v$ | $y = \bar{A_v}$ |
|-------|-----------------|
|       |                 |
|       |                 |

### NAND gate using NOR gates

Table 5.12.7 Truth Table

| A | B | $y = A \cdot B$ | $y = \overline{A \cdot B}$ |
|---|---|-----------------|----------------------------|
| 0 | 0 | 0               | 1                          |
| 0 | 1 | 0               | 1                          |
| 1 | 0 | 0               | 1                          |
| 1 | 1 | 1               | 0                          |

Table 5.11.8 Verification Table

| $A_v$ | $B_v$ | $y = \overline{A_v \cdot B_v}$ |
|-------|-------|--------------------------------|
|       |       |                                |
|       |       |                                |
|       |       |                                |
|       |       |                                |

### EX-OR gate using NOR gates

Table 5.12.9 Truth Table

| A | B | $y = A \oplus B$ |
|---|---|------------------|
| 0 | 0 | 0                |
| 0 | 1 | 1                |
| 1 | 0 | 1                |
| 1 | 1 | 0                |

Table 5.11.10 Verification Table

| $A_v$ | $B_v$ | $y = A_v \oplus B_v$ |
|-------|-------|----------------------|
|       |       |                      |
|       |       |                      |
|       |       |                      |
|       |       |                      |

### Result:

Thus the NORgate is justified as universal building blocks and their truth tables are verified using corresponding IC.

## HALF ADDER AND FULL ADDER

### Aim:

To construct the half adder and full adder circuit using IC 7408, IC 7486 and IC 7432 and to measure their respective output.

### Apparatus Required:

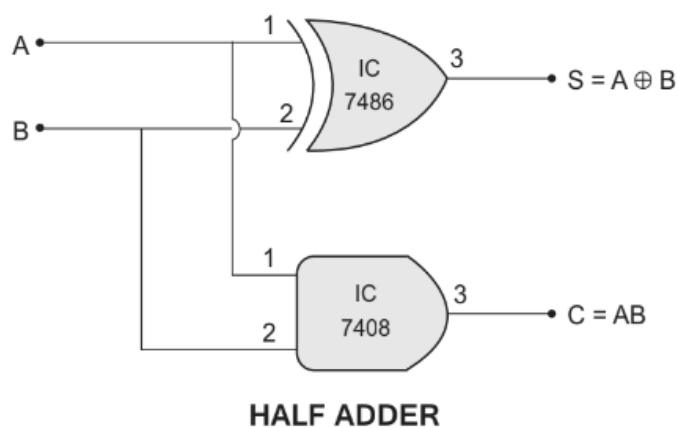
IC 7408, IC 7486, IC 7432, IC 7404, IC 7400, IC 7402, IC trainer kit, voltmeter and connecting wires.

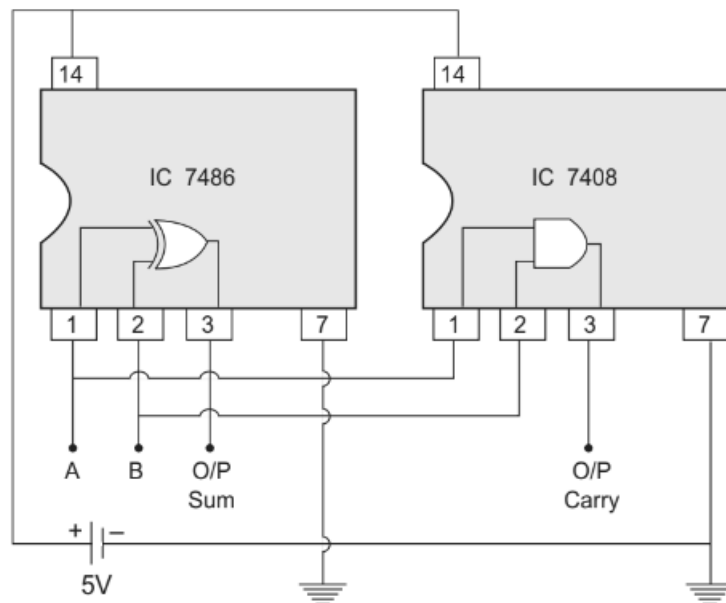
### Procedure:

1. The IC chips are fixed in the bread board of the IC kit and the connections are made using wires as per the circuit diagram.
2. In all the IC's the pin 14 is connected to the positive of the battery supply.  
Pin 7 is connected to the negative of the battery supply.
3. For various values of the input, the output is measured and tabulated.
4. It is verified with the respective truth table and compared with the ideal value.

### Formula:

Boolean expression for sum and carry of half adder





**CIRCUIT FOR HALF ADDER**

## HALF ADDER

**Table 5.5.1 Truth Table**

| Input |   | Output |       |
|-------|---|--------|-------|
| A     | B | Sum    | Carry |
| 0     | 0 | 0      | 0     |
| 0     | 1 | 1      | 0     |
| 1     | 0 | 1      | 0     |
| 1     | 1 | 0      | 1     |

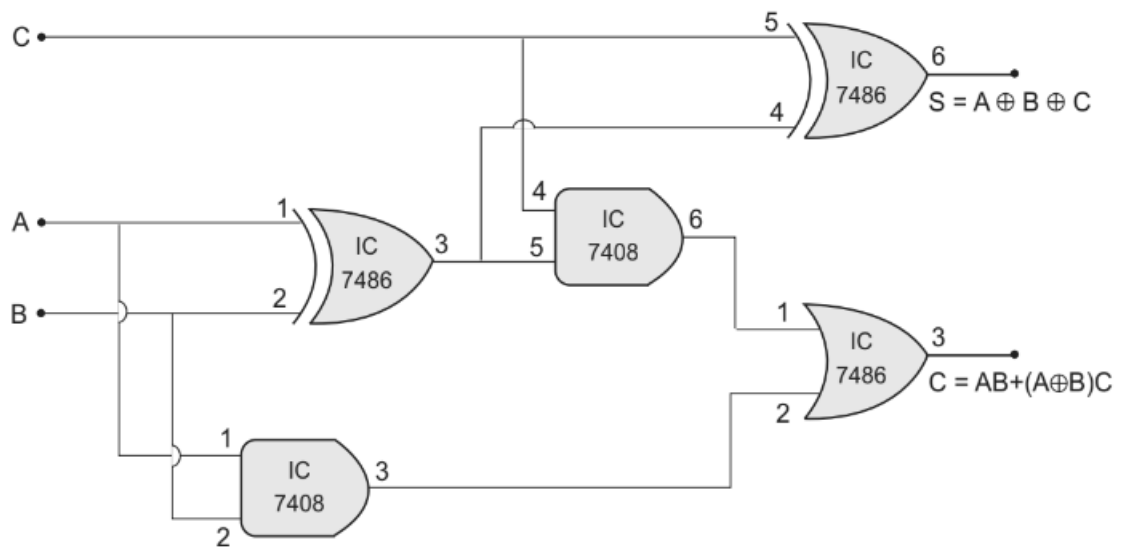
**Table 5.5.2 Verification Table**

| Input |   | Output |       |
|-------|---|--------|-------|
| A     | B | Sum    | Carry |
|       |   |        |       |
|       |   |        |       |
|       |   |        |       |
|       |   |        |       |

Boolean expression for sum and carry of full adder

$$\text{Sum} = A \oplus B \oplus C$$

$$\text{Carry} = A.B + (A \oplus B)C$$



**FULL ADDER**

**FULL ADDER**

Table 5.5.3 Truth Table

| Input |   |   | Output |       |
|-------|---|---|--------|-------|
| A     | B | C | Sum    | Carry |
| 0     | 0 | 0 | 0      | 0     |
| 0     | 0 | 1 | 1      | 0     |
| 0     | 1 | 0 | 1      | 0     |
| 0     | 1 | 1 | 0      | 1     |
| 1     | 0 | 0 | 1      | 0     |
| 1     | 0 | 1 | 0      | 1     |
| 1     | 1 | 0 | 0      | 1     |
| 1     | 1 | 1 | 1      | 1     |

Table 5.5.4 Verification Table

| Input |   |   | Output |       |
|-------|---|---|--------|-------|
| A     | B | C | Sum    | Carry |
|       |   |   |        |       |
|       |   |   |        |       |
|       |   |   |        |       |
|       |   |   |        |       |
|       |   |   |        |       |
|       |   |   |        |       |
|       |   |   |        |       |
|       |   |   |        |       |

## Result:

The half adder and full adder circuits are constructed and their outputs are measured.

## HALF SUBTRACTOR AND FULL SUBTRACTOR

### Aim:

To construct and study the following arithmetic circuits of half subtractor and full subtractor.

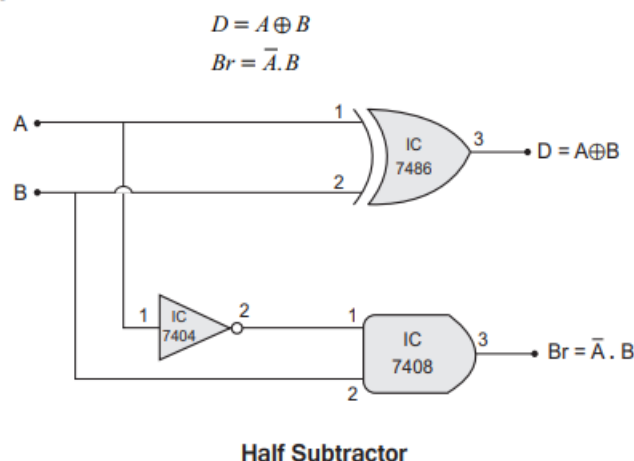
### Apparatus Required:

IC 7408, IC 7486, IC 7432, IC 7404, IC 7400, IC 7402, IC trainer kit, voltmeter and connecting wires

### Procedure:

1. The IC chips are fixed in the bread board of the IC kit and the connections are made using wires.
2. In all the IC's the pin 14 is connected to the positive of the battery supply. Pin 7 is connected to the negative of the battery supply.
3. For various values of the input, the output is measured and tabulated.
4. It is verified with the respective truth table and compared with the ideal value.

### Circuit Diagram:



### Half Subtractor

Table 5.13.1 Truth Table

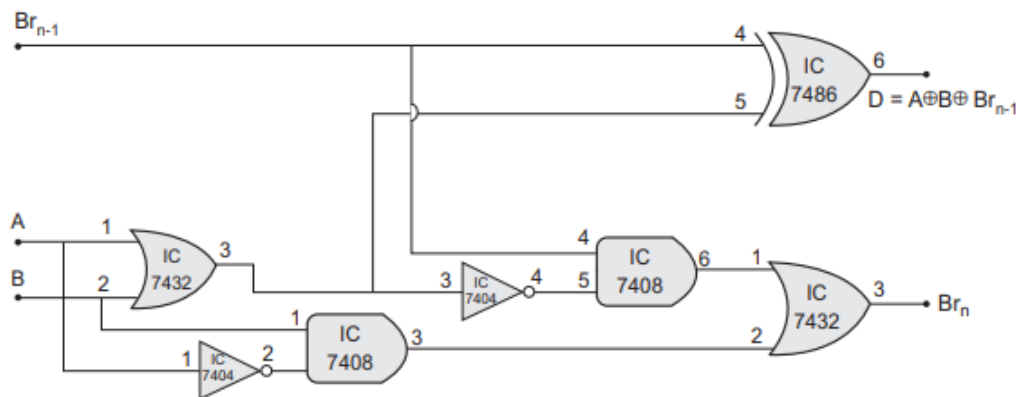
| Input |   | Output |    |
|-------|---|--------|----|
| A     | B | D      | Br |
| 0     | 0 | 0      | 0  |
| 0     | 1 | 1      | 1  |
| 1     | 0 | 1      | 0  |
| 1     | 1 | 0      | 0  |

Table 5.11.2 Verification Table

| Input |   | Output |    |
|-------|---|--------|----|
| A     | B | D      | Br |
|       |   |        |    |
|       |   |        |    |
|       |   |        |    |
|       |   |        |    |

$$D_n = A_n \oplus B_n \oplus Br_{n-1}$$

$$(i.e) Br_n = \bar{A}_n \cdot B_n + B_{n-1}(\bar{A}_n \oplus B_n)$$



### Full Subtractor

### Full Subtractor

Table 5.13.3 Truth Table

| Input |       |            | Output |        |
|-------|-------|------------|--------|--------|
| $A_n$ | $B_n$ | $Br_{n-1}$ | $D_n$  | $Br_n$ |
| 0     | 0     | 0          | 0      | 0      |
| 0     | 0     | 1          | 1      | 1      |
| 0     | 1     | 0          | 1      | 1      |
| 0     | 1     | 1          | 1      | 0      |
| 1     | 0     | 0          | 0      | 1      |
| 1     | 0     | 1          | 0      | 0      |
| 1     | 1     | 0          | 0      | 0      |
| 1     | 1     | 1          | 1      | 1      |

Table 5.13.4 Verification Table

| Input        |              |                   | Output       |               |
|--------------|--------------|-------------------|--------------|---------------|
| $A_n$<br>(V) | $B_n$<br>(V) | $Br_{n-1}$<br>(V) | $D_n$<br>(V) | $Br_n$<br>(V) |
|              |              |                   |              |               |
|              |              |                   |              |               |
|              |              |                   |              |               |
|              |              |                   |              |               |
|              |              |                   |              |               |
|              |              |                   |              |               |
|              |              |                   |              |               |
|              |              |                   |              |               |

### Result:

Thus arithmetic circuits of half subtractor and full subtractor are constructed and studied.

## FULL WAVE RECTIFIER

### Aim:

To construct a full wave rectifier circuit with  $\pi$ -filter and to measure its output voltage and to calculate its percentage of regulation

### Apparatus:

Digital Multimeter, Transformer (6V-0-6V) - 1No. Diode, 1N4007, Capacitor 100 $\mu$ f/470  $\mu$ ., Decade Resistance Box and Breadboard.

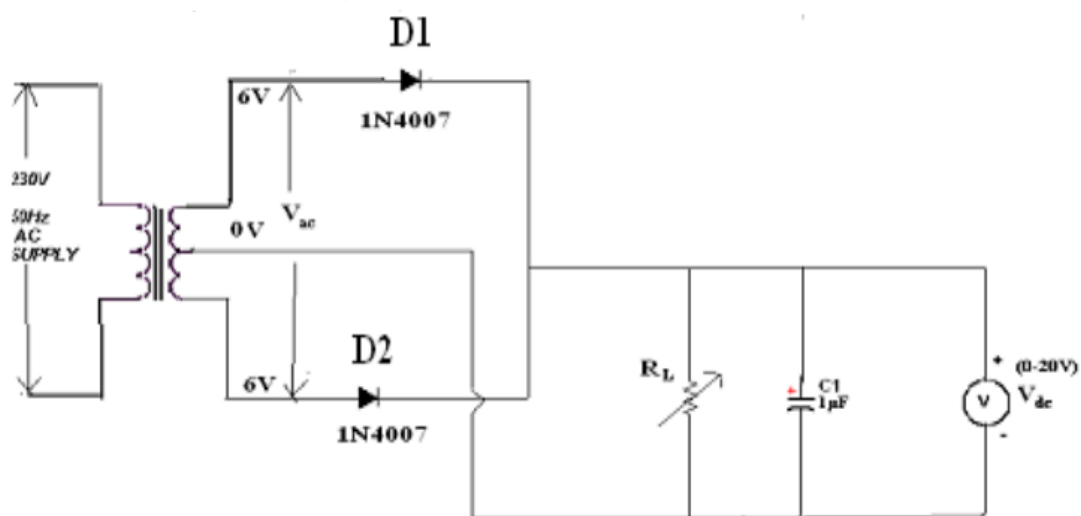
### Formula:

$$\text{Percentage of regulation} = \frac{V_{\text{no load}} - V_{\text{load}}}{V_{\text{load}}} (\text{no unit})$$

### Procedure

1. Connections are made as per the circuit diagram.
2. Connect the ac mains to the primary side of the transformer and the secondary side to the rectifier.
3. Measure the ac voltage at the input side of the rectifier.
4. Measure both ac and dc voltages at the output side the rectifier.

### Circuit Diagram:

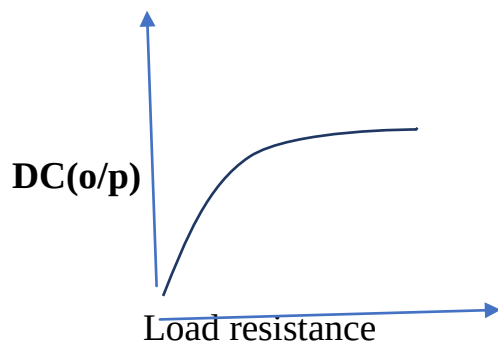


**Tabulation:**

DC Voltage with load=

DC Voltage without load=

| Sl.No | Load Resistance | DC output without load |
|-------|-----------------|------------------------|
|       |                 |                        |
|       |                 |                        |
|       |                 |                        |

**Model graph:****Result:**

The Full wave rectifier has been constructed by  $\pi$ -filter. Its output has been measured for various resistance and its percentage of regulation is-----(No unit).

## COMPARISON OF EMF'S – POTENTIOMETER

### Aim:

To compare the emf's of the two given primary cells

### Apparatus:

Potentiometer, Daniel cell, Leclanche cell, Jockey, Battery eliminator, Resistance box, Galvanometer, One way key, Two way key, Rheostat, Ammeter and Connecting wires.

### Formula:

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

Where

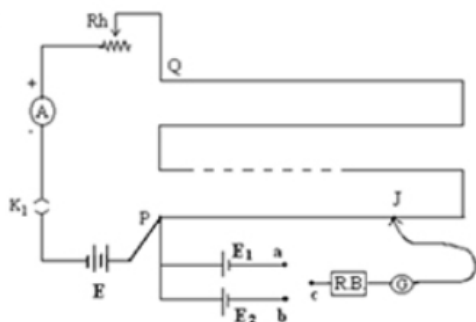
$E_1$  – emf of the first cell

$E_2$  – emf of the second cell

$l_1$  – Balancing length when  $E_1$  is introduced in the circuit

$l_2$  – Balancing length when  $E_2$  is introduced in the circuit

### Circuit Diagram:



### Procedure:

1. Arrange the required materials on a table and make the connections as per the connection diagram.
2. Note the reading on the ammeter.

3. Now, gently slide the jockey along the potentiometer wire and stop when null point is obtained.
4. Measure the length  $l_1$  between this point and the end P of the potentiometer. It is the balancing length for the cell  $E_1$ .
5. Disconnect the cell  $E_1$  by removing the plug from the gap ac of the two way key and connect the cell  $E_2$  by inserting plug into the gap bc of the two way key.
6. Again slide the jockey along the potentiometer wire to obtain the null point. Measure the new balancing length  $l_2$  for the cell  $E_2$  based on this point.
7. Make sure that the reading on the ammeter is constant throughout the observation.
8. The experiment by increasing the current by adjusting the rheostat and record the observations.

#### Tabulation:

| Sl.No | Ammeter reading | Balancing Length      |                       | $\frac{E_1}{E_2} = \frac{l_1}{l_2}$ |
|-------|-----------------|-----------------------|-----------------------|-------------------------------------|
|       |                 | $l_1$ , ( For $E_1$ ) | $l_2$ , ( For $E_2$ ) |                                     |
|       |                 |                       |                       |                                     |
|       |                 |                       |                       |                                     |

#### Calculations

Calculate the ratio of  $E_1$  and  $E_2$  for each set of  $l_1$  and  $l_2$ . The mean of the calculated values gives the ratio of emf's of the two given primary cells.

#### Result

The emf's of the two given primary cells are compared.

The ratio of emf's of the two given primary cells,  $E_1/E_2 = \dots\dots\dots$

## HARTLEY OSCILLATOR

### Aim:

To construct a Hartley oscillator to the given transistor an to measure the output frequencies for various values of capacitance and also calculate the inductance of the given coil.

### Apparatus:

PNP transistor, 33k, 25k, 1k, standrad resistance, inductance coli, variable capacitor, frequency meter.

### Formula:

$$L = 1 / 4\pi f^2 c \text{ (H)}$$

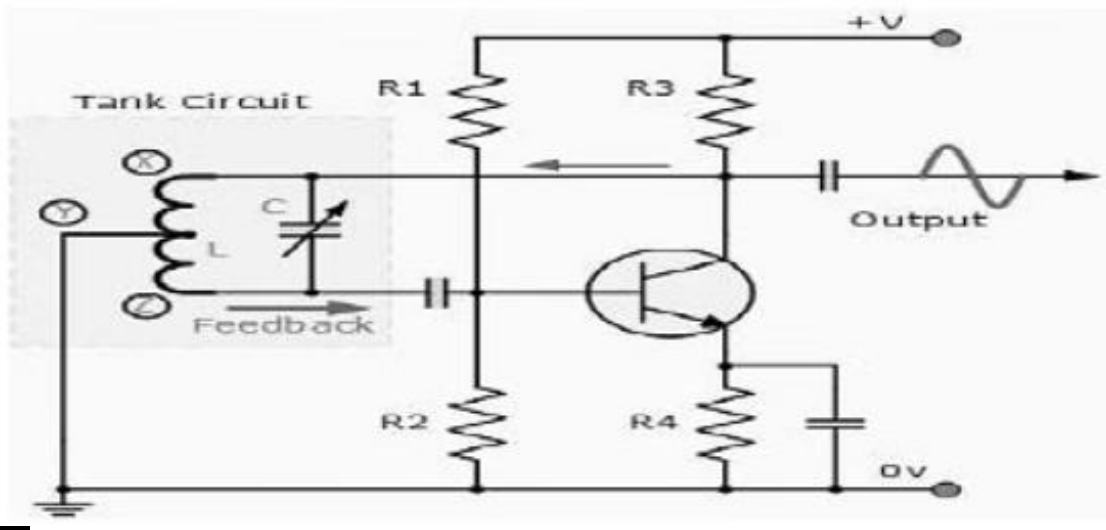
Where

f- Frequency of the given oscillator for various values of C(HZ)

C- Capacitance of the given capacitor( $\mu\text{f}$ )

L= Self inductance of the given coil(H)

### Circuit Diagram:



### Procedure:

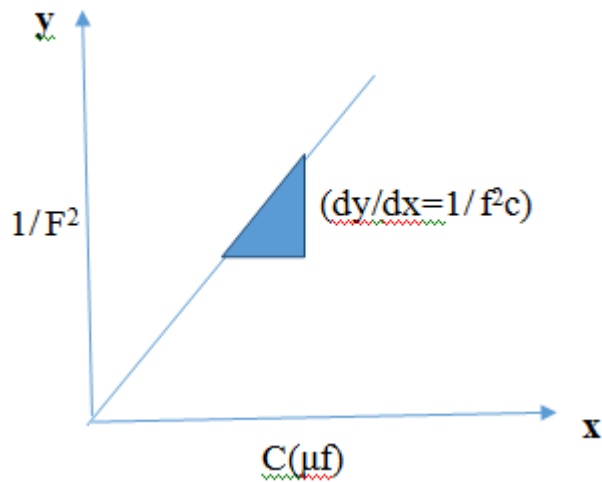
- 1.The connections are made as shown in figure.

3. Readings are noted in the table and the graph is drawn

**Tabulation:**

| Sl/No | C( $\mu$ f) | F(HZ) | F <sup>2</sup> | F <sup>2</sup> C | 1/ F <sup>2</sup> | 1/ F <sup>2</sup> C |
|-------|-------------|-------|----------------|------------------|-------------------|---------------------|
|       |             |       |                |                  |                   |                     |
|       |             |       |                |                  |                   |                     |
|       |             |       |                |                  |                   |                     |

**Model graph:**



**Calculation:**

$$L = 1/4\pi f^2 c \text{ (1/ } f^2 c \text{ from tabulation)}$$

$$L = 1/4\pi f^2 c \text{ (1/ } f^2 c \text{ from graph)}$$

**Result:**

A Hartley oscillator of a given transistor has been constructed and the inductance value of the given coil are calculated.

## SINGLE STAGE AMPLIFIER

### Aim:

To compare a single stage amplifier to measure the given amplifier for various frequencies of the output signal and drawn the frequency response curve to the given amplifier.

### Apparatus:

100  $\mu\text{f}$  capacitor, PNP Transistor, 47k $\Omega$ , 2.2k $\Omega$ , 22k $\Omega$ , 1k and Multimeter

### Formula:

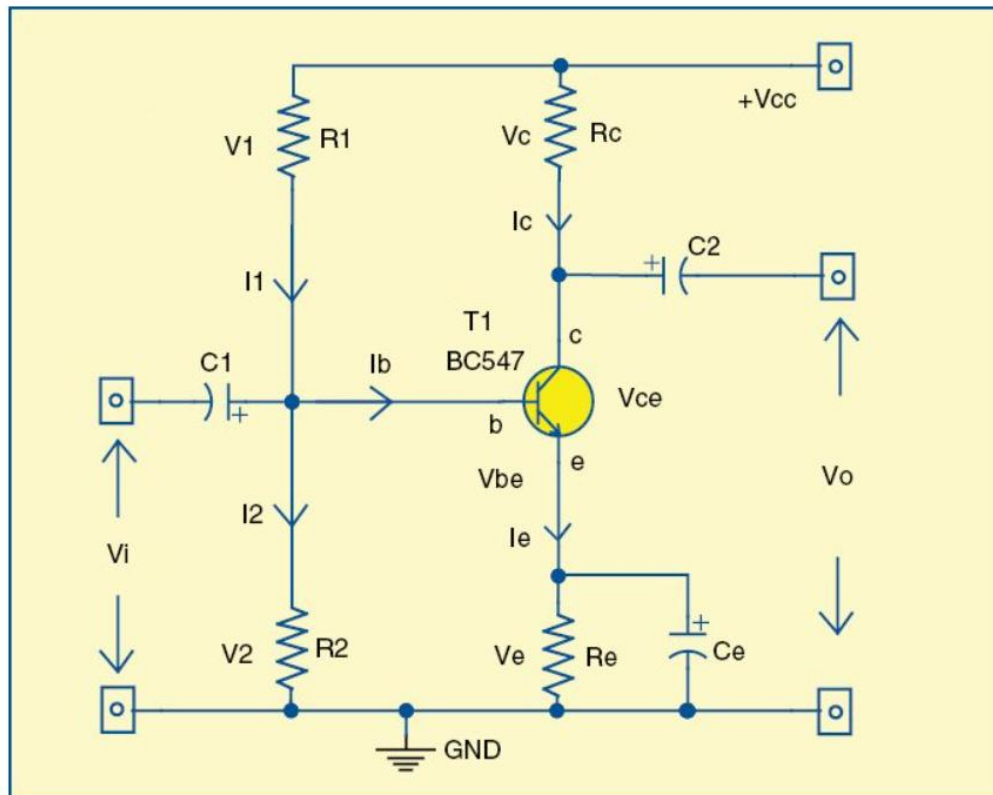
$$\text{Gain} = V_o / V_{in} \text{ (No unit)}$$

Where

$V_o$  – Output voltage(V)

$V_{in}$  – Input voltage(V)

### Circuit Diagram:



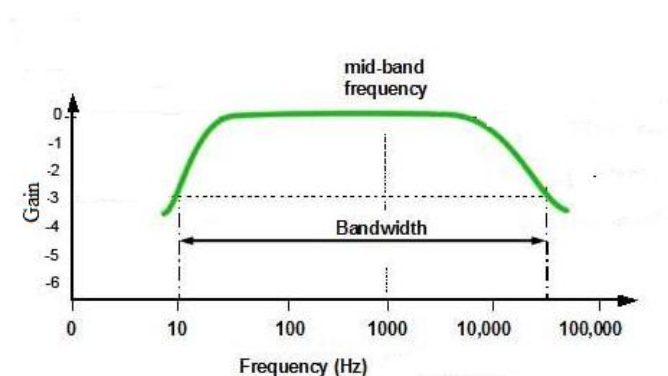
### Procedure:

- 1.The connections are made as shown in figure.
2. The frequency of the input signal is adjusted for 100 Hz and the output is measured.
- 3.The signal frequency is increased to 200HZ, 400HZ, 600HZ, 800HZ,1000HZ and the output is measured.
- 4.The gain of the amplifier at each frequency is calculated using the formula.

### Tabulation:

| Sl.NO | Frequency(HZ) | Output voltage( $V_o$ ) | Input voltage( $V_i$ ) | Gain= $V_o / V_i$<br>(No unit) |
|-------|---------------|-------------------------|------------------------|--------------------------------|
|       |               |                         |                        |                                |
|       |               |                         |                        |                                |

### Model graph:



### Result:

A single stage transistor amplifier is constructed and the voltage gain is measured at different frequencies and the frequency response curve is drawn.

## ACTIVE FILTERS

### Aim:

To construct the various active filters circuits low passfilter, High passfilter and Band pass filter and hence to study its frequency response.

### Apparatus Required:

IC 741, 1K $\Omega$ , 1.5K $\Omega$ , 10K $\Omega$ , 5K $\Omega$ , 0.1 $\mu$ F, Dual power supply, frequency generator etc..

### Formula:

$$F = \frac{1}{2\pi RC}(\text{Hz})$$

$$\text{DC Gain} = 1 + \frac{R_2}{R_1}$$

$$\text{Voltage gain} = \frac{V_{out}}{V_{in}}$$

Where

$R_1$  -- Input Resistance in  $\Omega$

$R_2$  -- Feedback Resistance in  $\Omega$

C -- Capacitance of given capacitor in  $\mu$ F

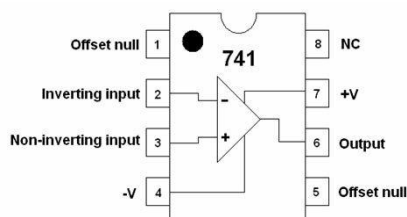
F – Input Frequency of the circuit given in Hz

$V_{out}$  – Output Voltage in volt

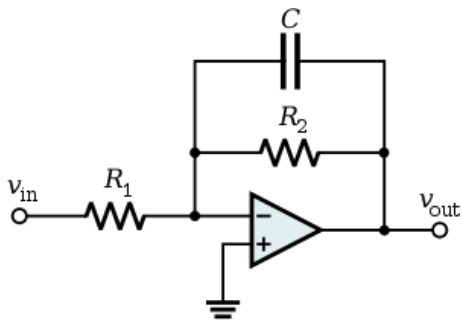
$V_{in}$  – Input voltage in volt

### Circuit Diagram:

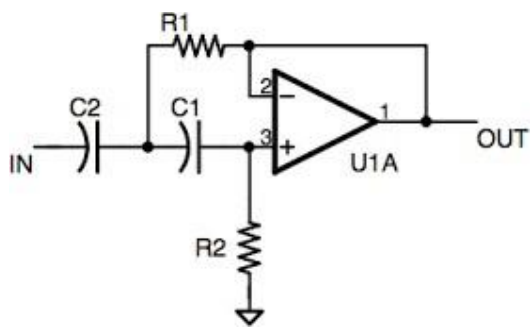
### Pin Configuration of IC 741



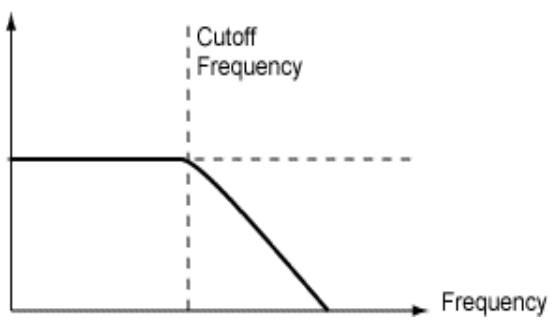
## Low Pass Filter



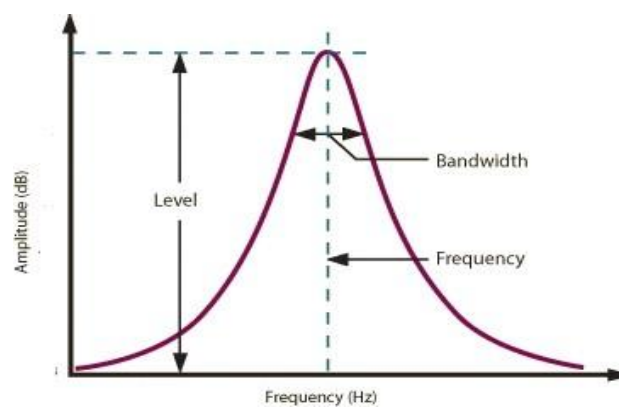
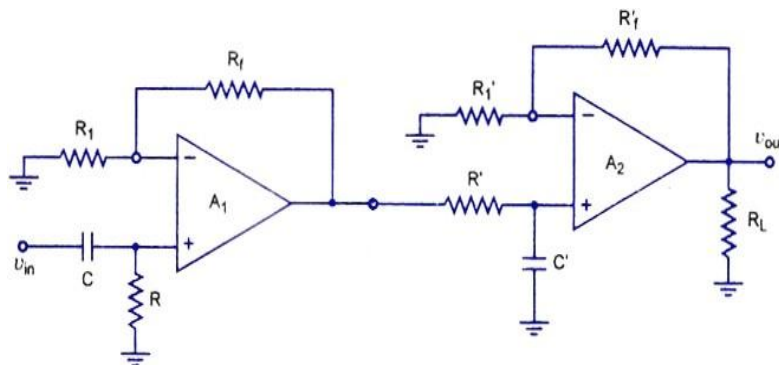
## High Pass Filter



Filter  
Gain



## Band PassFilter



## Tabulation:

### Low Pass Filter

| Sl.No | Input Frequency ( Hz) | Input Voltage<br>(V) | Output Voltage<br>(V) | Gain |
|-------|-----------------------|----------------------|-----------------------|------|
|       |                       |                      |                       |      |
|       |                       |                      |                       |      |
|       |                       |                      |                       |      |

### High Pass Filter

| Sl.No | Input Frequency ( Hz) | Input Voltage<br>(V) | Output Voltage<br>(V) | Gain |
|-------|-----------------------|----------------------|-----------------------|------|
|       |                       |                      |                       |      |
|       |                       |                      |                       |      |
|       |                       |                      |                       |      |

### Band Pass Filter

| Sl.No | Input Frequency ( Hz) | Input Voltage<br>(V) | Output Voltage<br>(V) | Gain |
|-------|-----------------------|----------------------|-----------------------|------|
|       |                       |                      |                       |      |
|       |                       |                      |                       |      |
|       |                       |                      |                       |      |

#### Procedure:

1. Connect the circuit as shown in diagram.
2. Connect the DSO to the probes and switch it on.
3. Check the graph for both positive and negative voltage and write down the output.

#### Result:

The various active filters circuits low pass filter, High pass filter and Band pass filter are constructed and hence its frequency response were studied.

## ASTABLE MULTIVIBRATOR USING IC -555

### Aim:

To construct an Astable multivibrator using IC 555 timer and measure its frequency of oscillation

### Apparatus Required:

IC- 555, 10 K $\Omega$ , variable capacitor, 0.01 $\mu$ F, 5V power supply, bread board, CRO,Frequency meter, connecting wires Etc....

### Formula:

$$F = \frac{1.44}{(R_1 + 2R_2)C}(\text{Hz})$$

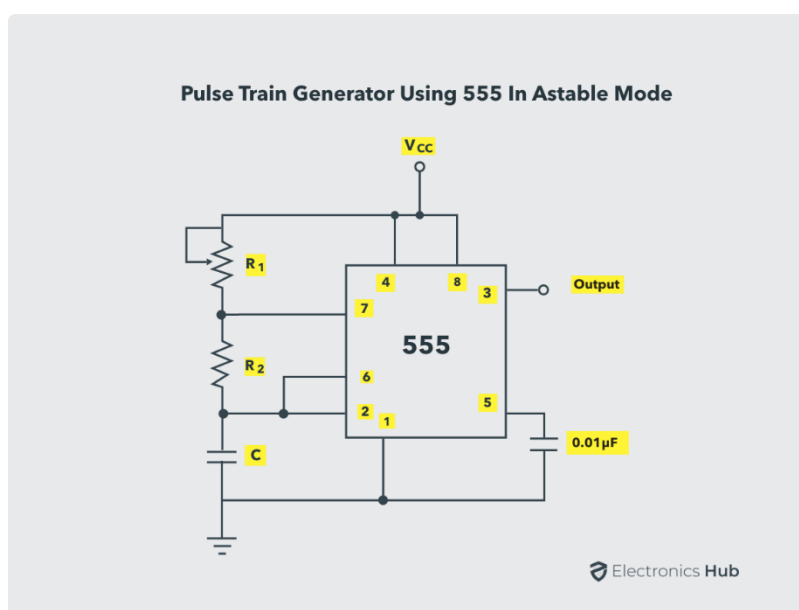
Where,

F -- Frequency of oscillation in Hz

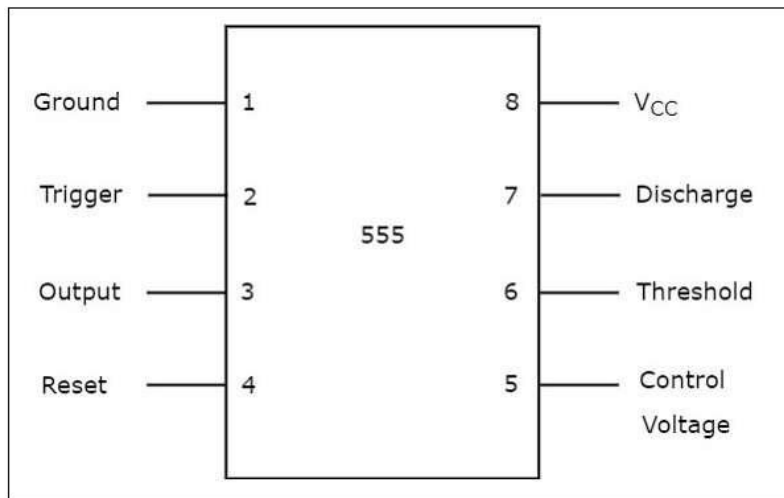
R<sub>1</sub>, R<sub>2</sub>-- Resistance in  $\Omega$

C --Capacitance of variable capacitor in  $\mu$ F

### Circuit Diagram :



### Pin Configuration:



### Tabulation:

$$R_1 = R_2 = 10 \text{ K}\Omega$$

| Sl.No. | Capacitance in ( $\mu\text{F}$ ) | $F = \frac{1.44}{(R_1 + 2R_2)C}(\text{Hz})$ |                    |
|--------|----------------------------------|---------------------------------------------|--------------------|
|        |                                  | Theoretical Value                           | Experimental Value |
|        |                                  |                                             |                    |
|        |                                  |                                             |                    |
|        |                                  |                                             |                    |

### Procedure:

1. Circuit is made as per the diagram above.
2. Power supply of 5V is switched on for a particular value of variable capacitance.
3. The output square wave is noted in the CRO connected between pin 3 and 1.
4. Time period of the square wave is noted for various capacitance values of the variable capacitor.

5. The frequency meter is also connected between the pin 3 and 1.
6. The experimental frequency is noted.
7. Frequency is calculated using the given formula.
8. The experimental value of  $F$  is compared with theoretical value.

**Result:**

Astable multivibrator is constructed using IC 555 timer and its frequency of oscillation is measured

## ASTABLE MULTIVIBRATOR USING IC -741

### Aim:

To construct an Astable Multivibrator using operational amplifier (IC 741) and measure its frequency of oscillation

### Apparatus Required:

IC- 741, 10 K $\Omega$ , variable capacitor, 0.01 $\mu$ F, Dual power supply, bread board, CRO, Frequency meter, connecting wires Etc....

### Formula:

$$T = 2.2 RC \text{ (seconds)}$$

$$F = \frac{1}{T} = \frac{1}{2.2 RC} \text{ (Hz)}$$

Where

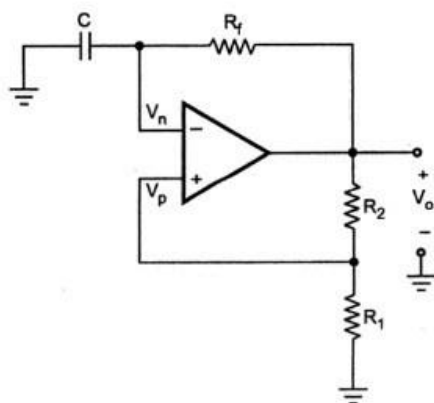
T --Period of oscillation in seconds

F -- Frequency of oscillation in Hz

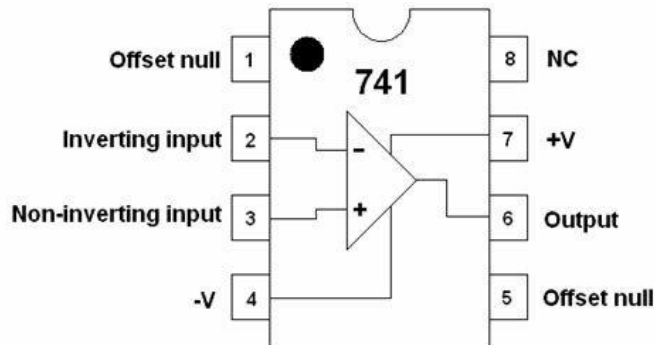
R -- Resistance in  $\Omega$

C -- Capacitance of variable capacitor in  $\mu$ F

### Circuit Diagram:



### Pin Configuration:



### Tabulation:

$$R=10\text{ K}\Omega$$

| Sl.No. | Capacitance in ( $\mu\text{F}$ ) | $F = \frac{1}{2.2 RC} \quad (\text{Hz})$ |                    |
|--------|----------------------------------|------------------------------------------|--------------------|
|        |                                  | Theoretical Value                        | Experimental Value |
|        |                                  |                                          |                    |
|        |                                  |                                          |                    |
|        |                                  |                                          |                    |
|        |                                  |                                          |                    |

### Procedure:

1. Circuit is made as per the diagram above.
2. Dual Power supply of is switched on for a particular value of variable capacitance.
3. The output square wave is noted in the CRO connected between pin 6 and ground.

4. Time period of the square wave is noted for various capacitance values of the variable capacitor.
5. The frequency meter is also connected between the pin 6 and ground.
6. The experimental frequency is noted.
7. Frequency is calculated using the given formula.
8. The experimental value of  $F$  is compared with theoretical value.

**Result:**

Astable multivibrator is constructed using IC 741 and its frequency of oscillation is measured

## OP AMP- ADDER AND SUBTRACTOR

### Aim:

To construct the adder and subtractor circuit using op-amp and to measure the output.

### Apparatus Required:

IC 741, dual regulated power supply, resistors, battery, IC trainer kit, voltmeter and connecting wires.

### Formula:

#### i) Adder

$$V_0 = -\frac{R_f}{R} (V_1 + V_2) \text{ (volt)}$$

If  $R_f = R$

$$V_0 = - (V_1 + V_2) \text{ (volt)}$$

#### ii) Subtractor

$$V_0 = (V_2 - V_1) \text{ (volt)}$$

Where,

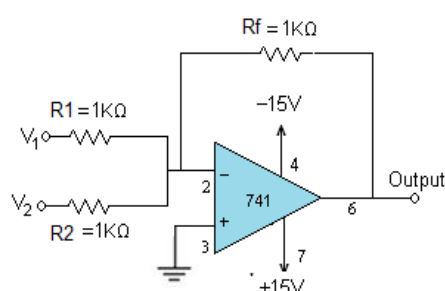
$V_1$  and  $V_2$  -- Input voltages in V

$V_0$  -- Output voltage in V

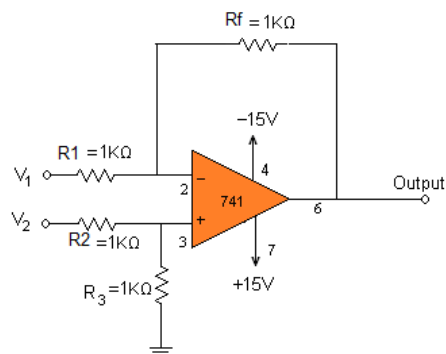
$R_f$  -- Feedback resistance in  $\Omega$

### Circuit Diagram:

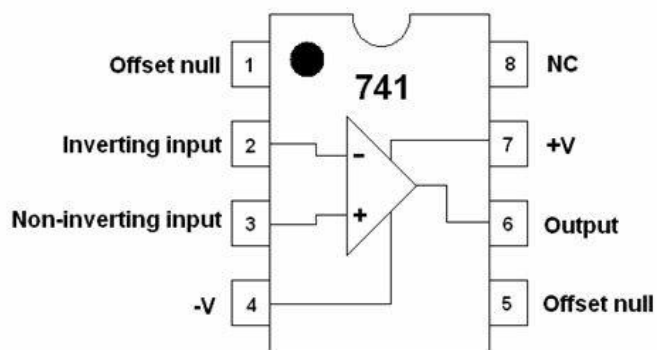
#### IC 741 - Adder



## IC 741 - Subtractor



### Pin Configuration:



### Tabulation: Adder

| Sl.No | $V_1$ in V | $V_2$ in V | $V_0 = - (V_1 + V_2)$ (volt) |                    |
|-------|------------|------------|------------------------------|--------------------|
|       |            |            | Theoretical Value            | Experimental value |
|       |            |            |                              |                    |
|       |            |            |                              |                    |
|       |            |            |                              |                    |

## Subtractor

| Sl.No | $V_1$ in V | $V_2$ in V | $V_0 = (V_2 - V_1)(\text{volt})$ |                    |
|-------|------------|------------|----------------------------------|--------------------|
|       |            |            | Theoretical Value                | Experimental value |
|       |            |            |                                  |                    |
|       |            |            |                                  |                    |
|       |            |            |                                  |                    |
|       |            |            |                                  |                    |
|       |            |            |                                  |                    |

### Procedure:

1. The circuit is made on the bread board as per the circuit diagram.
2. Dual power supply of 12 V-0V- 12V is switched on to start the experiment.
3. For various input voltages ( $V_1$ ) and ( $V_2$ ), the output ( $V_0$ ) is measured and the Table is filled.
4. The theoretical value and experimental value are noted and verified as per the formula for adder and subtractor.

### Result:

The adder and subtractor circuits are constructed using op-amp and the outputs are measured

## SHIFT REGISTERS

### Aim:

To realize and study the different Shift Register configurations and its operations.

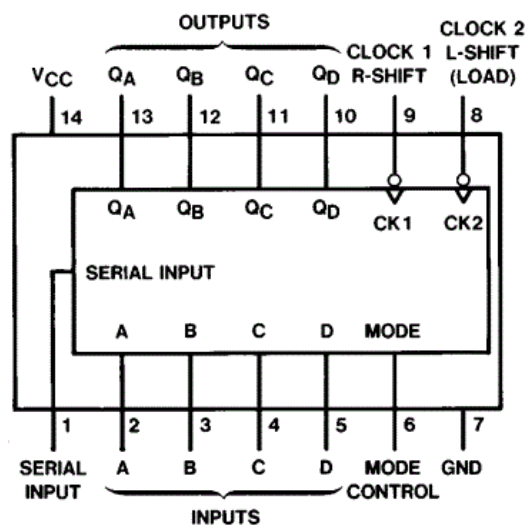
- 1) SISO (Serial in Serial out)
- 2) SIPO (Serial in Parallel out)
- 3) PIPO (Parallel in Parallel out)
- 4) PISO (Parallel in **Serial out**)

### Apparatus Required:

IC 7495, IC 7474, Patch Cords & IC Trainer Kit

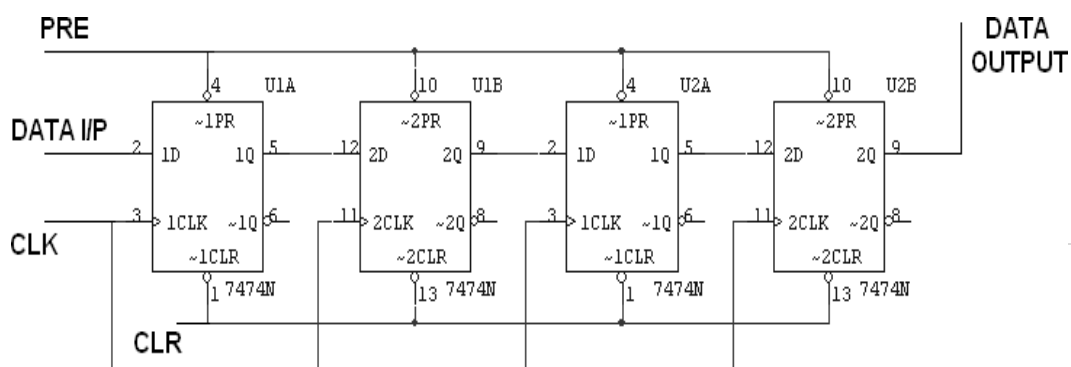
### Circuit Diagram:

#### PinDiagramofIC 7495:



#### Serial In Serial Out

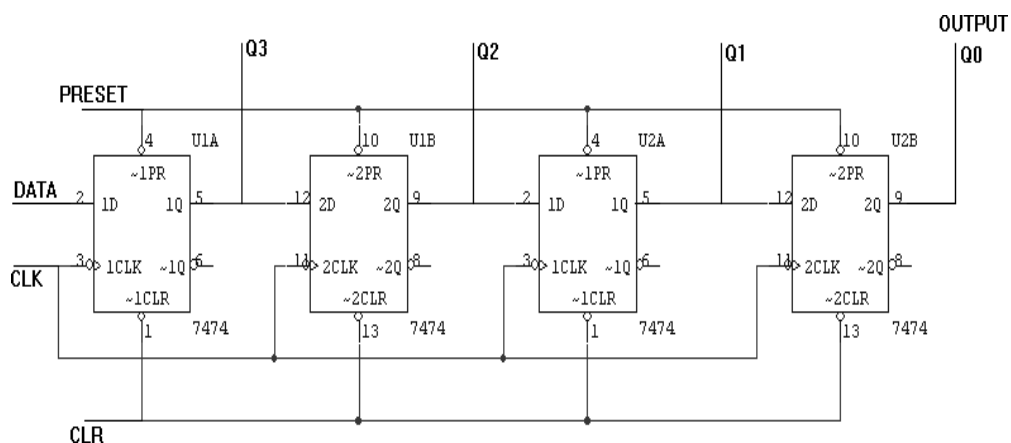
#### Logic Diagram:



### Truth Table:

| CLK | Serial in | Serial out |
|-----|-----------|------------|
| 1   | 1         | 0          |
| 2   | 0         | 0          |
| 3   | 0         | 0          |
| 4   | 1         | 1          |
| 5   | X         | 0          |
| 6   | X         | 0          |
| 7   | X         | 1          |

### Serial In Parallel out:

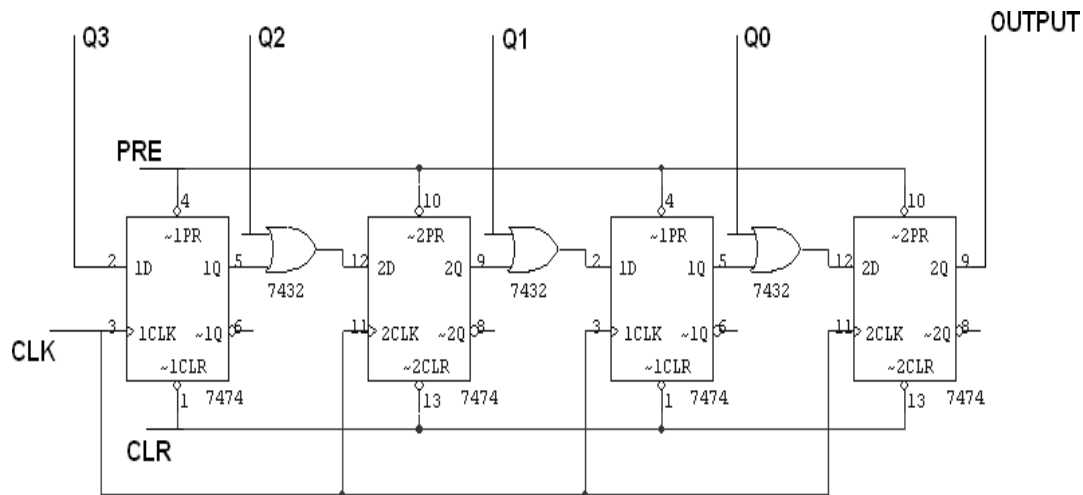


### Truth Table:

| CLK | DATA | OUTPUT         |                |                |                |
|-----|------|----------------|----------------|----------------|----------------|
|     |      | Q <sub>A</sub> | Q <sub>B</sub> | Q <sub>C</sub> | Q <sub>D</sub> |
| 1   | 1    | 1              | 0              | 0              | 0              |
| 2   | 0    | 0              | 1              | 0              | 0              |
| 3   | 0    | 0              | 0              | 1              | 1              |
| 4   | 1    | 1              | 0              | 0              | 1              |

## Parallel In Serial Out:

### Logic Diagram:

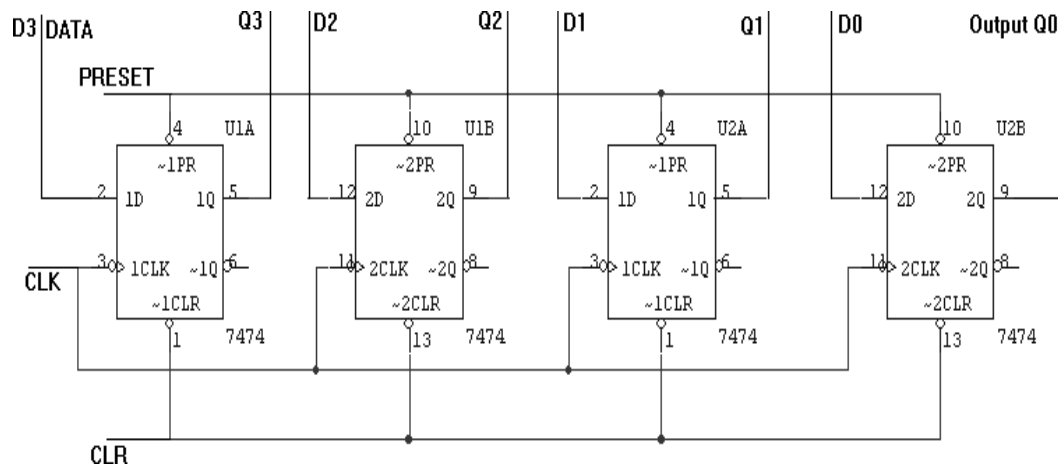


### Truth Table:

| CLK | Q3 | Q2 | Q1 | Q0 | O/P |
|-----|----|----|----|----|-----|
| 0   | 1  | 0  | 0  | 1  | 1   |
| 1   | 0  | 0  | 0  | 0  | 0   |
| 2   | 0  | 0  | 0  | 0  | 0   |
| 3   | 0  | 0  | 0  | 0  | 1   |

## Parallel In Parallel Out:

### Logic Diagram:



**TRUTH TABLE:**

| CLK | DATAINPUT      |                |                |                | OUTPUT         |                |                |                |
|-----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|     | D <sub>A</sub> | D <sub>B</sub> | D <sub>C</sub> | D <sub>D</sub> | Q <sub>A</sub> | Q <sub>B</sub> | Q <sub>C</sub> | Q <sub>D</sub> |
| 1   | 1              | 0              | 0              | 1              | 1              | 0              | 0              | 1              |
| 2   | 1              | 0              | 1              | 0              | 1              | 0              | 1              | 0              |

**Procedure:**

1. Check the components for their working.
  2. Insert the appropriate IC into the ICbase.
  3. Rig up the circuit as shown in the logic circuit diagram.
  4. Apply various input data to the logic circuit via the input logic switches.
  5. Note down the corresponding output and verify the truth table.
- Note: Write the pin numbers of each gate and also write the intermediate expressions.

**Result:**

The different Shift Register configurations and its operations are studied

## BCD ADDER AND SUBTRACTOR

### Aim:

To construct 4 bit binary adder and subtractor using IC 7483 and verify its operations.

### Apparatus Required:

IC 7483, trainer kit, patch cords.

### Circuit diagram:

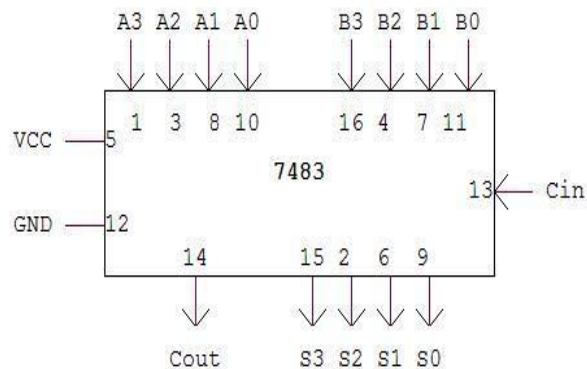
#### 4 Bit Binary Adder:

An Example:  $7+2=11$  (1001)

7 is realized at  $A_3 A_2 A_1 A_0 = 0111$

2 is realized at  $B_3 B_2 B_1 B_0 = 0010$

Sum = 1001



### Truth table:

| Inputs A       |                |                |                | Inputs B       |                |                |                | Sum            |                |                |                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | B <sub>3</sub> | B <sub>2</sub> | B <sub>1</sub> | B <sub>0</sub> | S <sub>3</sub> | S <sub>2</sub> | S <sub>1</sub> | S <sub>0</sub> |
|                |                |                |                |                |                |                |                |                |                |                |                |
|                |                |                |                |                |                |                |                |                |                |                |                |

#### 4 Bit Binary Subtractor:

Subtraction is carried out by adding 2's complement of the subtrahend.  
Example:  $8 - 3 = 5$  (0101)

8 is realized at  $A_3 A_2 A_1 A_0 = 1000$  3 is realized at  $B_3 B_2 B_1 B_0$  through X-OR gates = 0011 Output of X-OR gate is 1's complement of 3 = 1100 2's Complement can be obtained by adding  $C_{in} = 1$

Therefore

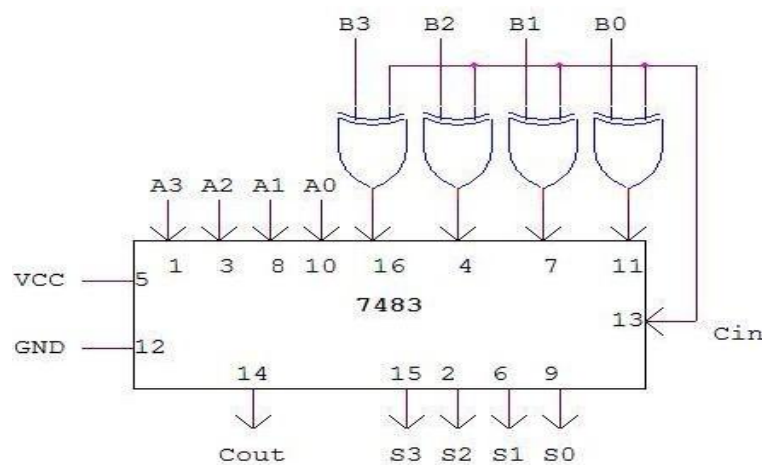
$C_{in} = 1$

$A_3 A_2 A_1 A_0 = 1 0 0 0$

$B_3 B_2 B_1 B_0 = 1 1 0 0$

$S_3 S_2 S_1 S_0 = 0 1 0 1$

$C_{out} = 1$  (Ignored)



**Truth table:**

| Inputs A |       |       |       | Inputs B |       |       |       | Difference |       |       |       |
|----------|-------|-------|-------|----------|-------|-------|-------|------------|-------|-------|-------|
| $A_3$    | $A_2$ | $A_1$ | $A_0$ | $B_3$    | $B_2$ | $B_1$ | $B_0$ | $S_3$      | $S_2$ | $S_1$ | $S_0$ |
|          |       |       |       |          |       |       |       |            |       |       |       |
|          |       |       |       |          |       |       |       |            |       |       |       |

**Procedure:**

1. Check the components for their working.
2. Insert the appropriate IC into the IC base.
3. Rig up the circuit as shown in the logic circuit diagram.
4. Apply various input data to the logic circuit via the input logic switches.

Note down the corresponding output and verify the truth table.

**Result:**

4 bit binary adder and subtractor using IC 7483 is constructed and its operations are verified.

## COUNTERS

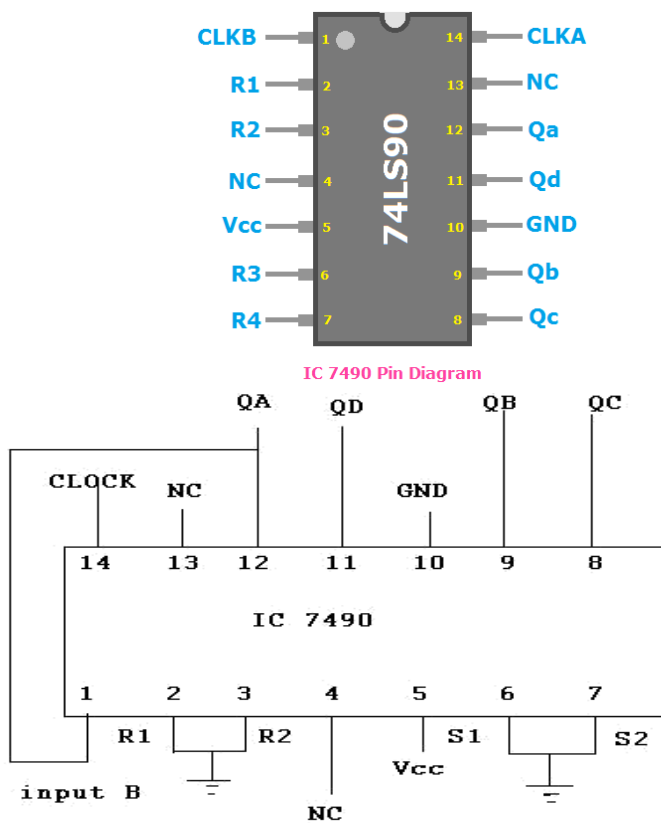
### Aim:

To design IC 7490 as a decade counter with BCD count sequence

### Apparatus Required:

IC 7490, Patch Cords & IC Trainer Kit

### Circuit diagram:



### Tabulation :

| Sl.No. | Q <sub>A</sub> | Q <sub>B</sub> | Q <sub>C</sub> | Q <sub>D</sub> |
|--------|----------------|----------------|----------------|----------------|
| 1      | 0              | 0              | 0              | 0              |
| 2      | 0              | 0              | 0              | 1              |
| 3      | 0              | 0              | 1              | 0              |
| 4      | 0              | 0              | 1              | 1              |

|    |   |   |   |   |
|----|---|---|---|---|
| 5  | 0 | 1 | 0 | 0 |
| 6  | 0 | 1 | 0 | 1 |
| 7  | 0 | 1 | 1 | 0 |
| 8  | 0 | 1 | 1 | 1 |
| 9  | 1 | 0 | 0 | 0 |
| 10 | 1 | 0 | 0 | 1 |
| 11 | 0 | 0 | 0 | 0 |

### **Procedure:**

1. Check the components for their working.
2. Insert the appropriate IC into the IC base.
3. Rig up the circuit as shown in the logic circuit diagram.
4. Apply various input data to the logic circuit via the input logic switches.
5. Note down the corresponding output and verify the truth table.

### **Result:**

IC 7490 as a decade counter with BCD count sequence has been designed and verified

# ENCODER AND DECODER

## Aim:

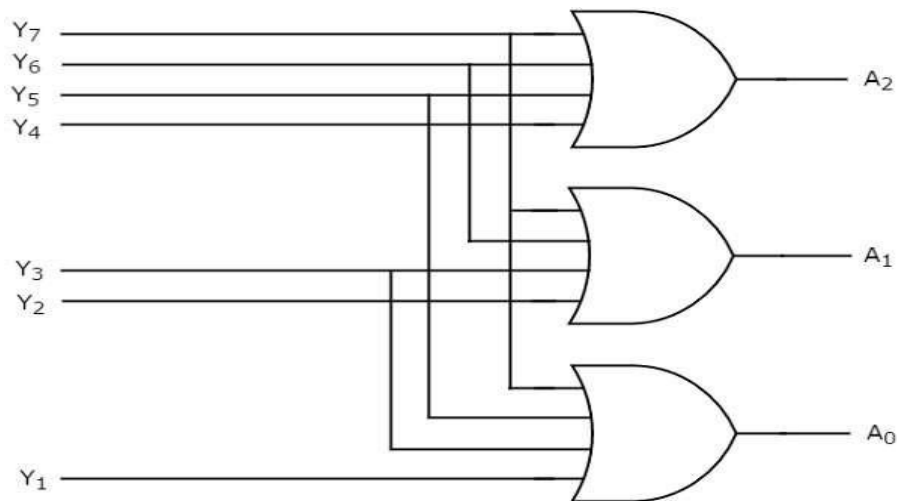
To Implement and verify the Encoder and Decoder using logic gates.

## Apparatus Required:

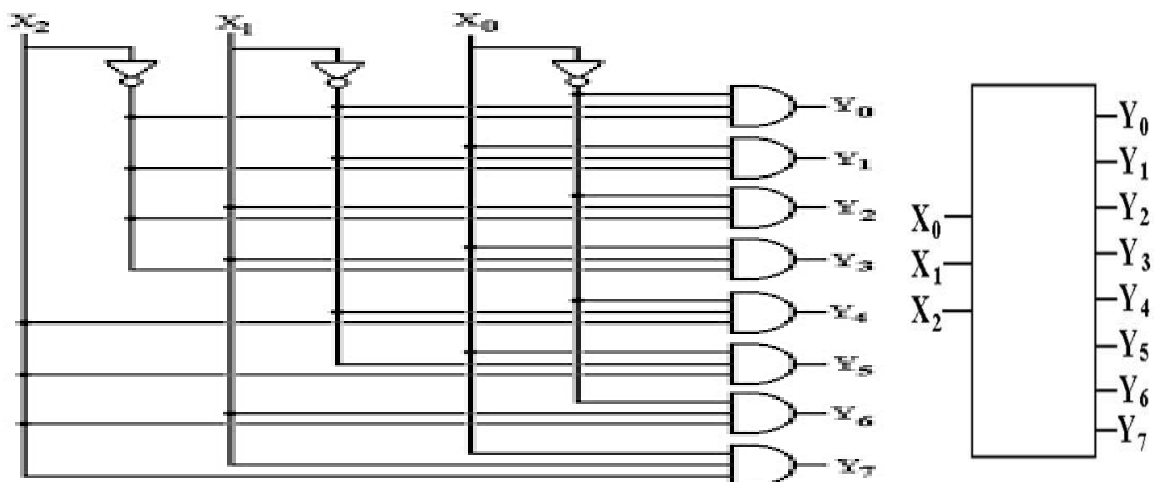
Bread Board, 3-input AND gate, OR gate and NOT gate ICs, Connecting wire etc.

## Circuit Diagram:

### Encoder



### Decoder



### Truth Table: Encoder

| Input          |                |                |                |                |                |                |                | Output         |                |                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Y <sub>1</sub> | Y <sub>2</sub> | Y <sub>3</sub> | Y <sub>4</sub> | Y <sub>5</sub> | Y <sub>6</sub> | Y <sub>7</sub> | Y <sub>8</sub> | A <sub>0</sub> | A <sub>1</sub> | A <sub>2</sub> |
| 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |
| 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |
| 0              | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | 0              |
| 0              | 0              | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 1              | 1              |
| 0              | 0              | 0              | 0              | 1              | 0              | 0              | 0              | 1              | 0              | 0              |
| 0              | 0              | 0              | 0              | 0              | 1              | 0              | 0              | 1              | 0              | 1              |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | 1              | 0              |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | 1              | 1              | 1              |

### Truth Table: Decoder

| Input          |                |                | Output         |                |                |                |                |                |                |                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| X <sub>0</sub> | X <sub>1</sub> | X <sub>2</sub> | Y <sub>0</sub> | Y <sub>1</sub> | Y <sub>2</sub> | Y <sub>3</sub> | Y <sub>4</sub> | Y <sub>5</sub> | Y <sub>6</sub> | Y <sub>7</sub> |
| 0              | 0              | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |
| 0              | 0              | 1              | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              |
| 0              | 1              | 0              | 0              | 0              | 1              | 0              | 0              | 0              | 0              | 0              |
| 0              | 1              | 1              | 0              | 0              | 0              | 1              | 0              | 0              | 0              | 0              |
| 1              | 0              | 0              | 0              | 0              | 0              | 0              | 1              | 0              | 0              | 0              |
| 1              | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 1              | 0              | 0              |
| 1              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              |
| 1              | 1              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 1              |

### Procedure: (Encoder)

An Encoder is a combinational circuit that converts binary information from  $2^n$  lines to a maximum of  $n$  unique output lines. Encoder do reverse operation to that of Decoder. It is used in the transmitter circuit.

1. Connections are made as per circuit diagram.
2. The inputs are given at the corresponding pins.
3. The outputs are verified at the corresponding output pins.

### Procedure: (Decoder)

A decoder is a combinational circuit that converts binary information

from  $n$  line to a maximum of  $2^n$  unique output lines . The name decoder is also used in conjunction with some code converters such as a BCD to seven segment decoder. The block diagram of a decoder is shown in the figure.

1. Connections are made as per the circuit diagram.
2. Connect the pins to the respective pins of the display board.
3. Give different combinations of the inputs and observe the numbers displayed on the board.

**Result:**

Encoder and Decoder circuit using logic gates are constructed and verified their operations.

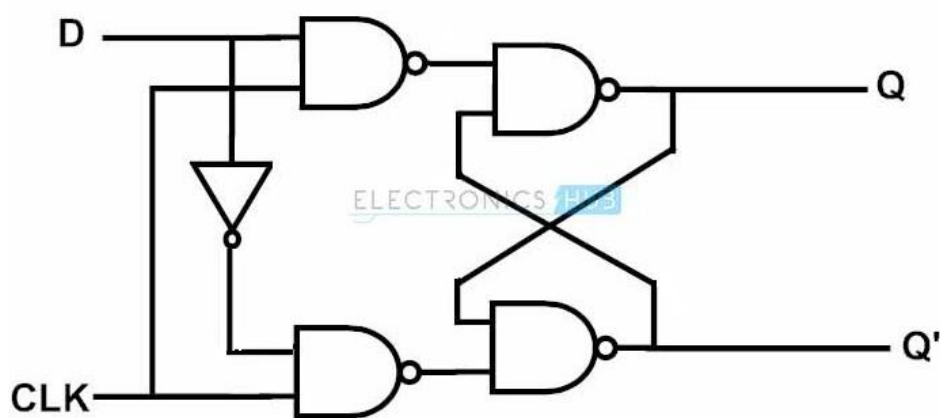
## FLIP – FLOPS

### Aim:

To verify the truth table of various flip-flops using logic gates

- i) D Flip-Flop
- ii) J-K Flip-Flop

### Circuit Diagram:



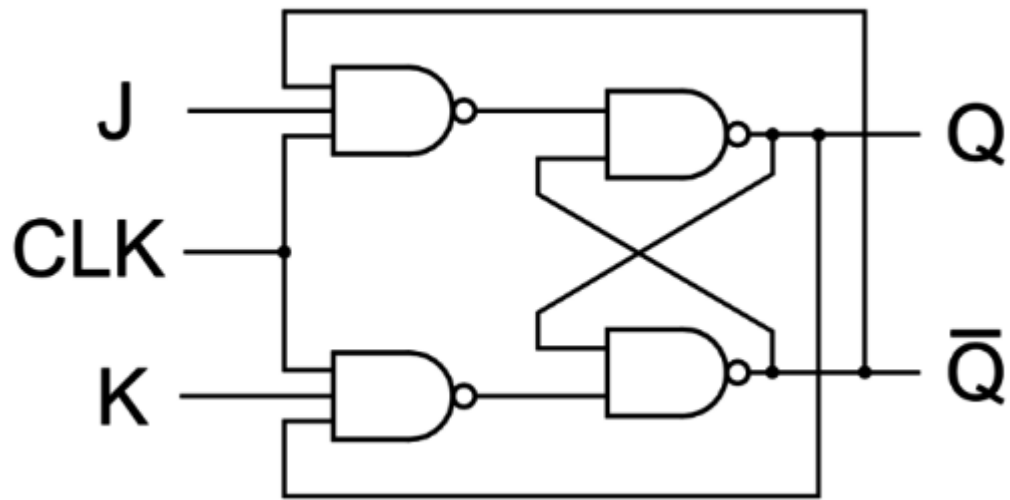
### Truth table:

| D | Q (current state) | Q'(next state) |
|---|-------------------|----------------|
| 0 | 0                 | 0              |
| 0 | 1                 | 0              |
| 1 | 0                 | 1              |
| 1 | 1                 | 1              |

### Procedure:

1. Construct the circuit as shown in figure using spice tool.
2. Select the switches D and CLK to provide input bit combinations.
3. Observe the LED output for each input bit combinations and verify the truth table.

### Circuit Diagram:



### Truth table:

| J | K | Q | $\bar{Q}$ |
|---|---|---|-----------|
| 0 | X | 0 | 0         |
| 1 | 0 | 0 | 1         |
| X | 1 | 1 | 0         |
| x | 0 | 1 | 1         |

### Procedure:

1. Construct the circuit as shown in figure.
2. Select the switches J and K to provide input bit combinations.
3. Observe the output LED for each input bit combinations and verify the truth table.

### Result:

Truth tables of D Flip Flop and JK Flip Flop using logic gates are verified.

## IMPEDENCE AND POWER FACTOR OF CR CIRCUIT

### Aim:

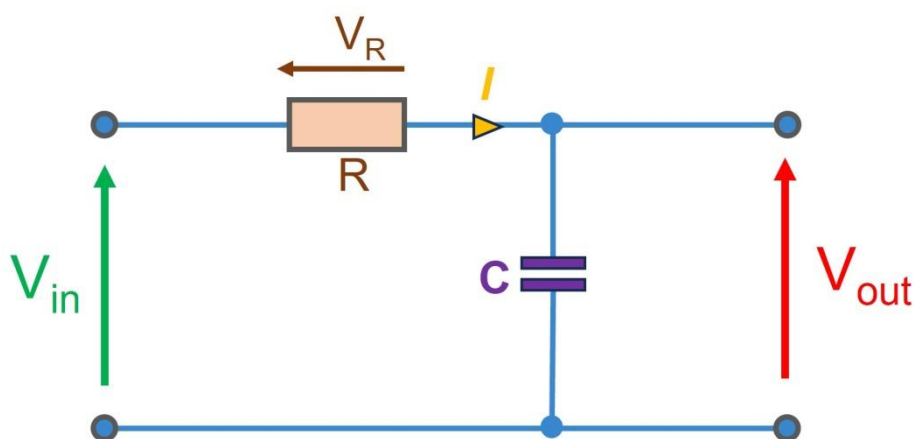
To construct a series resistance-capacitance (CR) circuit and to determine its impedance ( $Z$ ) and power factor ( $\cos \phi$ ).

### Apparatus Required:

- Audio Frequency Oscillator (AFO) / Oscillator
- Capacitance box
- Resistance box
- Voltmeter

### Circuit Diagram:

Figure 1: Schematic diagram of a Series CR Circuit setup.



### Formula:

- Effective Current ( $I_{eff}$ ):  $V_R / R$  (A)
- Impedance ( $Z$ ):  $V_{eff} / I_{eff}$  ( $\Omega$ )
- Power Factor (P.F.):  $V_R / V_{eff}$  (or  $\cos \phi$ )

### Tabulation-I:

Input Voltage: 20 V

Value of  $C$ :  $1 \mu F$

| S.No | Resistance ( $R$ in $\Omega$ ) | $V_R$ (V) | $V_{eff}$ (V) | $I_{eff}$ (A) | P.F. |
|------|--------------------------------|-----------|---------------|---------------|------|
| 1    |                                |           |               |               |      |
| 2    |                                |           |               |               |      |
| 3    |                                |           |               |               |      |

|    |  |  |  |  |  |
|----|--|--|--|--|--|
| 4  |  |  |  |  |  |
| 5  |  |  |  |  |  |
| 6  |  |  |  |  |  |
| 7  |  |  |  |  |  |
| 8  |  |  |  |  |  |
| 9  |  |  |  |  |  |
| 10 |  |  |  |  |  |

## Result:

Input Voltage: 20 V, Value of C: 1  $\mu$ F

\* Impedance of the circuit (Z) = \_\_\_\_\_  $\Omega$

\* Power Factor of the circuit ( $\cos \phi$ ) = \_\_\_\_\_

Input Voltage: 20 V, Value of C: 2  $\mu$ F

\* Impedance of the circuit (Z) = \_\_\_\_\_  $\Omega$

\* Power Factor of the circuit ( $\cos \phi$ ) = \_\_\_\_\_

## IMPEDANCE AND POWER FACTOR OF LR CIRCUIT

### Aim:

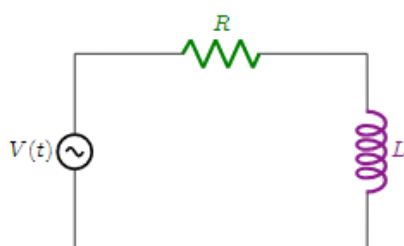
To construct a series resistance-Inductance (LR) circuit and to determine its impedance ( $Z$ ) and power factor ( $\cos \phi$ ).

### Apparatus Required:

- Audio Frequency Oscillator (AFO) / Oscillator
- Inductance Coil
- Resistance box
- Voltmeter

### Circuit Diagram:

Figure 1: Schematic diagram of a Series LR Circuit setup.



### Formula:

- Effective Current ( $I_{\text{eff}}$ ):  $V_R / R$  (A)
- Impedance ( $Z$ ):  $V_{\text{eff}} / I_{\text{eff}}$  ( $\Omega$ )
- Power Factor (P.F.):  $V_R / V_{\text{eff}}$  (or  $\cos \phi$ )

### Tabulation-I:

Input Voltage: 20 V

Value of C: 1  $\mu\text{F}$

| S.No | Resistance (R<br>in $\Omega$ ) | $V_R$ (V) | $V_{\text{eff}}$ (V) | $I_{\text{eff}}$ (A) | P.F. |
|------|--------------------------------|-----------|----------------------|----------------------|------|
| 1    |                                |           |                      |                      |      |
| 2    |                                |           |                      |                      |      |
| 3    |                                |           |                      |                      |      |
| 4    |                                |           |                      |                      |      |
| 5    |                                |           |                      |                      |      |
| 6    |                                |           |                      |                      |      |

|    |  |  |  |  |  |
|----|--|--|--|--|--|
| 7  |  |  |  |  |  |
| 8  |  |  |  |  |  |
| 9  |  |  |  |  |  |
| 10 |  |  |  |  |  |

## Result:

Input Voltage: 20 V, Value of C: 1  $\mu$ F

\* Impedance of the circuit (Z) = \_\_\_\_\_  $\Omega$

\* Power Factor of the circuit ( $\cos \phi$ ) = \_\_\_\_\_

Input Voltage: 20 V, Value of C: 2  $\mu$ F

\* Impedance of the circuit (Z) = \_\_\_\_\_  $\Omega$

\* Power Factor of the circuit ( $\cos \phi$ ) = \_\_\_\_\_

## Determination of Cauchy's constant and dispersive power of the Prism

### Aim:

To determine:

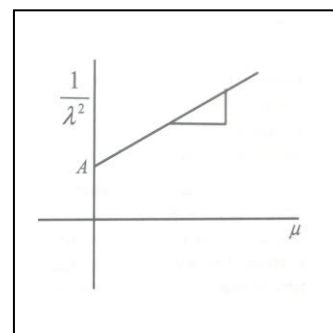
1. The Cauchy's constants (A and B).
2. The dispersive power ( $\omega$ ) of the material of the given prism.

### Apparatus Required:

- Spectrometer
- Flint glass prism
- Mercury vapor lamp
- Spirit level
- Reading lens

### Formulae:

1. Refractive Index ( $n$ ):  $n = \sin((A + D)/2) / \sin(A/2)$
2. Cauchy's Dispersion Formula:  $n = A + B/\lambda^2$
3. Dispersive Power ( $\omega$ ):  $\omega = (n_F - n_C) / (n_D - 1)$



### Procedure:

1. Perform preliminary adjustments: Level the spectrometer, adjust the eyepiece, and set the telescope and collimator for parallel rays.
2. Measure the prism angle (A) using the reflection method.
3. Set the prism in the minimum deviation position for different spectral lines of the mercury lamp.
4. Note the telescope readings to find the angle of minimum deviation (D) for each line.
5. Calculate the refractive index (n) for each wavelength.

### Observation Table:

| Colour | Refracted reading |     | D | $\mu$ |
|--------|-------------------|-----|---|-------|
|        | V_A               | V_B |   |       |
|        |                   |     |   |       |
|        |                   |     |   |       |

### Results:

1. Cauchy's constant A: \_\_\_\_\_
2. Cauchy's constant B: \_\_\_\_\_
3. Dispersive power ( $\omega$ ): \_\_\_\_\_

## ANDERSONS BRIDGE

### Aim:

To measure self-inductance of a coil using Anderson's Bridge.

### Apparatus:

Anderson's Bridge has been designed on a training board New Tech Type NTI – 117. It consists three fixed resistances  $R_1$ ,  $R_2$ ,  $R_3$ .  $R_1$  is connected in between A and B.  $R_2$  is connected in between B and C. Thus  $R_1$  and  $R_2$  form two ratio arms,  $R_3$  is connected in between A and D and a variable resistance  $R_4$  is connected in unknown arm C and D. The inductance ( $L$ ) to be measured is also connected in the same arm. Thus,  $R_4$  and  $L$  are in series. A set of seven capacitors  $C = C_1, C_2, C_3, C_4, C_5, C_6, C_7$  and resistance  $r$  in two steps of (i)  $\times 100\Omega$  upto  $1K\Omega$  (ii)  $\times 1K\Omega$  upto  $10 K\Omega$  are provided on the board. Fixed frequency oscillator is connected in the bridge two terminal provided for this. A headphone or galvanometer fitted with diode is joined in between two terminals marked for this purpose. Three inductances  $L_1$ ,  $L_2$  and  $L_3$  are also provided on the board.  $L_1$  is between first and second terminal,  $L_2$  is between second and third terminal,  $L_3$  is in between third and fourth terminal.

### Formula:

When Anderson Bridge is balanced in the sound in headphone or deflection in galvanometer fitted with diode is minimum. The potential at E & F is same then:

$$P = R Q S \therefore$$

$$R_1 = R_3$$

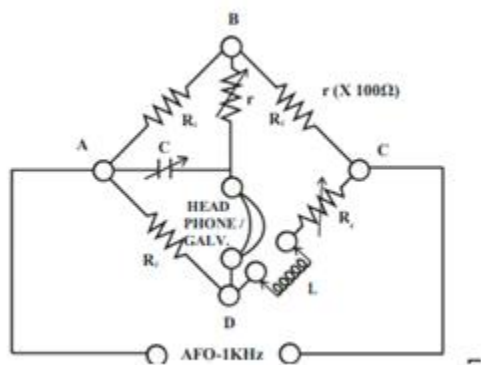
$$R_2 R_4$$

And if

$$P = Q \text{ or } R_1 = R_2$$

$$L = CR_3 (R_2 + 2r)$$

### Circuit Diagram:



**Procedure:**

- (1) Connect oneself inductance say  $L_2$  (second and third terminals) to the sockets provided across the symbol of the Coil in the bridge circuit.
- (2) Connect a Leclanche cell or lead accumulator in place of oscillator and Galvanometer at place of headphone. Adjust  $R_4$  so that Zero deflection is obtained in Galvanometer keeping  $R_0$  resistance.
- (3) Now disconnect Leclanche cell and at its place connect fixed frequency oscillator. Head phone or Galvanometer fitted with diode is connected at its proper place.
- (4) Set suitable value of  $C$  and by changing  $r$  obtain minimum sound in headphone or minimum deflection in Galvanometer. Record the value of  $C$  and  $r$  in O.T.
- (5) Changing value of  $C$  repeat step (4) several times. Record the value of  $C$  and  $r$  in O.T.
- (6) Calculate  $L$  using formula (1) given in theory.

**Observations :**

Given Values :  $R_1 = R_2 = R_3 = 1\text{K}\Omega$

$C_1 = \dots \mu\text{F}$ ,  $C_2 = \dots \mu\text{F}$ ,  $C_3 = \dots \mu\text{F}$

$C_4 = \dots \mu\text{F}$ ,  $C_5 = \dots \mu\text{F}$ ,  $C_6 = \dots \mu\text{F}$  and  $C_7 = \dots \mu\text{F}$

$L_1 = \dots \text{mH}$ ,  $L_2 = \dots \text{mH}$ ,  $L_3 = \dots \text{mH}$

| S. No. | Value of C ( $\mu\text{F}$ ) | Resistance r (Ohms) | Inductance L (mH) |
|--------|------------------------------|---------------------|-------------------|
|        |                              |                     |                   |
|        |                              |                     |                   |
|        |                              |                     |                   |
|        |                              |                     |                   |
|        |                              |                     |                   |

**Calculations:**

$$L = CR_3 (R_2 + 2r) \text{ Henry}$$

$$= CR_3 (R_2 + 2r) \times 10^3 \text{ mH}$$

**Result:**

Inductance of the given: Coil = .... mH

Standard Value = ....mH

## SONOMETER - TUNNING FORK

### Aim

To study the relation between the length of a given wire and tension for a constant frequency using a sonometer.

### Apparatus Required

- Sonometer with a wooden soundbox
- Tuning fork
- 0.5 kg hanger and five 0.5 kg slotted weights
- Rubber pad
- Paper rider
- Metre scale
- Screw gauge

### Theory

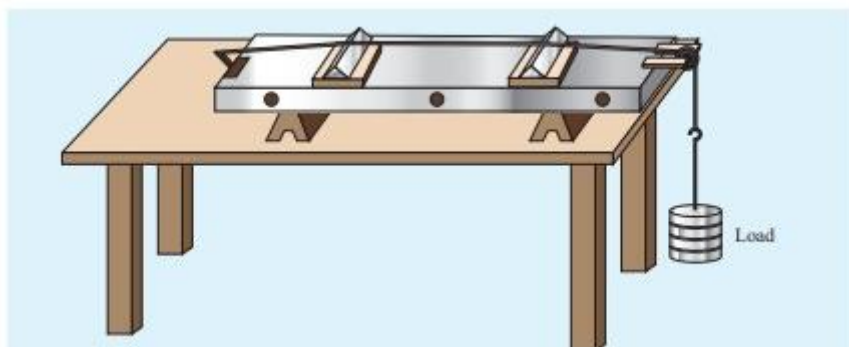
The frequency ( $\nu$ ) of a stretched string under tension  $T$  is given by:

$$\nu = (1 / 2l) * \sqrt{T / m}$$

Where  $l$  is the resonating length,  $T$  is the tension, and  $m$  is the mass per unit length.

For a constant frequency,  $T$  is directly proportional to  $l^2$  ( $T \propto l^2$ ), meaning a graph between  $T$  and  $l^2$  is a straight line.

### Diagram



### Procedure

1. Place the sonometer on a stable table and set an initial load (e.g., 1.5 kg) on the hanger.
2. Place an inverted paper rider at the midpoint between the two movable bridges under the wire.
3. Strike the given tuning fork gently against a rubber pad and place its stem in contact with the sonometer board.
4. Adjust the distance between the movable bridges until the string resonates with the fork, causing the paper rider to fall off.
5. Measure and record the resonating length ( $l$ ) using a metre scale.

6. Increase the tension by adding slotted weights one by one and repeat the steps to find the corresponding resonating lengths.

### Observation Table

| Sl. No. | Total Load M<br>(kg) | Tension $T = M \times g$ (N) | Resonating<br>Length $l$ (cm) | $l^2$ (cm <sup>2</sup> ) |
|---------|----------------------|------------------------------|-------------------------------|--------------------------|
|         |                      |                              |                               |                          |
|         |                      |                              |                               |                          |
|         |                      |                              |                               |                          |
|         |                      |                              |                               |                          |

### Results

1. It is verified that the tension is directly proportional to the square of the resonating length ( $T \propto l^2$ ) for a constant frequency.
2. The  $T$  versus  $l^2$  graph yields a straight line passing through the origin.

## RESISTIVITY OF THE GIVEN COIL - CAREY FOSTER'S BRIDGE

### Aim:

To determine the resistance per unit length of the bridge wire of a Carey Foster's bridge, and to use it as the foundation for finding unknown small resistances or the specific resistance of a wire.

### Apparatus :

---

Carey Foster Bridge

Standard resistance box

Known resistance

Unknown resistance

Galvanometer

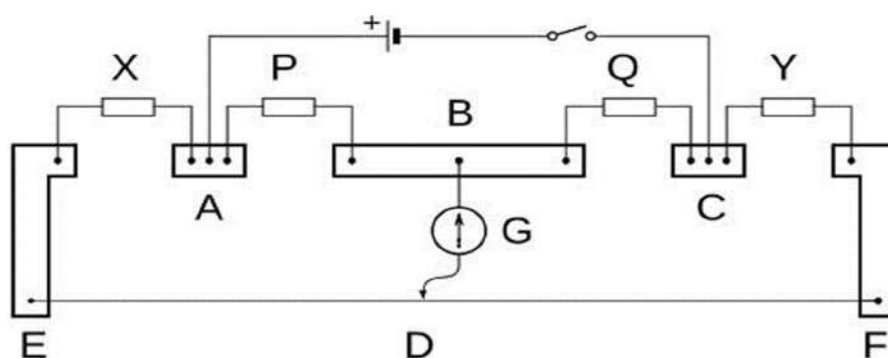
Jockey

Battery eliminator (or DC  
source)

Plug key

Connecting wires

Circuit Diagram:



### Experimental set-up: -

**Formula:**

Unknown resistance of the given wire / resistance,

$$Y = X - (l_2 - l_1) \rho$$

Where X = known resistance connected in the left gap. Y = the resistance of wire connected in the right gap.  $l_1$  and  $l_2$  respectively are the balancing length of the bridge wire measured from the left end, before and after interchanging positions of X and Y.

**Experimental Procedure:**

The experiment is carried out in two parts:

To Determine the Resistance of the Given Wire (Unknown Resistance)

1. Connect the unknown resistance (or the given wire) to the Y terminal on the right side of the bridge.
2. Select a suitable known resistance X using the resistance box on the left side.
3. Switch ON the bridge and locate the null point by sliding the jockey while pressing the jockey key.
4. Record the first balance length  $l_1$ .
5. Interchange the resistances and again locate the null point.
6. Record the second balance length  $l_2$ .
7. Calculate the unknown resistance Y using

$$Y = X - (l_2 - l_1) \rho$$

where,  $l_2$  = Known resistance ( $\Omega$ ),  $\rho$  = Resistance per unit length of the bridge wire ( $\Omega/\text{cm}$ )

8. Repeat the experiment with different values of X and calculate the average value of Y for greater accuracy.

**Observations Table: -**

For resistance of given wire / unknown resistance:

| S. No. | Known Resistance X (in ohms) | Balance Length $l_1$ (cm) | Balance Length $l_2$ (cm) | $(l_2 - l_1)$ (In cm) | Y ohms |
|--------|------------------------------|---------------------------|---------------------------|-----------------------|--------|
| 1.     |                              |                           |                           |                       |        |
| 2.     |                              |                           |                           |                       |        |
| 3.     |                              |                           |                           |                       |        |

Results:

1. The resistance per unit length of Carey foster's Bridge wire = \_\_\_\_\_ ohms
2. Resistance of the given resistance wire / unknown resistance = \_\_\_\_\_ ohms

## CLIPPER AND CLAMPER

### Aim:

To construct and study the operation of clipper and clamper circuits.

### Apparatus required:

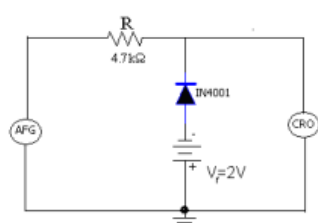
Resistor, Capacitor, Diode, DSO, Regulated power supply, Bread Board

### Procedure

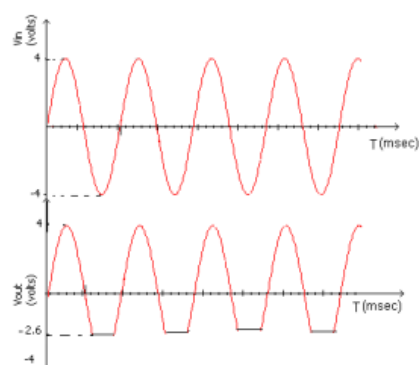
#### Clipper Circuit

1. Connect the components and apparatus as shown in the circuit diagram.
2. Set input, sinusoidal signal of 8Vp-p and 1 kHz frequency and the reference voltage as 2V using RPS.
3. Observe the output across the diode using DSO.
4. Plot the input and output signal in a linear graph.

#### NEGATIVE PEAK CLIPPER



**MODEL GRAPH**



#### Theoretical calculations:

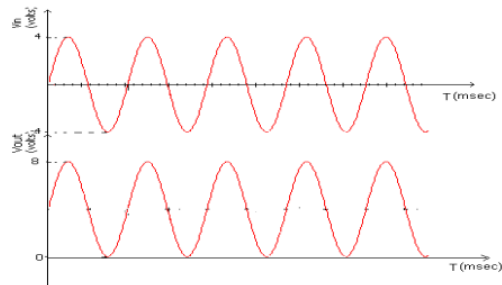
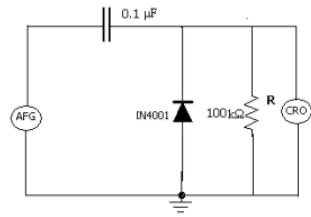
$$V_r = 2\text{V}, V_\gamma = 0.6\text{V}$$

When the diode is forward biased  $V_o = -(V_r + V_\gamma) = -(2\text{V} + 0.6\text{V}) = -2.6\text{V}$

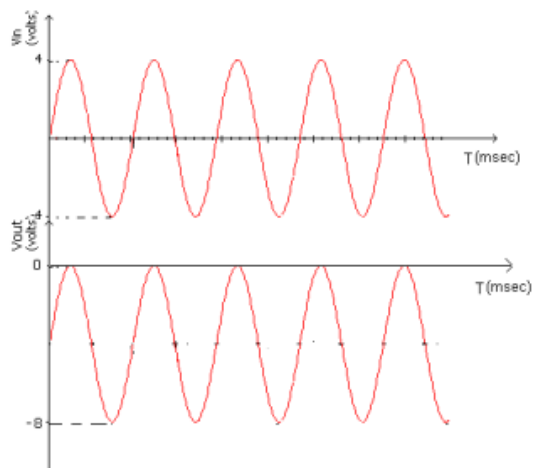
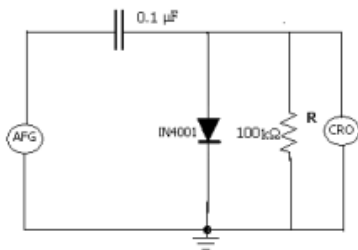
When the diode is reverse biased the  $V_o = V_i$

#### Clamper Circuit

1. Connect the components and apparatus as shown in the circuit diagram.
2. Set input, sinusoidal signal of 8Vp-p and 1kHz frequency
3. Observe the output across the load resistance using DSO.
4. Plot the input and output signal in a linear graph.



### NEGATIVE CLAMPER



### Result:

Thus the clipper and clamper circuits are designed and the output waveforms are observed.

## COMMON EMITTER CHARACTERISTICS OF BIPOLAR JUNCTION TRANSISTOR

### AIM:

To study the input and output characteristics of a Bipolar Junction Transistor (BJT) in Common Emitter (CE) configuration.

### Apparatus:

BC547 transistor, DC power supply, microammeter, milliammeter, voltmeters, resistors, connecting wires.

### Circuit Diagrams :

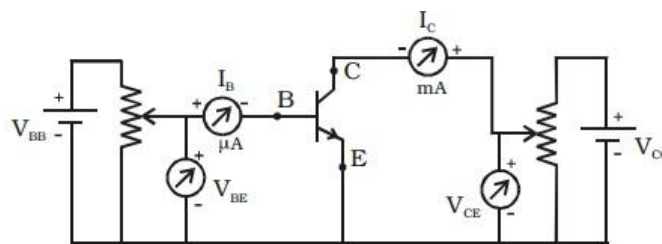


Fig Transistor circuit in CE mode.

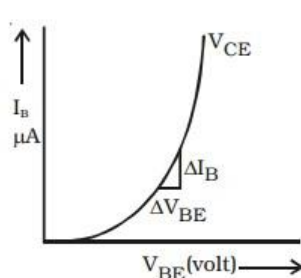


Fig Input characteristics

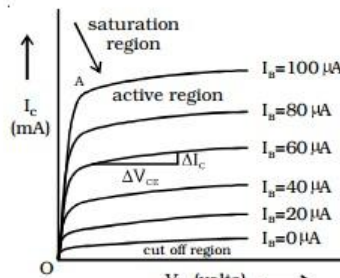


Fig Output characteristics

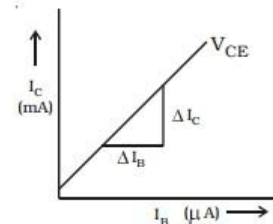


Fig Transfer characteristic curve

### Observation Table

| S.No | V <sub>BE</sub> (V) | I <sub>B</sub> (μA) |
|------|---------------------|---------------------|
| 1    | 0.1                 |                     |

### Procedure

1. Connect the circuit.
2. Record input readings for V<sub>CE</sub>=2 V and 3 V.
3. Record output readings for I<sub>B</sub>=10 μA and 20 μA.

4. Plot  $I_B$  vs  $V_{BE}$  and  $I_C$  vs  $V_{CE}$  graphs.

### **Result**

The input and output characteristics of the BC547 transistor in Common Emitter configuration were studied successfully. The input resembles a forward-biased diode, and the output characteristics show cut-off, active and saturation regions.

## STUDY OF ZENER DIODE AS A VOLTAGE REGULATOR

### Aim:

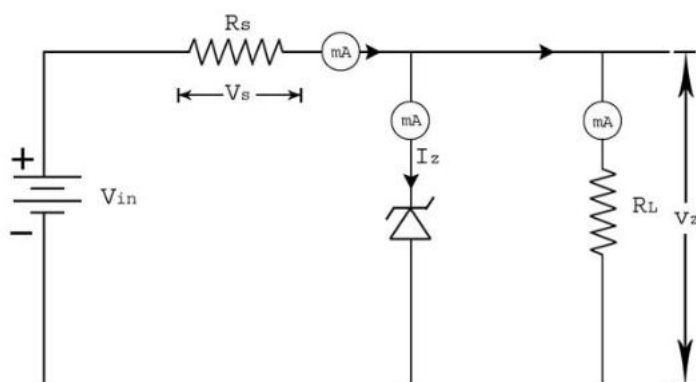
To study the regulation of Voltage using Zener Diode.

### Apparatus required :

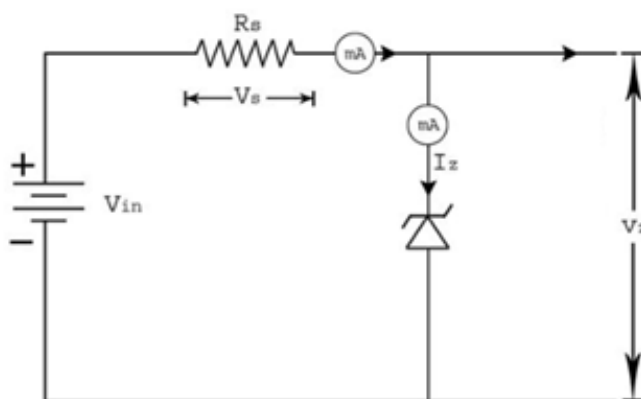
1. Zener Diode Trainer Kit. a. DC Voltage regulator (0 to 15V). b. Source Resistance ( $470\ \Omega$ ). c. Load Resistance ( $470\ \Omega$ ). d. Input Volt Meter. e. Output Volt Meter.
2. Zener diode kit power supply.
3. Port Connecting Wires.
4. Zener Diode.

### Circuit Diagram:-

#### 1. With Load Voltage Regulation:-



#### 2. Without Load Voltage Regulation:-



### Procedures:-

#### 1. With Load Voltage Regulation:-

- I. From a reverse characteristic of Zener diode the reverse breakdown voltage is found.
- II. Make connections as shown in circuit diagram.
- III. Make sure the Zener is connected in reverse bias i.e. +V terminal of supply being

connected to Negative and  $-V$  terminal is connected to Positive of Zener.

IV. Any two terminal of load resistance is connected to form one end and the other terminal acts as the other end. Connect the load resistance in parallel to the Zener Diode.

V. Increase the supply DC voltage to enter into the Zener Breakdown region or the voltage which is found.

VI. Now change the variable point of the load resistance and measure the corresponding voltage.

VII. Continue the taking voltage until the voltage falls below the constant value.

## **2. Without Load Voltage Regulation:--**

I. From a reverse characteristic of Zener diode the reverse breakdown voltage is found.

II. Make connections as shown in circuit diagram.

III. Make sure the Zener is connected in reverse bias i.e.  $+V$  terminal of supply being connected to Negative and  $-V$  terminal is connected to Positive of Zener.

IV. Increase the supply DC voltage to enter into the Zener Breakdown region or the voltage which is found.

V. Now vary the supply voltage and measure the corresponding voltage.

VI. Continue the taking voltage until the voltage falls below the constant value

### **Experiment Result:- 1. With Load Voltage Regulation:-**

| S.No | Supply Voltage | Output Voltage/Load Voltage |
|------|----------------|-----------------------------|
|      |                |                             |
|      |                |                             |
|      |                |                             |
|      |                |                             |

### **2. Without Load Regulation:-**

| S.No | Supply Voltage | Output Voltage/Load Voltage |
|------|----------------|-----------------------------|
|      |                |                             |
|      |                |                             |
|      |                |                             |
|      |                |                             |

Result:

Zener Diode Voltage regulation has been studied.