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# PHYSICS PRACTICAL GUIDE



## HIGHER SECONDARY SECOND YEAR (+2)

| INTERNAL PRACTICAL (5 MARKS)  | EXPERIMENT SKILL                            |                      | 2 | 5 MARKS  |
|-------------------------------|---------------------------------------------|----------------------|---|----------|
|                               | RECORD NOTE                                 |                      | 3 |          |
| EXTERNAL PRACTICAL (15 MARKS) | FORMULA                                     | EQUATION ONLY (1)    | 2 | 15 MARKS |
|                               |                                             | WITH EXPLANATION (1) |   |          |
|                               | PROCEDURE (1½)                              |                      | 3 |          |
|                               | CIRCUIT DIAGRAM (1½)                        |                      |   |          |
|                               | TABULAR COLUMN AND OBSERVATION              |                      | 5 |          |
|                               | ARITHMETIC CALCULATION AND GRAPHICAL METHOD |                      | 4 |          |
|                               | RESULT                                      | ONLY ANSWER (½)      | 1 |          |
|                               |                                             | WITH S I UNIT (½)    |   |          |



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# HIGHER SECONDARY SECOND YEAR PHYSICS PRACTICAL OBSERVATION NOTE

NAME :

CLASS & SECTION : 12

EXAM No. :

SCHOOL :

| S.No | DATE | EXPERIMENT                                                            | PAGE | TEACHER SIGNATURE |
|------|------|-----------------------------------------------------------------------|------|-------------------|
| 1    |      | Metre Bridge - Specific Resistance of the wire                        |      |                   |
| 2    |      | Potentiometer - Comparison of emf of two cells                        |      |                   |
| 3    |      | Tangent Galvanometer - Horizontal component of Earth's magnetic field |      |                   |
| 4    |      | Spectrometer - Refractive index of the prism                          |      |                   |
| 5    |      | Spectrometer with diffraction grating                                 |      |                   |
| 6    |      | PN Junction diode - Voltage Current characteristics                   |      |                   |
| 7    |      | Zener diode - Voltage Current characteristics                         |      |                   |
| 8    |      | NPN Junction transistor in CE mode - characteristics                  |      |                   |
| 9    |      | Integrated circuit Logic gates - Verification of Truth tables         |      |                   |
| 10   |      | De Morgan's first and second theorems - Verification                  |      |                   |

யாதும் ஊரே யாவரும் கேளிர் !

தீதும் நன்றும் பிறர் தர வாரா !!

## Experiment - 1

Date ;

### SPECIFIC RESISTANCE OF THE MATERIAL OF THE COIL USING METRE BRIDGE

#### AIM:

- To determine the specific resistance of the material of the given coil using metre bridge.

#### APPARATUS:

- Meter bridge, galvanometer, key, resistance box, connecting wires, Lechlanche cell, jockey and high resistance.

#### FORMULA:

- Specific resistance of the given coil

$$\rho = \frac{X \pi r^2}{L}$$

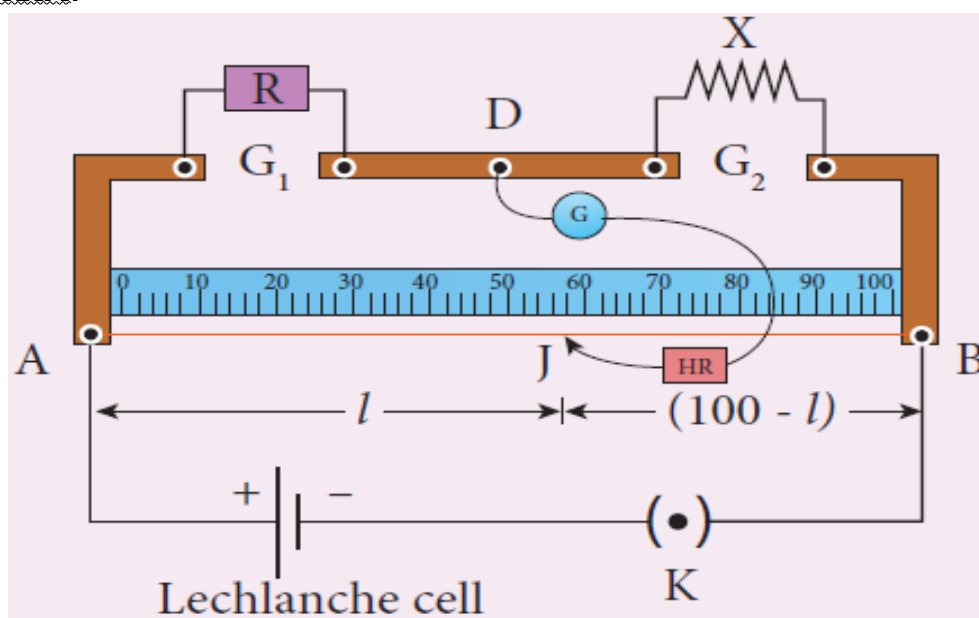
Where

$X \rightarrow$  Resistance of the given coil ( $\Omega$ )

$L \rightarrow$  Length of the coil (m)

$r \rightarrow$  Radius of the wire (m)

#### CIRCUIT DIAGRAM:



#### PROCEDURE:

- The connections are made as shown in the circuit diagram.
- With a suitable resistance included in the resistance box, the circuit is switched on.
- The circuit is checked for opposite side deflections.
- By moving the jockey over the wire, the point on the wire at which the galvanometer shows null deflection i.e., balancing point J is found. The balancing length  $AJ = l$  is noted.
- The unknown resistance  $X_1$  is found using the formula  $X_1 = \frac{R(100-l)}{l}$
- The experiment is repeated for different values of R.
- The same procedure is repeated after interchanging R and X.
- The unknown resistance  $X_2$  is found using the formula  $X_2 = \frac{Rl}{(100-l)}$
- The experiment is repeated for same values of R as before.
- The resistance of the given coil is found from the mean value of  $X_1$  and  $X_2$ .
- The radius of the wire r is found using screw gauge.
- The length of the coil L is measured using meter scale.
- From the values of X, r and L, the specific resistance of the material of the wire is determined.

**TABULAR COLUMN AND OBSERVATIONS :**

- Length of the coil ;  $L = 1 \text{ m}$

**(i) To find resistance of the given coil ;**

| S.No                    | Resistance<br>R | Before interchanging |                            | After interchanging |                            | Mean<br>$X = \frac{X_1 + X_2}{2}$ |
|-------------------------|-----------------|----------------------|----------------------------|---------------------|----------------------------|-----------------------------------|
|                         |                 | $l$                  | $X_1 = \frac{R(100-l)}{l}$ | $l$                 | $X_2 = \frac{Rl}{(100-l)}$ |                                   |
|                         | ( $\Omega$ )    | (cm)                 | ( $\Omega$ )               | (cm)                | ( $\Omega$ )               | ( $\Omega$ )                      |
| 1                       | 1               | 14.4                 | 5.9444                     | 85.3                | 5.8027                     | 5.8736                            |
| 2                       | 2               | 25.2                 | 5.9365                     | 74.6                | 5.8740                     | 5.9052                            |
| 3                       | 3               | 33.5                 | 5.9552                     | 66.1                | 5.8496                     | 5.9024                            |
| 4                       | 4               | 41.5                 | 5.6385                     | 58.4                | 5.6153                     | 5.6269                            |
| 5                       | 5               | 46                   | 5.8695                     | 54                  | 5.8695                     | 5.8695                            |
| Mean Resistance ; $X =$ |                 |                      |                            |                     |                            | 5.8355                            |

**(ii) To find radius of the wire ;**

$ZE = -0.05 \text{ mm}$

$ZC = +0.05 \text{ mm}$

$LC = 0.01 \text{ mm}$

| S.No                   | PSR  | HSC       | Total reading<br>$TR = PSR + (HSC \times LC)$ | Corrected Reading<br>$2r = TR \pm ZC$ |
|------------------------|------|-----------|-----------------------------------------------|---------------------------------------|
|                        | (mm) | divisions | (mm)                                          | (mm)                                  |
| 1                      | 0    | 57        | 0.57                                          | 0.62                                  |
| 2                      | 0    | 58        | 0.58                                          | 0.63                                  |
| 3                      | 0    | 59        | 0.59                                          | 0.64                                  |
| Mean diameter ; $2r =$ |      |           |                                               | 0.63                                  |
| Radius ; $r =$         |      |           |                                               | 0.315                                 |

**CALCULATION :****Table - 1**

$$1. X_1 = \frac{R(100-l)}{l} = \frac{1 \times (100-14.4)}{14.4} = \frac{85.4}{14.4} = 5.9444 \Omega$$

$$X_2 = \frac{Rl}{(100-l)} = \frac{1 \times 85.3}{(100-85.3)} = \frac{85.3}{14.7} = 5.8027 \Omega$$

$$X = \frac{X_1 + X_2}{2} = \frac{5.9444 + 5.8027}{2} = \frac{11.7471}{2} = 5.8735 \Omega$$

$$2. X_1 = \frac{R(100-l)}{l} = \frac{2 \times (100-25.2)}{25.2} = \frac{2 \times 74.8}{25.2} = \frac{149.6}{25.2} = 5.9365 \Omega$$

$$X_2 = \frac{Rl}{(100-l)} = \frac{2 \times 74.6}{(100-74.6)} = \frac{149.2}{25.4} = 5.8740 \Omega$$

$$X = \frac{X_1 + X_2}{2} = \frac{5.9365 + 5.8740}{2} = \frac{11.8105}{2} = 5.9052 \Omega$$

$$3. X_1 = \frac{R(100-l)}{l} = \frac{3 \times (100-33.5)}{33.5} = \frac{3 \times 66.5}{33.5} = \frac{199.5}{33.5} = 5.9552 \Omega$$

$$X_2 = \frac{Rl}{(100-l)} = \frac{3 \times 66.1}{(100-66.1)} = \frac{198.3}{33.9} = 5.8496 \Omega$$

$$X = \frac{X_1 + X_2}{2} = \frac{5.9552 + 5.8496}{2} = \frac{11.8048}{2} = 5.9024 \Omega$$

$$4. X_1 = \frac{R(100-l)}{l} = \frac{4 \times (100-41.5)}{41.5} = \frac{4 \times 58.5}{41.5} = \frac{234}{41.5} = 5.6385 \Omega$$

$$X_2 = \frac{Rl}{(100-l)} = \frac{4 \times 58.4}{(100-58.4)} = \frac{233.6}{41.6} = 5.6153 \Omega$$

$$X = \frac{X_1 + X_2}{2} = \frac{5.6385 + 5.6153}{2} = \frac{11.2538}{2} = 5.6269 \Omega$$

$$5. X_1 = \frac{R(100-l)}{l} = \frac{5 \times (100-46)}{46} = \frac{5 \times 54}{46} = \frac{270}{46} = 5.8695 \Omega$$

$$X_2 = \frac{Rl}{(100-l)} = \frac{5 \times 54}{(100-54)} = \frac{270}{46} = 5.8695 \Omega$$

$$X = \frac{X_1 + X_2}{2} = \frac{5.8695 + 5.8695}{2} = \frac{11.7390}{2} = 5.8695 \Omega$$

Mean Resistance ;

$$X = \frac{5.8735 + 5.9052 + 5.9024 + 5.6269 + 5.8695}{5} = \frac{29.1775}{5} = 5.8355 \Omega$$

### Table - 2

1.  $TR = 0 + (57 \times 0.01) = 0 + 0.57 = 0.57$  ;  $2r = 0.57 + 0.05 = 0.62 \text{ mm}$
2.  $TR = 0 + (58 \times 0.01) = 0 + 0.58 = 0.58$  ;  $2r = 0.58 + 0.05 = 0.63 \text{ mm}$
3.  $TR = 0 + (59 \times 0.01) = 0 + 0.59 = 0.59$  ;  $2r = 0.59 + 0.05 = 0.64 \text{ mm}$

$$\text{Mean diameter ; } 2r = \frac{0.62 + 0.63 + 0.64}{3} = \frac{1.89}{3} = 0.63 \text{ mm}$$

$$\text{Radius of the wire ; } r = \frac{0.63}{2} = 0.315 \text{ mm} = 0.315 \times 10^{-3} \text{ m}$$

- Thus the Specific resistance of the coil is,

$$\rho = \frac{X \pi r^2}{L} = \frac{5.8355 \times 3.14 \times (0.315 \times 10^{-3})^2}{1}$$

$$\rho = 5.8355 \times 3.14 \times 0.315 \times 0.315 \times 10^{-6}$$

$$\rho = 1.818 \times 10^{-6} \Omega \text{ m}$$

### RESULT :

- The specific resistance of the material of the given coil ;  $\rho = 1.818 \times 10^{-6} \Omega \text{ m}$

## Experiment - 2

Date :

### COMPARISON OF EMF'S BY POTENTIOMETER

AIM :

- To compare the emf of the given two cells using a potentiometer

APPARATUS REQUIRED :

- Battery eliminator, key, rheostat, DPDT switch, Leclanche and Daniel cells, galvanometer, high resistance box, pencil jockey and connecting wires.

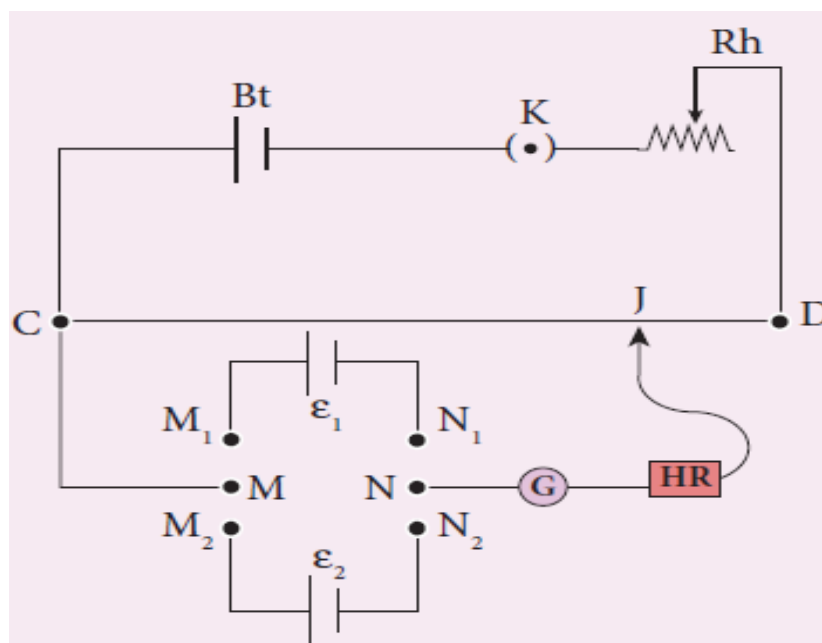
FORMULA :

- The ratio of emf's of Leclanche cell and Daniel cell is,

$$\frac{\epsilon_1}{\epsilon_2} = \frac{l_1}{l_2}$$

Where,  $\epsilon_1 \rightarrow$  emf of Leclanche cell (V)  
 $\epsilon_2 \rightarrow$  emf of Daniel cell (V)  
 $l_1 \rightarrow$  balancing length for Leclanche cell (m)  
 $l_2 \rightarrow$  balancing length for Daniel cell (m)

CIRCUIT DIAGRAM :



PROCEDURE :

- The connections are made as shown in the circuit diagram.
- The circuit is checked for opposite side deflections.
- Using DPDT switch the Leclanche cell is included in the secondary circuit.
- The jockey is pressed on the potentiometer wire.
- The point (J) where the galvanometer wire shows full scale deflection is noted.
- The balancing length  $AJ = l_1$  is measured.
- Using DPDT switch the Daniel cell is included in the secondary circuit.
- The above steps are repeated and the balancing length  $AJ = l_2$  is measured.
- By varying the rheostat,  $l_1$  and  $l_2$  values are measured and the readings are tabulated.

**TABULAR COLUMN AND OBSERVATIONS :**

| S.No                                   | Balancing length<br>for Lechlanche cell<br>$l_1$ | Balancing length for<br>Lechlanche cell<br>$l_2$ | $\frac{\epsilon_1}{\epsilon_2} = \frac{l_1}{l_2}$ |
|----------------------------------------|--------------------------------------------------|--------------------------------------------------|---------------------------------------------------|
|                                        | cm                                               | cm                                               |                                                   |
| 1                                      | 520.8                                            | 387.2                                            | <b>1.345</b>                                      |
| 2                                      | 547.3                                            | 407.8                                            | <b>1.342</b>                                      |
| 3                                      | 563.6                                            | 418.4                                            | <b>1.347</b>                                      |
| 4                                      | 612.7                                            | 456.8                                            | <b>1.341</b>                                      |
| 5                                      | 663.2                                            | 493.8                                            | <b>1.343</b>                                      |
| 6                                      | 715.3                                            | 531.4                                            | <b>1.346</b>                                      |
| Mean : $\frac{\epsilon_1}{\epsilon_2}$ |                                                  |                                                  | <b>1.344</b>                                      |

**CALCULATION :**

$$1. \frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{520.8 \times 10^{-2}}{387.2 \times 10^{-2}} = \frac{520.8}{387.2} = 1.345$$

$$2. \frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{547.3 \times 10^{-2}}{407.8 \times 10^{-2}} = \frac{547.3}{407.8} = 1.342$$

$$3. \frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{563.6 \times 10^{-2}}{418.4 \times 10^{-2}} = \frac{563.6}{418.4} = 1.347$$

$$4. \frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{612.7 \times 10^{-2}}{456.8 \times 10^{-2}} = \frac{612.7}{456.8} = 1.341$$

$$5. \frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{663.2 \times 10^{-2}}{493.8 \times 10^{-2}} = \frac{663.2}{493.8} = 1.343$$

$$6. \frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{715.3 \times 10^{-2}}{531.4 \times 10^{-2}} = \frac{715.3}{531.4} = 1.346$$

Mean :

$$\frac{\epsilon_1}{\epsilon_2} = \frac{1.345 + 1.342 + 1.347 + 1.341 + 1.343 + 1.346}{6} = \frac{8.064}{6} = 1.344$$

**RESULT:**

- Ratio of emf of the given two cells ;  $\frac{\epsilon_1}{\epsilon_2} = \mathbf{1.344}$  (*no unit*)

### Experiment - 3

Date :

## TANGENT GALVANOMETER

AIM :

- To determine the horizontal component of the Earth's magnetic field using tangent galvanometer.

APPARATUS REQUIRED :

- Tangent galvanometer (TG), commutator, battery, rheostat, ammeter, key and connecting wires

FORMULA :

- Horizontal component of the Earth's magnetic field

$$B_H = \frac{\mu_0 n k}{2r}$$

here,  $k = \left( \frac{I}{\tan \theta} \right)$

Where,  $\mu_0 \rightarrow$  permeability of free space ( $\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}$ )

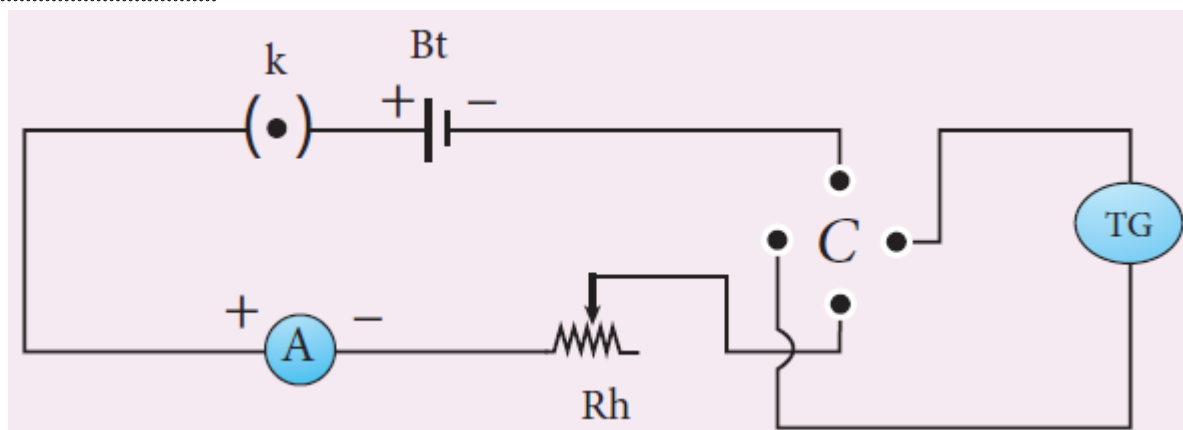
$n \rightarrow$  number of turns,

$I \rightarrow$  current (A)

$\theta \rightarrow$  mean deflection produced in TG (degree)

$r \rightarrow$  radius of the coil (m)

CIRCUIT DIAGRAM :



PROCEDURE:

- The connections are made as shown in the circuit diagram.
- The preliminary adjustments of the tangent galvanometer are done.
- The plane of TG coil is placed parallel to the earth's magnetic field.
- For a current of 0.6 A, the readings  $\theta_1, \theta_2$  are noted in tangent galvanometer.
- The commutator is reversed, and the readings  $\theta_3, \theta_4$  are noted in tangent galvanometer.
- The readings are tabulated. Now the mean deflection ( $\theta$ ) is calculated.
- By changing the values of current 'I' in T.G the  $\theta_1, \theta_2, \theta_3, \theta_4$  are measured and tabulated.
- The circumference of the circular coil ( $2\pi r$ ) is measured and from which 'r' is calculated.
- From this, the horizontal component of earth's magnetic field is found out.

### TABULAR COLUMN AND OBSERVATIONS :

- Number of turns ;  $n = 5$
- Circumference of the coil ;  $2 \pi r = 50 \text{ cm} = 50 \times 10^{-2} \text{ m}$
- Radius of the coil ;  $r = \frac{50 \times 10^{-2}}{2 \pi} = 7.961 \times 10^{-2} \text{ m}$

| S.No         | Current<br>I<br>(A) | Deflection in TG     |                      |                      |                      | Mean<br>$\theta$<br>degree | tan $\theta$ | $k = \frac{I}{\tan \theta}$<br>(A) |
|--------------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------------|--------------|------------------------------------|
|              |                     | $\theta_1$<br>degree | $\theta_2$<br>degree | $\theta_4$<br>degree | $\theta_4$<br>degree |                            |              |                                    |
| 1            | 0.6                 | 32°                  | 32°                  | 34°                  | 34°                  | 33°                        | 0.6494       | 0.9239                             |
| 2            | 0.8                 | 40°                  | 40°                  | 42°                  | 42°                  | 41°                        | 0.8693       | 0.9203                             |
| 3            | 1.0                 | 47°                  | 47°                  | 45°                  | 45°                  | 46°                        | 1.0355       | 0.9657                             |
| 4            | 1.2                 | 50°                  | 50°                  | 52°                  | 52°                  | 51°                        | 1.2349       | 0.9717                             |
| Mean ; $k =$ |                     |                      |                      |                      |                      |                            |              | 0.9454                             |

### CALCULATION :

$$\begin{aligned}
 1. \quad \theta &= \frac{32 + 32 + 34 + 34}{4} = \frac{132^\circ}{4} = 33^\circ ; \quad k = \frac{I}{\tan \theta} = \frac{0.6}{0.6494} = 0.9239 \\
 2. \quad \theta &= \frac{40 + 40 + 42 + 42}{4} = \frac{164^\circ}{4} = 41^\circ ; \quad k = \frac{I}{\tan \theta} = \frac{0.8}{0.8693} = 0.9203 \\
 3. \quad \theta &= \frac{47 + 47 + 45 + 45}{4} = \frac{184^\circ}{4} = 46^\circ ; \quad k = \frac{I}{\tan \theta} = \frac{1.0}{1.0355} = 0.9657 \\
 4. \quad \theta &= \frac{50 + 50 + 52 + 52}{4} = \frac{204^\circ}{4} = 51^\circ ; \quad k = \frac{I}{\tan \theta} = \frac{1.2}{1.2349} = 0.9717
 \end{aligned}$$

$$\text{Mean ; } k = \left( \frac{I}{\tan \theta} \right) = \frac{0.9293 + 0.9203 + 0.9657 + 0.9717}{5} = \frac{3.7816}{4} = 0.9454 \text{ A}$$

- Hence horizontal component of earth's magnetic field,

$$B_H = \frac{\mu_0 n}{2 r} k = \frac{4 \pi \times 10^{-7} \times 5}{2 \times 7.961 \times 10^{-2}} \times 0.9454$$

$$B_H = \frac{2 \times 3.14 \times 5 \times 0.9454 \times 10^{-5}}{7.961}$$

$$B_H = 3.859 \times 10^{-5} \text{ tesla}$$

| No       | Log                 |
|----------|---------------------|
| Nr 2     | 0.3010              |
| 3.14     | 0.4969              |
| 5        | 0.6990              |
| 0.9464   | 1.9756              |
| +        | 1.4725              |
| Dr 7.961 | 0.8860              |
| -        | 0.5865              |
| Alog     | $3.859 \times 10^0$ |

### RESULT :

- The horizontal component of earth's magnetic field ;  $B_H = 3.859 \times 10^{-5} \text{ tesla}$

## Experiment - 4

Date :

### **SPECTROMETER – REFRACTIVE INDEX OF THE PRISM**

**AIM :**

- To determine the refractive index of the material of a prism using spectrometer.

**APPARATUS REQUIRED :**

- Spectrometer, prism, prism clamp, sodium vapour lamp, spirit level.

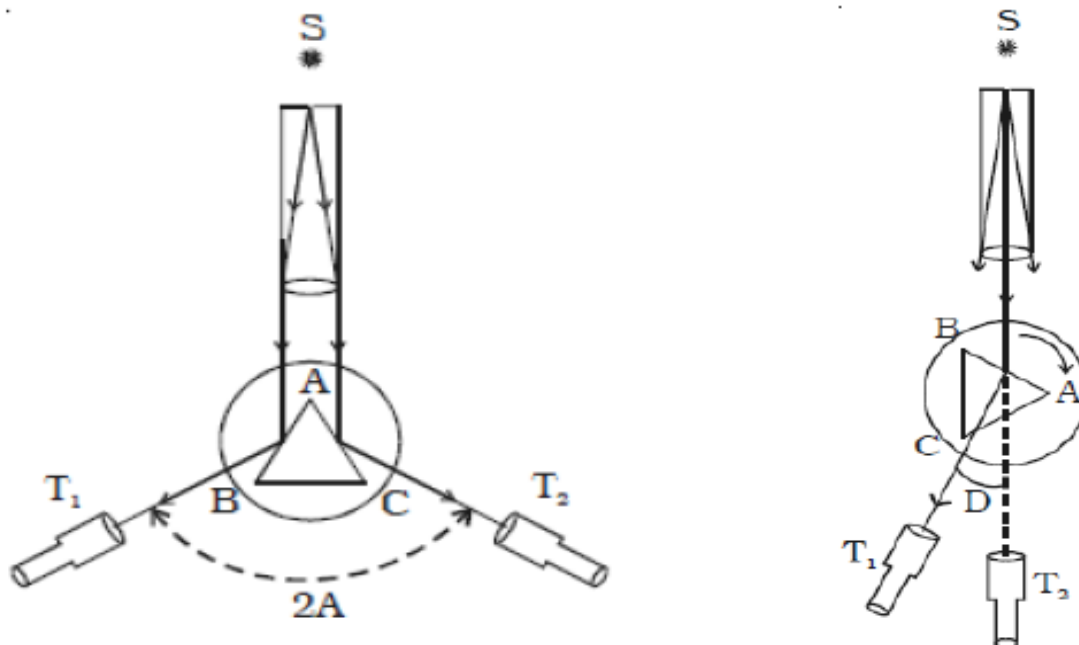
**FORMULA :**

- Refractive index of the material of the prism

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

Where, ,  $A \rightarrow$  Angle of the prism (degree)  
 $D \rightarrow$  Angle of minimum deviation (degree)

**DIAGRAMS :**



**PROCEDURE :**

#### **1) Initial adjustments of the spectrometer**

- Eye-piece:** The eye-piece of the telescope is adjusted so that the cross-wires are seen clearly.
- Slit:** The slit of the collimator is adjusted such that it is very thin and vertical.
- Base of the spectrometer:** The base of the spectrometer is adjusted to be horizontal using leveling screws.
- Telescope:** The telescope is turned towards a distant object and is adjusted till the clear inverted image of the distant object is seen. Now the telescope is adjusted to receive parallel rays.
- Collimator:** The telescope is brought in line with the collimator. Collimator is adjusted until a clear image of the slit is seen in the telescope. Now the collimator gives parallel rays.
- Prism table:** Using a spirit level, the prism table is adjusted to be horizontal with the three leveling screws provided in the prism table.

#### **2) Determination of angle of the prism (A)**

- The slit is illuminated by yellow light from sodium vapour lamp.
- The given equilateral prism is placed on the prism table in such a way that refracting edge of the prism is facing the collimator.

- The light emerging from the collimator is incident on both reflecting faces of the prism and is reflected.
- The telescope is rotated towards left to obtain reflected image of the slit from face 1 of the prism and is fixed.
- Using tangential screws, the telescope is adjusted until the vertical cross-wire coincides with the reflected image of the slit.
- The main scale reading and vernier coincidence are noted from both vernier scales.
- The telescope is now rotated towards right to obtain the reflected image from face 2 of the prism. As before, the readings are taken.
- The difference between the two readings gives  $2A$  from which the angle of the prism  $A$  is calculated.

### 3) Determination of angle of minimum deviation (D)

- The prism table is rotated such that the light emerging from the collimator is incident on one of the refracting faces of the prism, gets refracted and emerges out from the other refracting face.
- The telescope is turned to view the refracted image.
- Looking through the telescope, the prism table is rotated in such a direction that the image moves towards the direct ray
- At one particular position, the refracted ray begins to retrace its path. The position where the refracted image returns is the position of minimum deviation.
- The telescope is fixed in this position and is adjusted until the vertical cross-wire coincides with the refracted image of the slit.
- The readings are taken from both vernier scales.
- The prism is now removed and the telescope is rotated to obtain the direct ray image and the readings are taken.
- The readings are tabulated and the difference between these two readings gives the angle of minimum deviation  $D$ .
- From the values of  $A$  and  $D$ , the refractive index of the material of the glass prism is determined.

### TABULAR COLUMN AND OBSERVATIONS :

- **Least count**

$$1 \text{ MSD} = 30'$$

$$\text{Number of vernier scale divisions} = 30$$

For spectrometer, 30 vernier scale divisions will cover 29 main scale divisions.

$$\therefore 30 \text{ VSD} = 29 \text{ MSD}$$

$$(\text{or}) 1 \text{ VSD} = \frac{29}{30} \text{ MSD}$$

$$\text{Hence, least count (LC)} = 1 \text{ MSD} - 1 \text{ VSD} = 1 \text{ MSD} - \frac{29}{30} \text{ MSD} = \frac{1}{30} \text{ MSD} = \frac{1}{30} \times 30' = 1'$$

(i) To find the angle of the prism (A)

$$TR = MSR + (VSC \times LC)$$

| Image                                          | Vernier I                            |          |          | Vernier II                           |         |          |
|------------------------------------------------|--------------------------------------|----------|----------|--------------------------------------|---------|----------|
|                                                | MSR                                  | VSC      | TR       | MSR                                  | VSC     | TR       |
|                                                | (degree)                             | (degree) | (degree) | (degree)                             | degree) | (degree) |
| Reflected image from face AB (R <sub>1</sub> ) | 36                                   | 12       | 36°12'   | 216                                  | 16      | 216°16'  |
| Reflected image from face AC (R <sub>2</sub> ) | 156                                  | 16       | 156°16'  | 336                                  | 20      | 336°20'  |
| Difference                                     | 2A = R <sub>1</sub> ~ R <sub>2</sub> |          | 120°4'   | 2A = R <sub>1</sub> ~ R <sub>2</sub> |         | 120°4'   |

(ii) To find angle of minimum deviation (D):  $TR = MSR + (VSC \times LC)$

| Image                             | Vernier I                          |          |          | Vernier II                         |          |          |
|-----------------------------------|------------------------------------|----------|----------|------------------------------------|----------|----------|
|                                   | MSR                                | VSC      | TR       | MSR                                | VSC      | TR       |
|                                   | (degree)                           | (degree) | (degree) | (degree)                           | (degree) | (degree) |
| Refracted image (R <sub>3</sub> ) | 39.5                               | 20       | 39°50'   | 219.5                              | 22       | 219°52'  |
| Direct image (R <sub>4</sub> )    | 0                                  | 0        | 0        | 180                                | 0        | 180°     |
| Difference                        | D= R <sub>3</sub> ~ R <sub>4</sub> |          | 39°50'   | D= R <sub>3</sub> ~ R <sub>4</sub> |          | 39°52'   |

### CALCULATIONS :

#### TABLE (i)

$$\begin{aligned} \text{Vernier I : } 2A &= R_1 \sim R_2 = 156^\circ 16' = 36^\circ 12' = 120^\circ 4' \\ \text{Vernier II : } 2A &= R_1 \sim R_2 = 336^\circ 20' = 216^\circ 16' = 120^\circ 4' \\ \text{Mean : } 2A &= \frac{120^\circ 4' + 120^\circ 4'}{2} = \frac{240^\circ 8'}{2} = 120^\circ 4' \\ \therefore A &= 60^\circ 2' \end{aligned}$$

#### TABLE (ii)

$$\begin{aligned} \text{Vernier I : } D &= R_3 \sim R_4 = 39^\circ 50' - 0^\circ = 39^\circ 50' \\ \text{Vernier II : } D &= R_3 \sim R_4 = 219^\circ 52' - 180^\circ = 39^\circ 52' \\ \text{Mean : } D &= \frac{39^\circ 50' + 39^\circ 52'}{2} = \frac{78^\circ 102'}{2} = 39^\circ 51' \\ \frac{A + D}{2} &= \frac{60^\circ 2' + 39^\circ 51'}{2} = \frac{99^\circ 53'}{2} = 49^\circ 56' \\ \frac{A}{2} &= \frac{60^\circ 2'}{2} = 30^\circ 1' \end{aligned}$$

- The refractive index of the material of the prism,

$$\begin{aligned} \mu &= \frac{\sin\left(\frac{A + D}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin 49^\circ 56'}{\sin 30^\circ 1'} \\ \mu &= \frac{0.7585}{0.5009} \\ \mu &= 1.514 \end{aligned}$$

### RESULT :

- Angle of the Prism ;  $A = 60^\circ 2'$
- Angle of the minimum deviation of the prism ;  $D = 39^\circ 51'$
- Refractive index of the material of the Prism ;  $\mu = 1.514$  (No unit)

## Experiment - 5

Date :

### SPECTROMETER WITH DIFFRACTION GRATING

#### AIM:

- To find the wavelength of the constituent colours of a composite light using diffraction grating and spectrometer.

#### FORMULA:

- The wavelength ( $\lambda$ ) of a spectral line using normal incidence arrangement of the grating is

$$\lambda = \frac{\sin \theta}{n N}$$

Where,

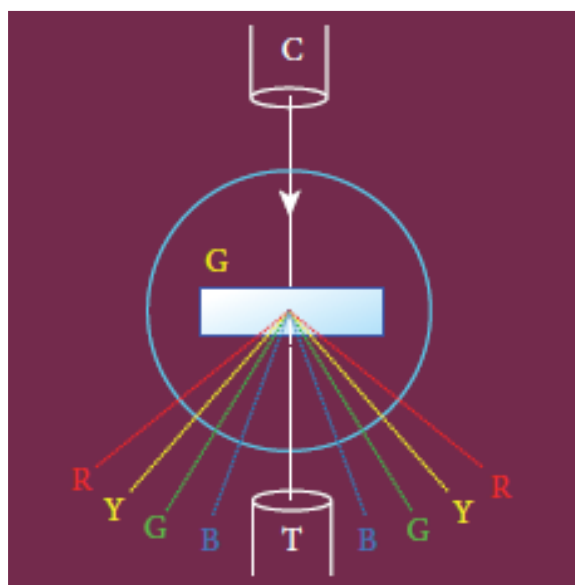
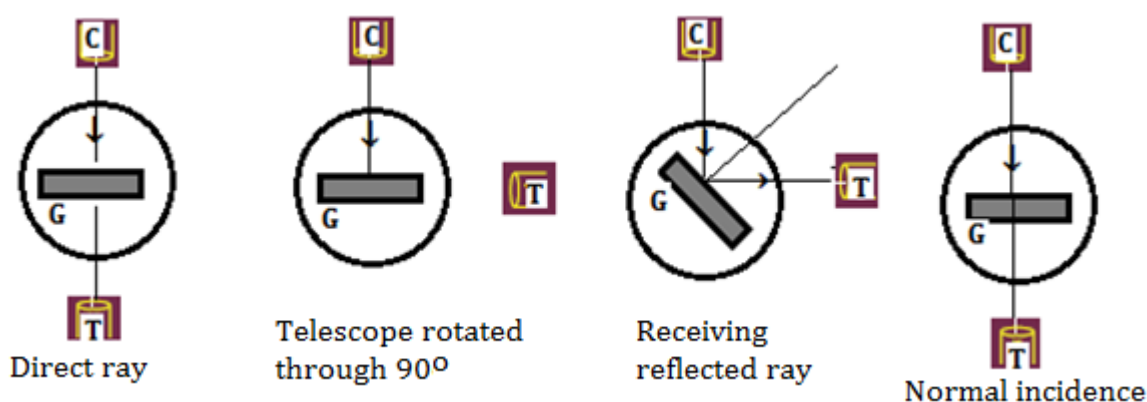
$\theta \rightarrow$  angle of diffraction (degree)

$n \rightarrow$  order of diffraction ( $n=1$ )

$N \rightarrow$  Number of lines per unit length drawn on the grating

#### DIAGRAM:

##### 1. Adjusting for normal incidence :



#### PROCEDURE:

##### (1) Initial adjustments of the spectrometer :

- The eye-piece of the telescope is adjusted so that the cross-wires are seen clearly.
- The slit of the collimator is adjusted such that it is very thin and vertical.
- The base of the spectrometer is adjusted to be horizontal using leveling screws.
- The telescope is turned towards a distant object and is adjusted till the clear image of the distant object is seen. Now the telescope is adjusted to receive parallel rays.
- The telescope is brought in line with the collimator. Collimator is adjusted until a clear image of the slit is seen in the telescope. Now the collimator gives parallel rays.
- Using a spirit level, the grating table is adjusted to be horizontal with the three leveling screws provided in the grating table.

## (2) Adjustment of the grating for normal incidence :

- The slit is illuminated with a composite light (white light) from mercury vapour lamp.
- The telescope is brought in line with the collimator. The vertical cross-wire is made to coincide with the image of the slit.
- The vernier disc alone is rotated till the vernier scale reads  $0^{\circ} - 180^{\circ}$  and is fixed. This is the reading for the direct ray.
- The telescope is then rotated (anti-clockwise) through an angle of  $90^{\circ}$  and fixed.
- Now the plane transmission grating is mounted on the grating table.
- The grating table alone is rotated so that the light reflected from the grating coincides with vertical cross-wire of the telescope. The reflected image is white in colour.
- Now the vernier disc is released. The vernier disc along with grating table is rotated through an angle of  $45^{\circ}$  in the appropriate direction such that the light from the collimator is incident normally on the grating.

## (3) Determination of wave length of the constituent colours of the mercury spectrum

- The telescope is released and is brought in line with the collimator to receive central direct image. This undispersed image is white in colour.
- The diffracted images of the slit are observed on either side of the direct image.
- The diffracted image consists of the prominent colours of mercury spectrum in increasing order of wavelength.
- The telescope is turned to any one side (say left) of direct image to observe first order diffracted image.
- The vertical cross-wire is made to coincide with the prominent spectral lines (violet, blue, yellow and red) and the readings of both vernier scales for each case are noted.
- Now the telescope is rotated to the right side of the direct image and the first order image is observed.
- The vertical cross-wire is made to coincide with the same prominent spectral lines and the readings of both vernier scales for each case are again noted.
- The readings are tabulated. The difference between these two readings gives the value of  $2\theta$  for the particular spectral line.
- The number of lines per metre length of the given grating  $N$  is noted from the grating.
- From the values of  $N$ ,  $n$  and  $\theta$ , the wave length of the prominent colours of the mercury light is determined using the given formula.

### TABULAR COLUMN AND OBSERVATIONS :

$$\text{Least count (LC)} = 1'$$

$$TR = MSR + (VSC \times LC)$$

| Colour | Diffracted ray reading (degree) |     |         |            |     |         |           |     |         |            |     |         | Difference<br>2 θ<br>(degree) |            |        | θ<br>(degree) |
|--------|---------------------------------|-----|---------|------------|-----|---------|-----------|-----|---------|------------|-----|---------|-------------------------------|------------|--------|---------------|
|        | Left                            |     |         |            |     |         | Right     |     |         |            |     |         |                               |            |        |               |
|        | Vernier I                       |     |         | Vernier II |     |         | Vernier I |     |         | Vernier II |     |         |                               |            |        |               |
|        | MSR                             | VSC | TR      | MSR        | VSC | TR      | MSR       | VSC | TR      | MSR        | VSE | TR      | Vernier I                     | Vernier II | Mean   |               |
| Blue   | 122.5                           | 15  | 122°45' | 302.5      | 10  | 302°40' | 147.5     | 15  | 147°45' | 327.5      | 0   | 327°30' | 25°                           | 24°50'     | 24°55' | 12°28'        |
| Green  | 119.5                           | 9   | 119°39' | 299.5      | 0   | 299°30' | 151       | 0   | 151°    | 330.5      | 19  | 330°49' | 31°21'                        | 31°19'     | 31°20' | 15°40'        |
| Yellow | 118.5                           | 13  | 118°43' | 298.5      | 0   | 298°30' | 151.5     | 21  | 151°51' | 331.5      | 12  | 331°42' | 33°8'                         | 33°12'     | 33°10' | 16°35'        |
| Red    | 117                             | 29  | 117°29' | 297        | 20  | 297°20' | 153       | 9   | 153°9'  | 333        | 0   | 333°    | 35°40'                        | 35°40'     | 35°40' | 17°50'        |

## CALCULATIONS :

### (1) For blue colour :

- Vernier - I ;  $2\theta = 147^{\circ}45' - 122^{\circ}45' = 25^{\circ}$   
Vernier -II ;  $2\theta = 327^{\circ}30' - 302^{\circ}40' = 24^{\circ}50'$   
Mean :  $2\theta = \frac{25^{\circ} + 24^{\circ}50'}{2} = \frac{49^{\circ}50'}{2} = 24^{\circ}55'$

(or)  $\theta_B = 12^{\circ}28'$

- Hence Wavelength of blue colour ;

$$\lambda_B = \frac{\sin \theta_B}{n N} = \frac{\sin 12^{\circ}28'}{1 \times 5 \times 10^5} = \frac{0.2164 \times 10^{-5}}{5} = 0.04328 \times 10^{-5}$$

$$\lambda_B = 4328 \times 10^{-10} \text{ m} = 4328 \text{ \AA}$$

### (2) For green colour :

- Vernier - I ;  $2\theta = 151^{\circ} - 119^{\circ}39' = 31^{\circ}21'$   
Vernier -II ;  $2\theta = 330^{\circ}49' - 299^{\circ}30' = 31^{\circ}19'$   
Mean :  $2\theta = \frac{31^{\circ}21' + 31^{\circ}19'}{2} = \frac{62^{\circ}40'}{2} = 31^{\circ}20'$

(or)  $\theta_G = 15^{\circ}40'$

- Hence wavelength of green colour ;

$$\lambda_G = \frac{\sin \theta_G}{n N} = \frac{\sin 15^{\circ}40'}{1 \times 5 \times 10^5} = \frac{0.2672 \times 10^{-5}}{5} = 0.05344 \times 10^{-5}$$

$$\lambda_G = 5344 \times 10^{-10} \text{ m} = 5344 \text{ \AA}$$

### (3) For yellow colour :

- Vernier - I ;  $2\theta = 151^{\circ}51' - 118^{\circ}43' = 33^{\circ}8'$   
Vernier -II ;  $2\theta = 331^{\circ}42' - 298^{\circ}30'' = 33^{\circ}12'$   
Mean :  $2\theta = \frac{33^{\circ}8' + 33^{\circ}12'}{2} = \frac{66^{\circ}20'}{2} = 33^{\circ}10'$

(or)  $\theta_Y = 16^{\circ}35'$

- Hence wavelength of yellow colour ;

$$\lambda_Y = \frac{\sin \theta_Y}{n N} = \frac{\sin 16^{\circ}35'}{1 \times 5 \times 10^5} = \frac{0.2840 \times 10^{-5}}{5} = 0.05680 \times 10^{-5}$$

$$\lambda_Y = 5680 \times 10^{-10} \text{ m} = 5680 \text{ \AA}$$

### (4) For red colour :

- Vernier - I ;  $2\theta = 153^{\circ}9' - 117^{\circ}29' = 35^{\circ}40''$   
Vernier -II ;  $2\theta = 333^{\circ} - 297^{\circ}20' = 35^{\circ}40'$   
Mean :  $2\theta = \frac{35^{\circ}40' + 35^{\circ}40'}{2} = \frac{70^{\circ}80'}{2} = 35^{\circ}40'$

(or)  $\theta_R = 17^{\circ}50'$

- Hence wavelength of yellow colour ;

$$\lambda_R = \frac{\sin \theta_R}{n N} = \frac{\sin 17^{\circ}50'}{1 \times 5 \times 10^5} = \frac{0.3090 \times 10^{-5}}{5} = 0.06180 \times 10^{-5}$$

$$\lambda_R = 6180 \times 10^{-10} \text{ m} = 6180 \text{ \AA}$$

## RESULT :

- Wavelength of composite colours of mercury vapour lamp ;
  - Wavelength of blue line :  $\lambda_B = 4328 \times 10^{-10} \text{ m} = 4328 \text{ \AA}$
  - Wavelength of green line :  $\lambda_G = 5344 \times 10^{-10} \text{ m} = 5344 \text{ \AA}$
  - Wavelength of yellow line :  $\lambda_Y = 5680 \times 10^{-10} \text{ m} = 5680 \text{ \AA}$
  - Wavelength of red line :  $\lambda_R = 6180 \times 10^{-10} \text{ m} = 6180 \text{ \AA}$

## Experiment - 6

Date :

### VOLTAGE – CURRENT CHARACTERISTICS OF A PN JUNCTION DIODE

#### AIM :

- To draw the voltage-current (V- I) characteristics of the PN junction diode and to determine its knee voltage and forward resistance.

#### APPARATUS REQUIRED :

- PN junction diode (IN4007), variable DC power supply, milli-ammeter, micro-ammeter, voltmeter, resistance and connecting wires.

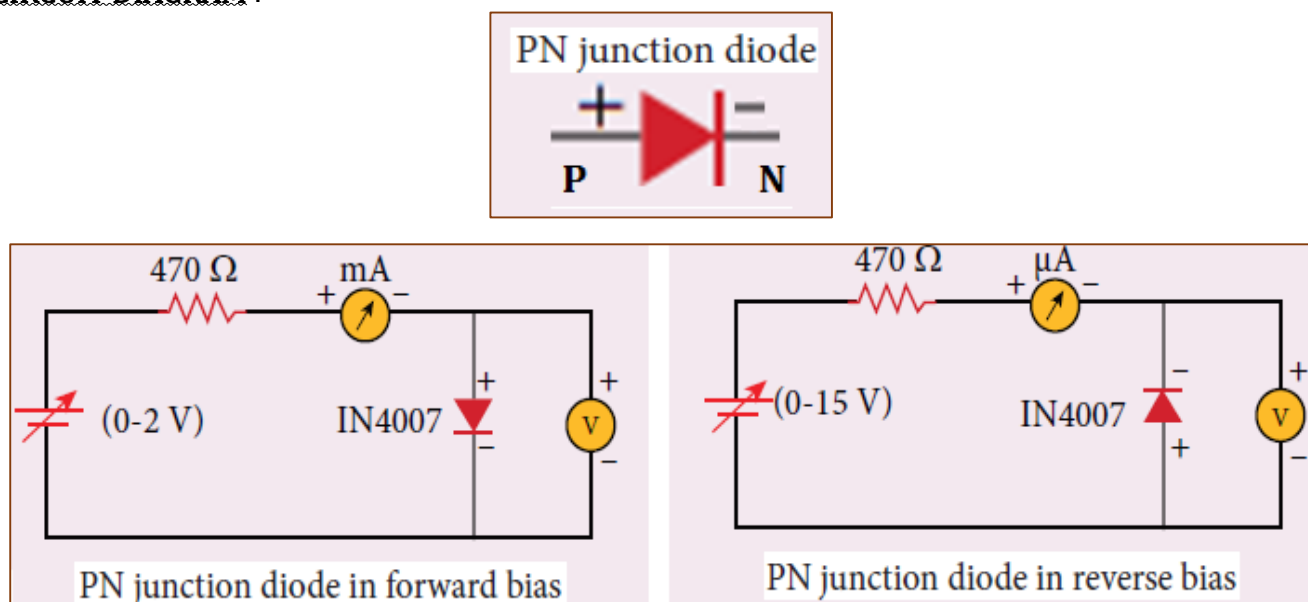
#### FORMULA :

- Forward resistance of the PN junction diode

$$R_f = \frac{\Delta V_f}{\Delta I_f}$$

Where,  $\Delta V_f \rightarrow$  change in forward voltage (volt)  
 $\Delta I_f \rightarrow$  change in forward current (volt)

#### CIRCUIT DIAGRAM :



#### PROCEDURE :

##### (1) Forward bias characteristics :

- In the forward bias, the P- region of the diode is connected to the positive terminal and N-region to the negative terminal of the DC power supply.
- The connections are given as per the circuit diagram.
- The voltage across the diode can be varied with the help of the variable DC power supply.
- The forward voltage ( $V_F$ ) across the diode is increased from 0.1 V in steps of 0.1 V up to 0.8 V and the forward current ( $I_F$ ) through the diode is noted from the milli-ammeter. The readings are tabulated.
- The forward voltage  $V_F$  and the forward current  $I_F$  are taken as positive.
- A graph is drawn taking the forward voltage ( $V_F$ ) along the x-axis and the forward current ( $I_F$ ) along the y-axis.
- The voltage corresponding to the dotted line in the forward characteristics gives the knee voltage or threshold voltage or turn-on voltage of the diode.
- The slope in the linear portion of the forward characteristics is calculated. The reciprocal of the slope gives the forward resistance of the diode.

##### (2) Reverse bias characteristics :

- In the reverse bias, the polarity of the DC power supply is reversed so that the P- region of the diode is connected to the negative terminal and N-region to the positive terminal of the DC power supply.
- The connections are made as given in the circuit diagram.

- The voltage across the diode can be varied with the help of the variable DC power supply.
- The reverse voltage ( $V_R$ ) across the diode is increased from 1 V in steps of 1 V up to 5 V and the reverse current ( $I_R$ ) through the diode is noted from the micro-ammeter. The readings are tabulated.
- The reverse voltage  $V_R$  and reverse current  $I_R$  are taken as negative.
- A graph is drawn taking the reverse bias voltage ( $V_R$ ) along negative x-axis and the reverse bias current ( $I_R$ ) along negative y-axis.

#### TABULAR COLUMN AND OBSERVATIONS :

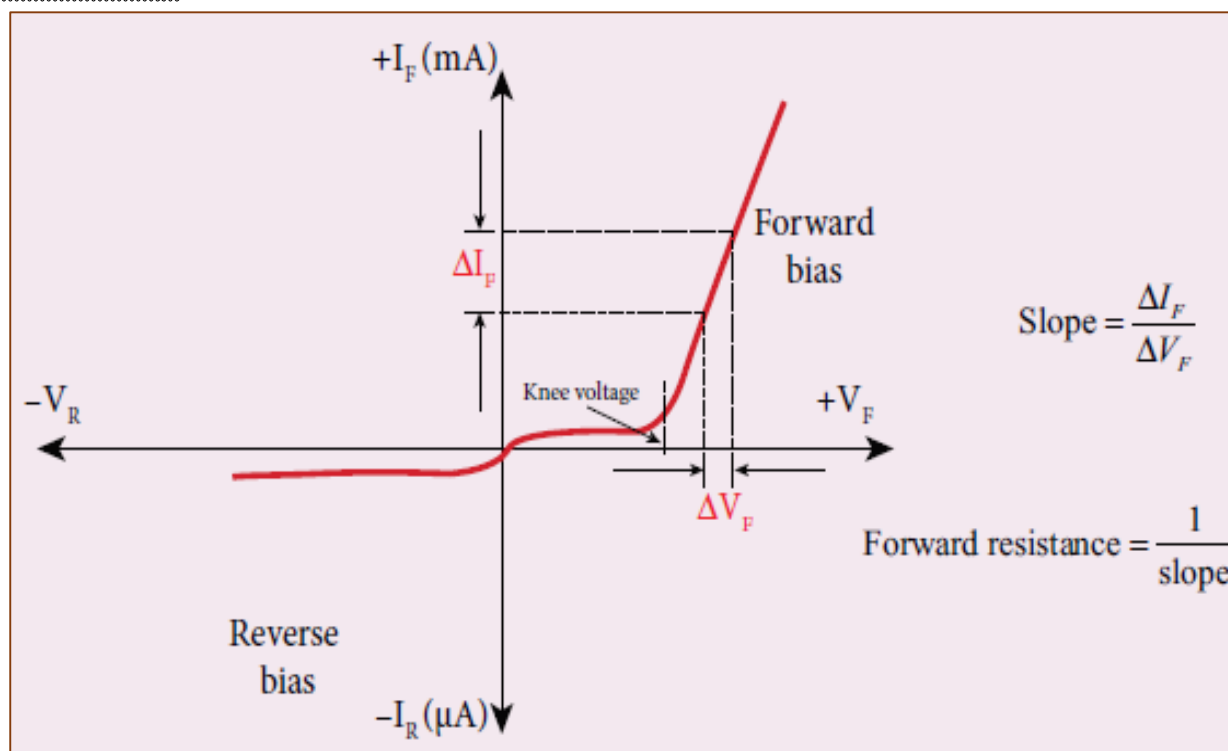
##### (1) Forward bias characteristics

| S.No | Forward bias voltage<br>$V_F$ | Forward bias current<br>$I_F$ |
|------|-------------------------------|-------------------------------|
|      | V                             | mA                            |
| 1    | 0.1                           | 0                             |
| 2    | 0.2                           | 0                             |
| 3    | 0.3                           | 0                             |
| 4    | 0.4                           | 0                             |
| 5    | 0.5                           | 0.5                           |
| 6    | 0.6                           | 3.5                           |
| 7    | 0.7                           | 17.5                          |

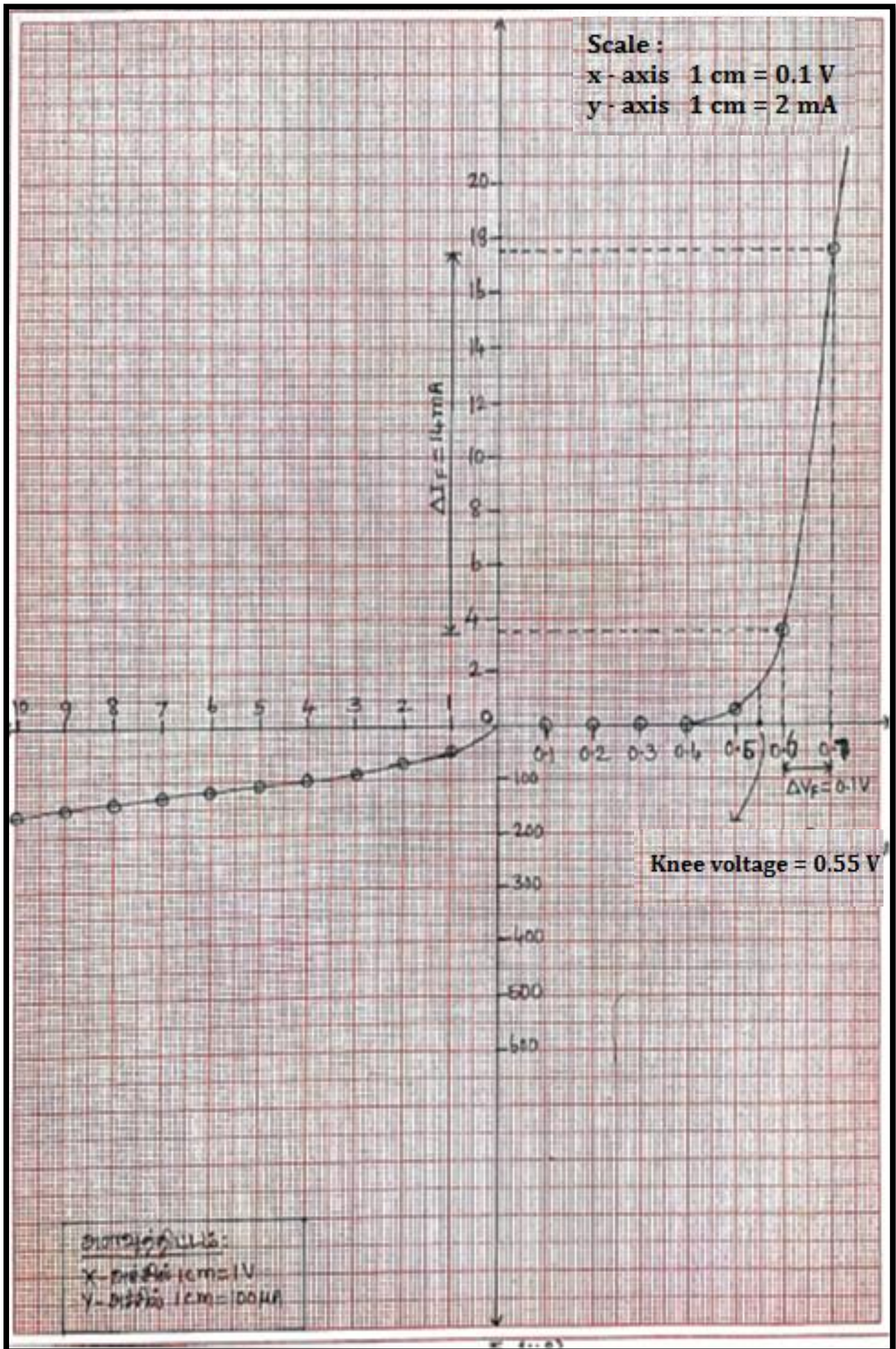
##### (2) Reverse bias characteristics

| S.No | Reverse bias voltage<br>$V_R$ | Reverse bias current<br>$I_R$ |
|------|-------------------------------|-------------------------------|
|      | V                             | $\mu A$                       |
| 1    | 1                             | 50                            |
| 2    | 2                             | 70                            |
| 3    | 3                             | 90                            |
| 4    | 4                             | 100                           |
| 5    | 5                             | 110                           |
| 6    | 6                             | 120                           |
| 7    | 7                             | 130                           |
| 8    | 8                             | 140                           |
| 9    | 9                             | 150                           |
| 10   | 10                            | 160                           |

#### MODEL GRAPH :



# GRAPH :



### CALCULATION :

- From the graph, the knee voltage is =  $0.55\text{ V}$
- Also from the graph,

$$\Delta V_F = 0.1\text{ V}$$

$$\Delta I_F = 14\text{ mA} = 14 \times 10^{-3}\text{ A}$$

$$\text{Hence, Slope} = \frac{\Delta I_F}{\Delta V_F}$$

- Therefore Forward resistance,

$$R_F = \frac{1}{\text{slope}} = \frac{\Delta V_F}{\Delta I_F}$$

$$R_F = \frac{0.1}{14 \times 10^{-3}} = 0.007142 \times 10^3$$

$$R_F = 7.142\ \Omega$$

### **RESULT**

- The V-I characteristics of the PN junction diode are studied.

(1) Knee voltage of the PN junction diode =  $0.55\text{ V}$

(2) Forward resistance of the diode ;  $R_F = 7.142\ \Omega$

## Experiment - 7

Date :

### VOLTAGE-CURRENT CHARACTERISTICS OF A ZENER DIODE

#### AIM :

- To draw the voltage-current (V-I) characteristic curves of a Zener diode and to determine its knee voltage, forward resistance and reverse breakdown voltage.

#### APPARATUS REQUIRED :

- Zener diode 1Z5.6V, variable dc power supply (0 - 15V), milli ammeter, volt meter, 470  $\Omega$  resistance, and connecting wires.

#### FORMULA :

- Forward resistance of the PN junction diode

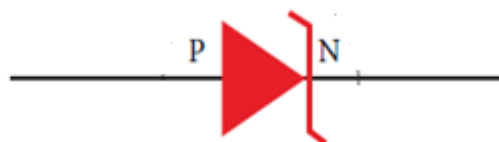
$$R_f = \frac{\Delta V_f}{\Delta I_f}$$

Where,

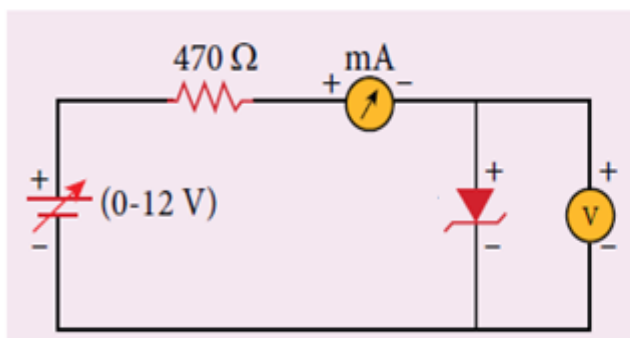
$\Delta V_f \rightarrow$  change in forward voltage (volt)

$\Delta I_f \rightarrow$  change in forward current (volt)

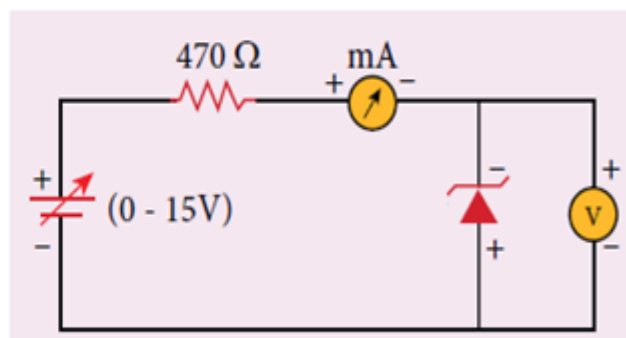
#### CIRCUIT DIAGRAM :



Zener diode in forward bias



Zener diode in reverse bias



#### PROCEDURE :

##### i) Forward bias characteristics :

- In the forward bias, the P- region of the diode is connected to the positive terminal and N- region to the negative terminal of the DC power supply.
- The connections are given as per the circuit diagram.
- The voltage across the diode can be varied with the help of the variable DC power supply.
- The forward voltage ( $V_f$ ) across the diode is increased from 0.1V in steps of 0.1V up to 0.8V and the forward current ( $I_f$ ) through the diode is noted from the milli-ammeter.
- The readings are tabulated.
- The forward voltage and the forward current are taken as positive.
- A graph is drawn taking the forward voltage along the x-axis and the forward current along the y-axis.
- The voltage corresponding to the dotted line in the forward characteristics gives the knee voltage or threshold voltage or turn-on voltage of the diode.
- The slope in the linear portion of the forward characteristics is calculated. The reciprocal of the slope gives the forward resistance of the diode.

##### ii) Reverse bias characteristics :

- In the reverse bias, the polarity of the DC power supply is reversed so that the P- region of the diode is connected to the negative terminal and N-region to the positive terminal of the DC power supply
- The connections are made as given in the circuit diagram.

- The voltage across the diode can be varied with the help of the variable DC power supply.
- The reverse voltage ( $V_R$ ) across the diode is increased from 0.5V in steps of 0.5V up to 6V and the reverse current ( $I_R$ ) through the diode is noted from the milli-ammeter. The readings are tabulated.
- Initially, the voltage is increased in steps of 0.5V. When the breakdown region is approximately reached, then the input voltage may be raised in steps of, say 0.1V to find the breakdown voltage.
- The reverse voltage and reverse current are taken as negative.
- A graph is drawn taking the reverse bias voltage along negative x-axis and the reverse bias current along negative y-axis.
- In the reverse bias, Zener breakdown occurs at a particular voltage called Zener voltage  $V_Z$  and a large amount of current flows through the diode which is the characteristics of a Zener diode.
- The breakdown voltage of the Zener diode is determined from the graph as shown.

#### TABULAR COLUMN AND OBSERVATIONS :

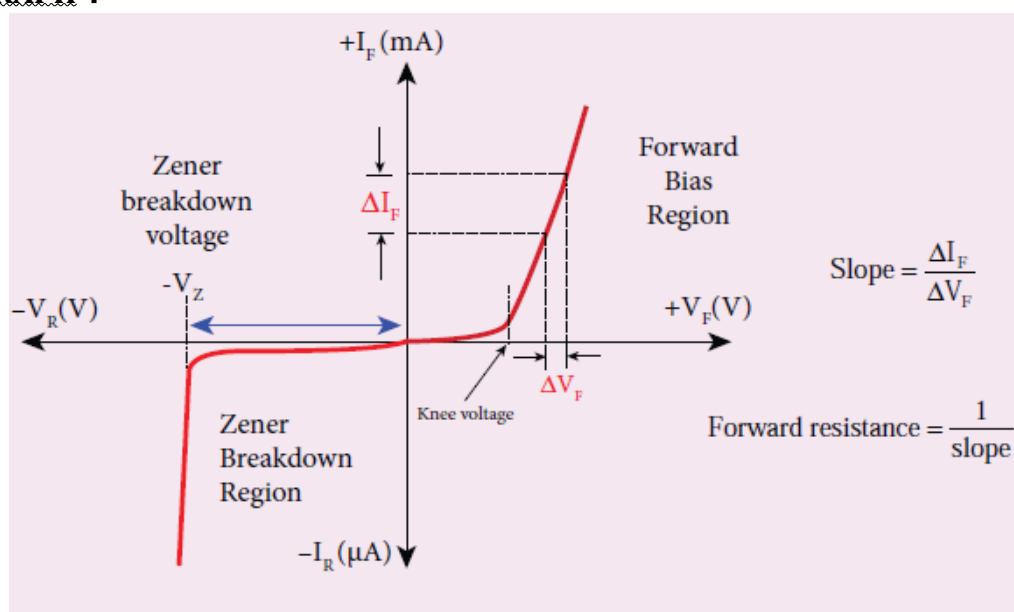
##### (1) Forward bias characteristics

| S.No | Forward bias voltage<br>$V_F$ | Forward bias current<br>$I_F$ |
|------|-------------------------------|-------------------------------|
|      | V                             | mA                            |
| 1    | 0.1                           | 0                             |
| 2    | 0.2                           | 0                             |
| 3    | 0.3                           | 0                             |
| 4    | 0.4                           | 0                             |
| 5    | 0.5                           | 0                             |
| 6    | 0.6                           | 0                             |
| 7    | 0.7                           | 0                             |
| 8    | 0.8                           | 4                             |
| 9    | 0.9                           | 14                            |

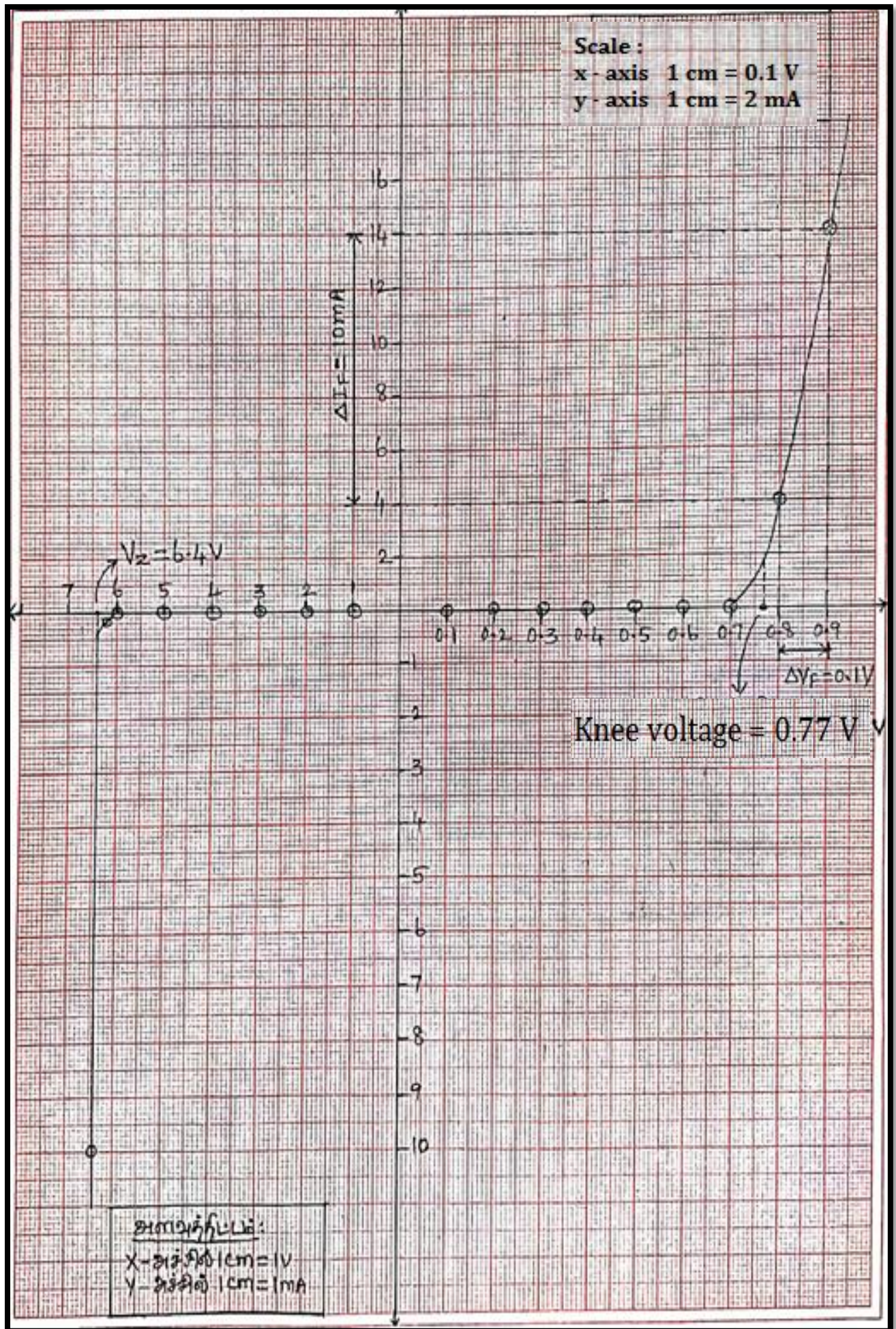
##### (2) Reverse bias characteristics

| S.No | Reverse bias voltage<br>$V_R$ | Reverse bias current<br>$I_R$ |
|------|-------------------------------|-------------------------------|
|      | V                             | mA                            |
| 1    | 1                             | 0                             |
| 2    | 2                             | 0                             |
| 3    | 3                             | 0                             |
| 4    | 4                             | 0                             |
| 5    | 5                             | 0                             |
| 6    | 6                             | 0                             |
| 7    | 6.2                           | 0.2                           |
| 8    | 6.3                           | 0.5                           |
| 9    | 6.4                           | 10                            |
| 10   | 10                            | 160                           |

#### MODEL GRAPH :



# GRAPH :



### CALCULATION :

- From the graph, the knee voltage is =  $0.77\text{ V}$
- Also from the graph,

$$\Delta V_F = 0.1\text{ V}$$

$$\Delta I_F = 10\text{ mA} = 10 \times 10^{-3}\text{ A}$$

$$\text{Hence, Slope} = \frac{\Delta I_F}{\Delta V_F}$$

- Therefore Forward resistance,

$$R_F = \frac{1}{\text{slope}} = \frac{\Delta V_F}{\Delta I_F}$$

$$R_F = \frac{0.1}{10 \times 10^{-3}} = 0.01 \times 10^3$$

$$R_F = 10\ \Omega$$

### RESULT :

- The V-I characteristics of the Zener diode are studied.

$$(1) \text{ Forward resistance of the diode} : R_F = 10\ \Omega$$

$$(2) \text{ Knee voltage} = 0.77\text{ V}$$

$$(3) \text{ The breakdown voltage of the Zener diode} : V_Z = 6.4\text{ V}$$

## Experiment - 8

Date :

### CHARACTERISTICS OF A NPN JUNCTION TRANSISTOR IN CE CONFIGURATION

#### AIM :

- To study the characteristics and to determine the current gain of a NPN junction transistor in common emitter configuration.

#### APPARATUS REQUIRED :

- Transistor - BC 548/BC107, bread board, micro ammeter, milli ammeter, voltmeters variable DC power supply and connecting wires.

#### FORMULA :

(1) Input impedance,

$$r_i = \left[ \frac{\Delta V_{BE}}{\Delta I_B} \right]_{V_{CE}}$$

Where,  $\Delta V_{BE} \rightarrow$  The change in base-emitter voltage (volt)

$\Delta I_B \rightarrow$  The change in base current ( $\mu A$ )

(2) Output impedance,

$$r_o = \left[ \frac{\Delta V_{CE}}{\Delta I_C} \right]_{I_B}$$

Where,  $\Delta V_{CE} \rightarrow$  The change in collector-emitter voltage (volt)

$\Delta I_C \rightarrow$  The change in collector current (mA)

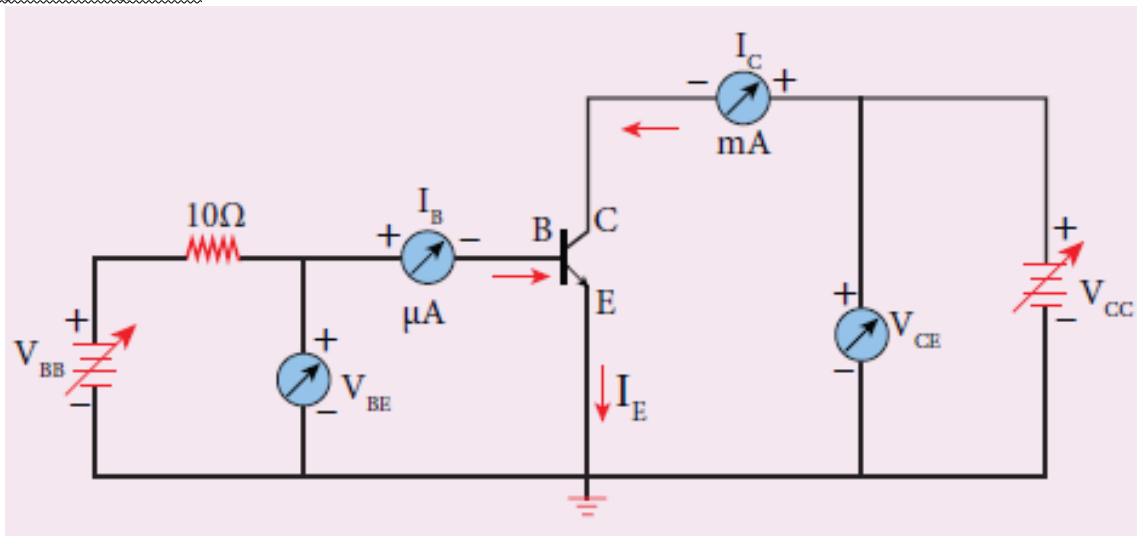
(3) Current gain,

$$\beta = \left[ \frac{\Delta I_C}{\Delta I_B} \right]_{V_{CE}}$$

Where,  $\Delta I_B \rightarrow$  The change in base current ( $\mu A$ )

$\Delta I_C \rightarrow$  The change in collector current (mA)

#### CIRCUIT DIAGRAM :



#### PROCEDURE :

- The connections are given as shown in the diagram.
- The current and voltage at the input and output regions can be varied by adjusting the DC power supply.

#### (i) Input characteristic curve : $V_{BE}$ vs $I_B$ ( $V_{CE}$ constant)

- The collector-emitter voltage  $V_{CE}$  is kept constant.
- The base-emitter voltage  $V_{BE}$  is varied in steps of 0.1 V and the corresponding base current ( $I_B$ ) is noted. The readings are taken till  $V_{CE}$  reaches a constant value.
- The same procedure is repeated for different values of  $V_{CE}$ . The readings are tabulated.
- A graph is plotted by taking  $V_{BE}$  along x-axis and  $I_B$  along y-axis for both the values of  $V_{CE}$ .
- The curves thus obtained are called the input characteristics of a transistor.
- The reciprocal of the slope of these curves gives the input impedance of the transistor.

### (ii) Output characteristic curve : $V_{CE}$ vs $I_C$ ( $I_B$ constant)

- The base current  $I_B$  is kept constant.  $V_{CE}$  is varied in steps of 1V and the corresponding collector current  $I_C$  is noted.
- The readings are taken till the collector current becomes almost constant.
- Initially  $I_B$  is kept at 0 mA and the corresponding collector current is noted. This current is the reverse saturation current  $I_{CEO}$ .
- The experiment is repeated for various values of  $I_B$ . The readings are tabulated.
- A graph is drawn by taking  $V_{CE}$  along x-axis and  $I_C$  along y-axis for various values of  $I_B$ .
- The set of curves thus obtained is called the output characteristics of a transistor.
- The reciprocal of the slope of the curve gives output impedance of the transistor.

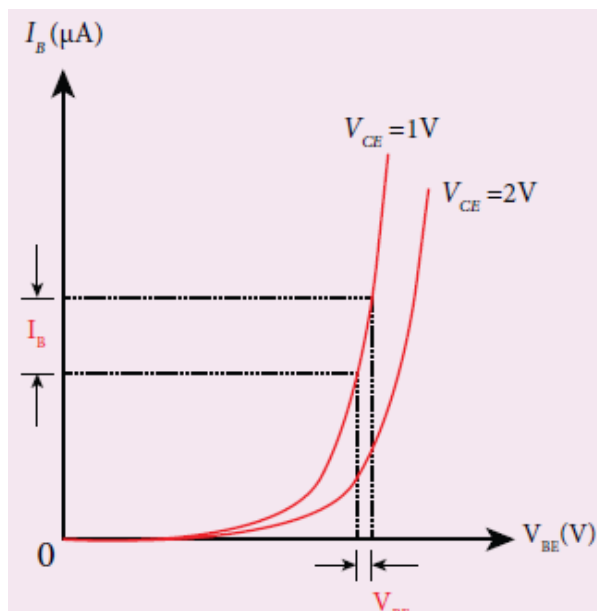
### (iii) Transfer characteristic curve : $I_B$ vs $I_C$ ( $V_{CE}$ constant)

- The collector-emitter voltage  $V_{CE}$  is kept constant.
- The base current  $I_B$  is varied in steps of 20  $\mu A$  and the corresponding collector current  $I_C$  is noted.
- The transfer characteristics is a plot between the input current  $I_B$  along x-axis and the output current  $I_C$  along y-axis keeping  $V_{CE}$  constant.
- The slope of the transfer characteristics plot gives the current gain  $\beta$  can be calculated.

### TABULAR COLUMN AND OBSERVATIONS :

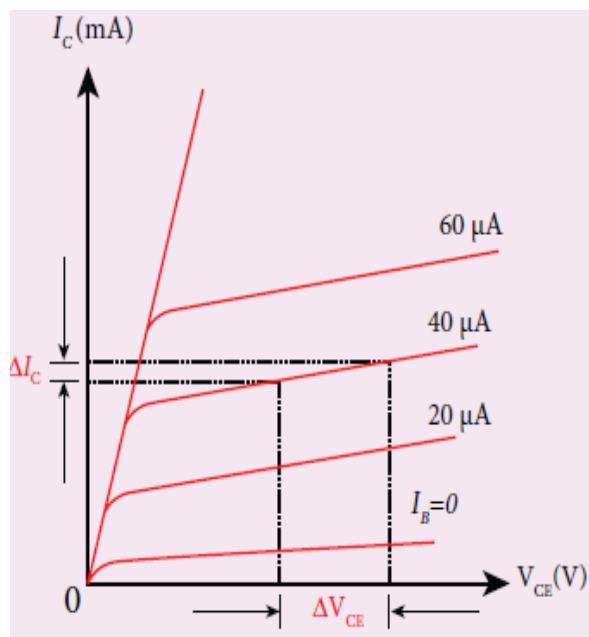
#### (i) For drawing Input characteristic curve :

| S.No | $V_{CE} = 2 V$ |             | $V_{CE} = 5 V$ |             |
|------|----------------|-------------|----------------|-------------|
|      | $V_{BE}$       | $I_B$       | $V_{BE}$       | $I_B$       |
|      | (V)            | ( $\mu A$ ) | (V)            | ( $\mu A$ ) |
| 1    | 0.1            | 0           | 0.1            | 0           |
| 2    | 0.2            | 0           | 0.2            | 0           |
| 3    | 0.3            | 0           | 0.3            | 0           |
| 4    | 0.4            | 0           | 0.4            | 0           |
| 5    | 0.5            | 0           | 0.5            | 0           |
| 6    | 0.6            | 12          | 0.6            | 14          |
| 7    | 0.7            | 48          | 0.7            | 76          |
| 8    | 0.8            | 86          | 0.8            | 192         |
| 9    | 0.9            | 148         | 0.9            | -           |
| 10   | 1.0            | 200         | 1.0            | -           |



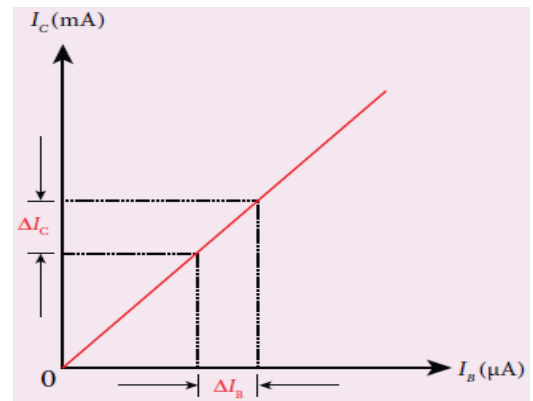
#### (ii) For drawing output characteristic curve :

| S.No | $I_B = 40 \mu A$ |       | $I_B = 60 \mu A$ |       |
|------|------------------|-------|------------------|-------|
|      | $V_{CE}$         | $I_C$ | $V_{CE}$         | $I_C$ |
|      | (V)              | (mA)  | (V)              | (mA)  |
| 1    | 0.2              | 1.7   | 0.2              | 2.8   |
| 2    | 0.4              | 2.6   | 0.4              | 4.0   |
| 3    | 0.6              | 2.7   | 0.6              | 4.3   |
| 4    | 0.8              | 2.8   | 0.8              | 4.4   |
| 5    | 1.0              | 2.8   | 1.0              | 4.5   |
| 6    | 2.0              | 2.8   | 2.0              | 4.6   |
| 7    | 3.0              | 2.8   | 3.0              | 4.7   |
| 8    | 4.0              | 2.8   | 4.0              | 4.8   |
| 9    | 5.0              | 2.8   | 5.0              | 5.0   |
| 10   | 6.0              | 2.8   | 6.0              | 5.0   |



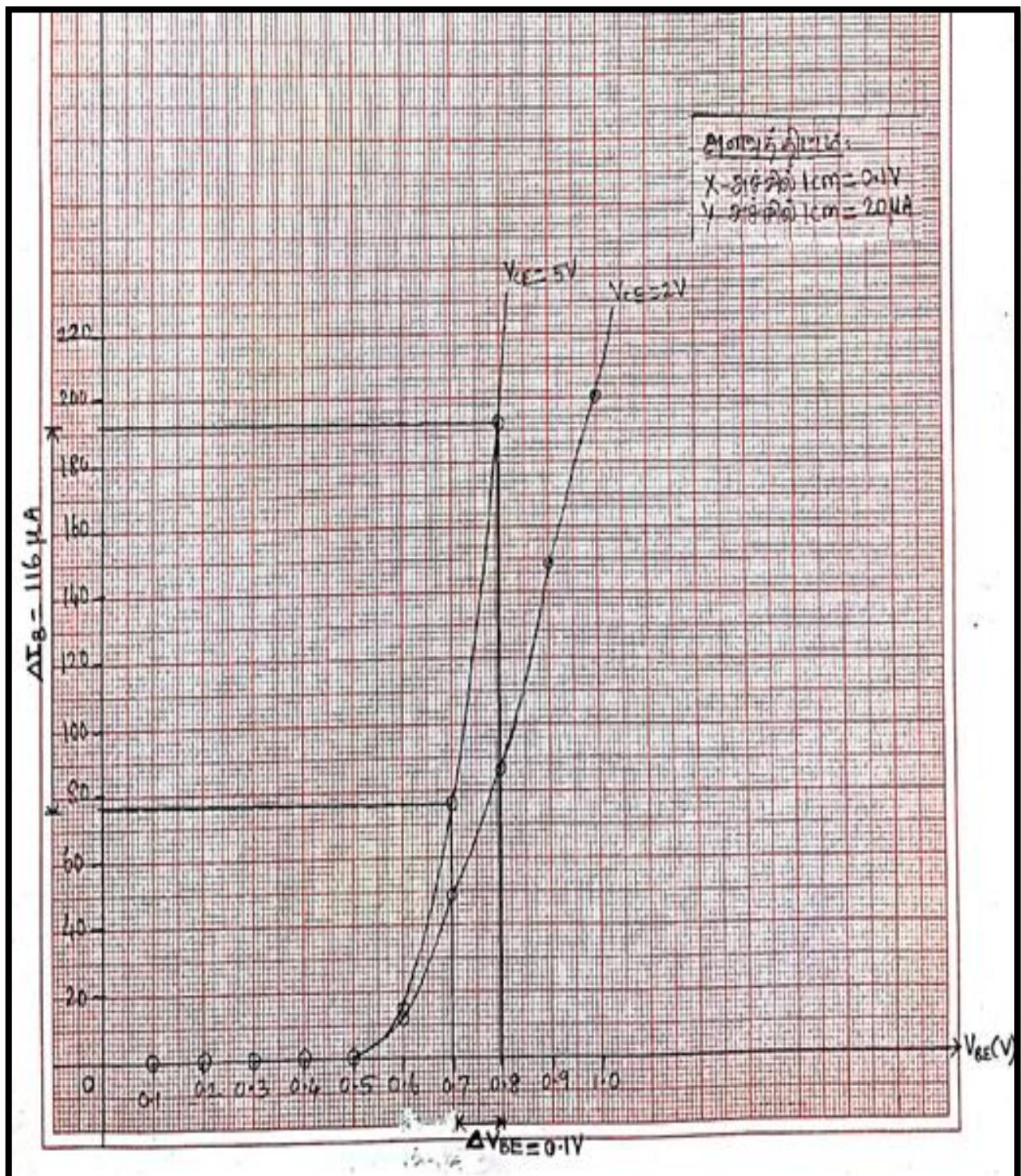
(iii) For drawing transfer characteristic curve :

| S.No | $V_{CE} = 5\text{ V}$ |       |
|------|-----------------------|-------|
|      | $I_B$                 | $I_C$ |
|      | ( $\mu\text{A}$ )     | (mA)  |
| 1    | 20                    | 0.2   |
| 2    | 40                    | 2.1   |
| 3    | 60                    | 4.2   |
| 4    | 80                    | 6.2   |



GRAPHS :

(i) Input characteristic curve :



#### CALCULATION :

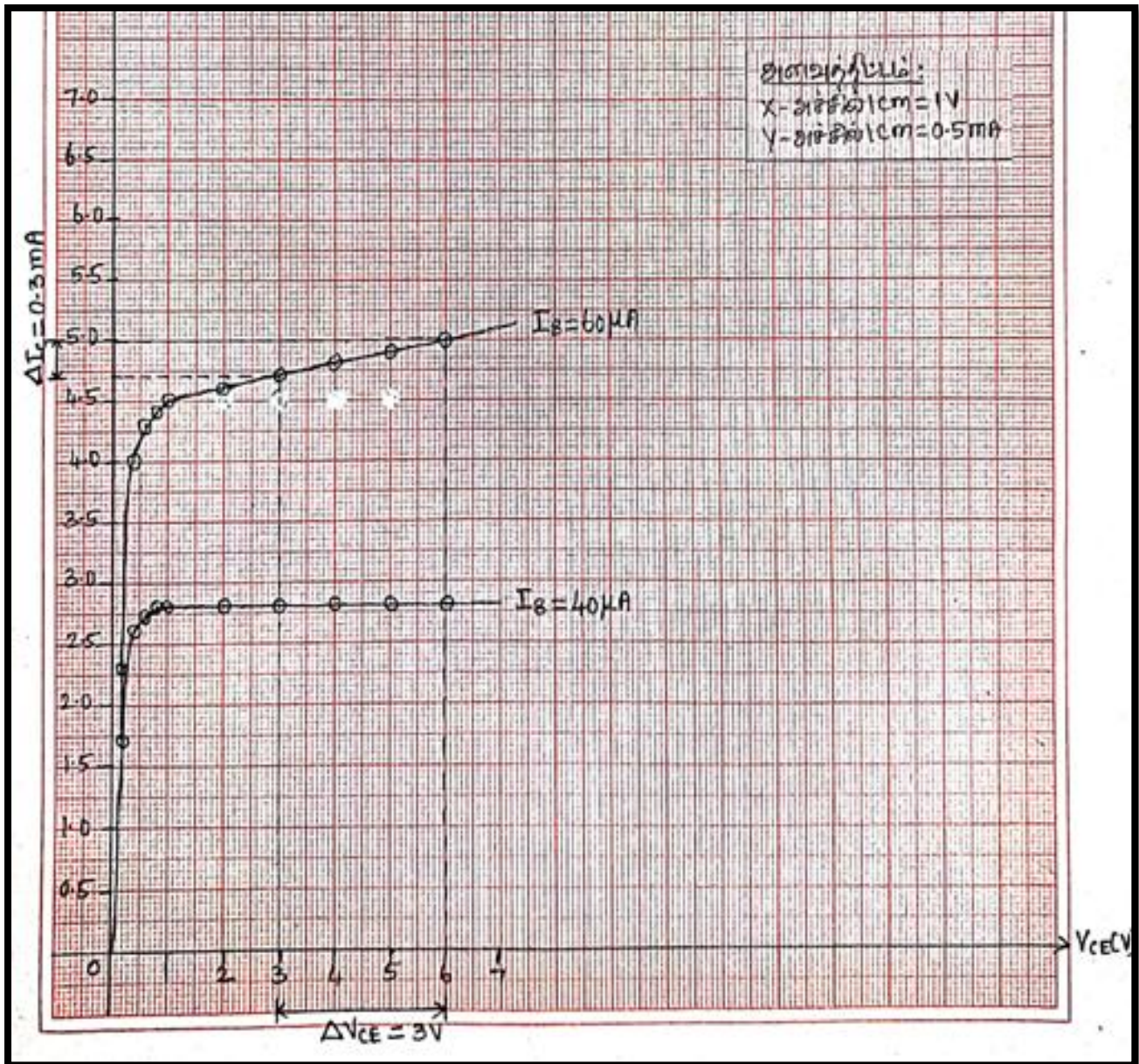
- From the input characteristic curve,  $\Delta V_{BE} = 0.1 \text{ V}$  and  $\Delta I_B = 116 \mu\text{A} = 116 \times 10^{-6} \text{ A}$
- Slope =  $\frac{\Delta I_B}{\Delta V_{BE}}$
- Hence, the input impedance ( $r_i$ ) of the transistor,

$$r_i = \frac{1}{\text{Slope}} = \frac{\Delta V_{BE}}{\Delta I_B}$$

$$r_i = \frac{0.1}{116 \times 10^{-6}} = 0.000862 \times 10^6$$

$$r_i = 862 \Omega$$

#### (ii) Output characteristic curve :



#### CALCULATION :

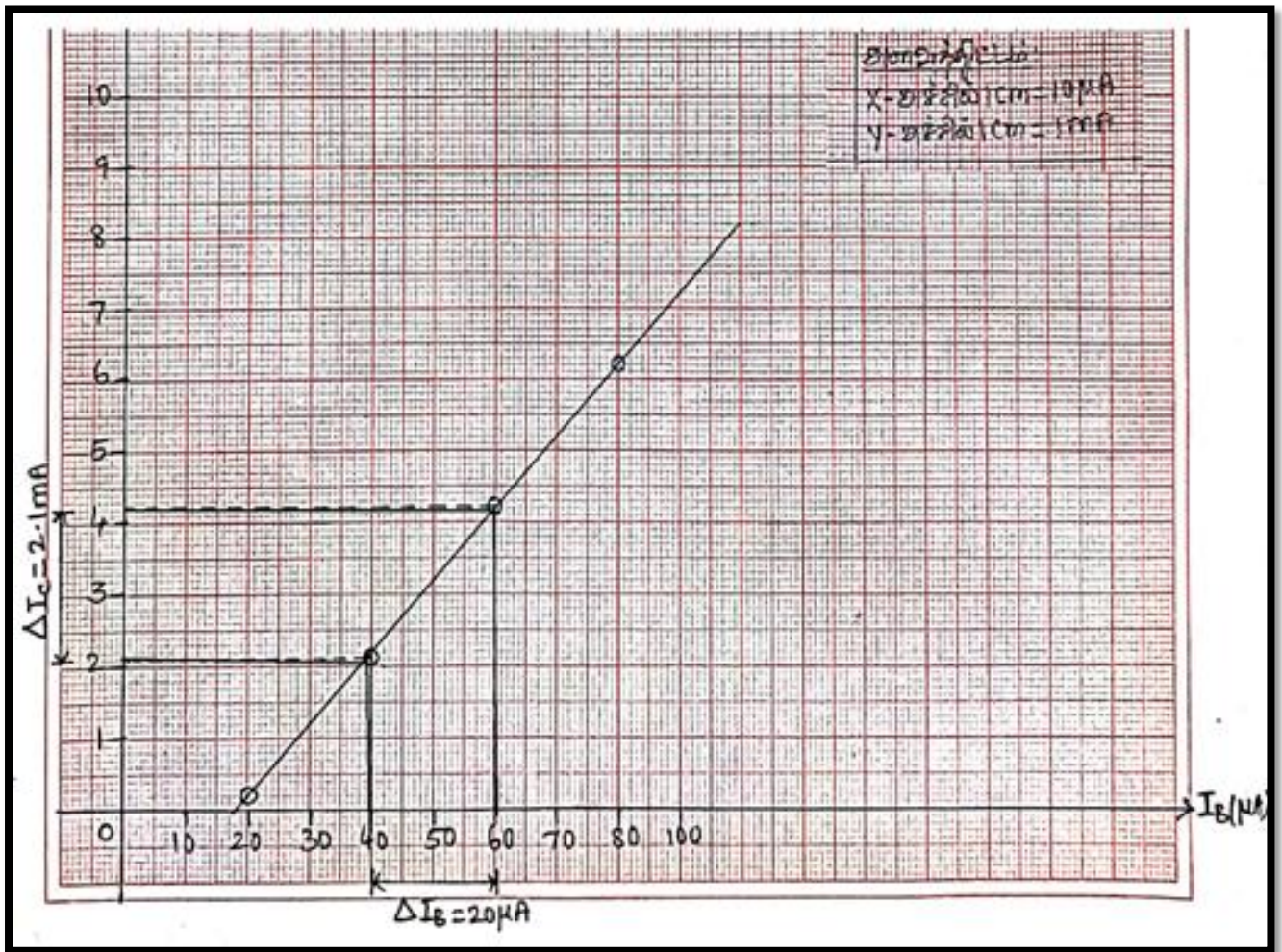
- From the output characteristic curve,  $\Delta V_{CE} = 3 \text{ V}$  and  $\Delta I_C = 0.3 \text{ mA} = 0.3 \times 10^{-3} \text{ A}$
- Slope =  $\frac{\Delta I_C}{\Delta V_{CE}}$
- Hence, the output impedance ( $r_o$ ) of the transistor,

$$r_o = \frac{1}{\text{Slope}} = \frac{\Delta V_{CE}}{\Delta I_C}$$

$$r_o = \frac{3}{0.3 \times 10^{-3}} = 10 \times 10^3$$

$$r_o = 10000 \Omega$$

(iii) Transfer characteristic curve :



CALCULATION :

- From the transfer characteristic curve,  $\Delta I_B = 20 \mu A = 20 \times 10^{-6} A$   
 $\Delta I_C = 2.1 mA = 2.1 \times 10^{-3} A$

- Slope =  $\frac{\Delta I_C}{\Delta I_B}$

- Current gain ( $\beta$ ) of the transistor,

$$\beta = \text{slope} = \frac{\Delta I_C}{\Delta I_B}$$

$$\beta = \frac{2.1 \times 10^{-3}}{20 \times 10^{-6}} = 0.105 \times 10^3$$

$$\beta = 105 \text{ (no unit)}$$

RESULT :

- The input, output and transfer characteristics of the NPN junction in common emitter mode are drawn.

(a) Input impedance  $r_i = 862 \Omega$

(b) Output impedance  $r_o = 10000 \Omega$

(c) Current gain  $\beta = 105 \text{ (no unit)}$

## Experiment - 9

Date :

### VERIFICATION OF TRUTH TABLES OF LOGIC GATES USING INTEGRATED CIRCUITS

#### AIM :

- To verify the truth tables of AND, OR, NOT, NAND, NOR and EX-OR gates using integrated circuits

#### COMPONENTS REQUIRED :

- AND gate (IC 7408), NOT gate (IC 7404), OR gate (IC 7432), NAND gate (IC 7400), NOR gate (IC 7402), X-OR gate (IC 7486), Power supply, Digital IC trainer kit, connecting wires.

#### BOOLEAN EXPRESSIONS :

- (i) AND gate :  $Y = A \cdot B$
- (ii) OR gate :  $Y = A + B$
- (iii) NOT gate :  $Y = \overline{A}$
- (iv) NAND gate :  $Y = \overline{A \cdot B}$
- (v) NOR gate :  $Y = \overline{A + B}$
- (vi) EX-OR gate :  $Y = A \oplus B = A \overline{B} + \overline{A} B$

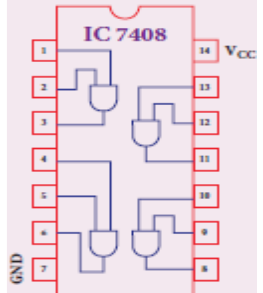
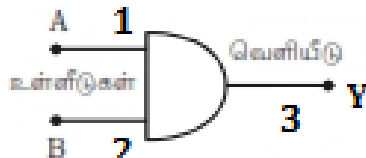
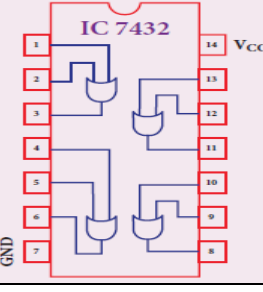
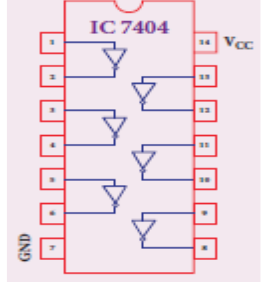
Where,

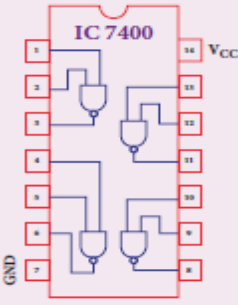
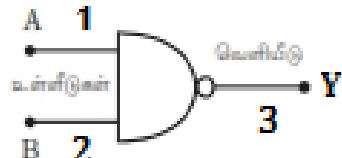
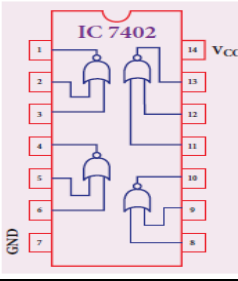
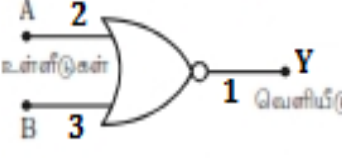
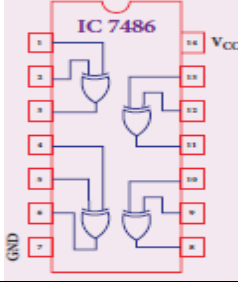
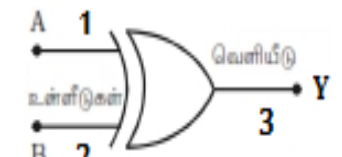
A and B  $\rightarrow$  Logical input  
Y  $\rightarrow$  Logical output

#### PROCEDURE :

- To verify the truth table of a logic gate, the suitable IC is taken and the connections are given using the circuit diagram.
- For all the ICs, 5V is applied to the pin 14 while the pin 7 is connected to the ground.
- The logical inputs of the truth table are applied and the corresponding output is noted.
- Similarly the output is noted for all other combinations of inputs.
- In this way, the truth table of a logic gate is verified.

#### LOGICAL SYMBOL, TRUTH TABLE AND OBSERVATION :

|                                                                                     |                                                                                                        |                 |   |   |             |             |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------|---|---|-------------|-------------|
|  | <b>AND GATE</b><br> | $Y = A \cdot B$ | A | B | Y           | Observation |
|                                                                                     |                                                                                                        |                 | 0 | 0 | 0           | 0           |
|                                                                                     |                                                                                                        |                 | 0 | 1 | 0           | 0           |
|                                                                                     |                                                                                                        |                 | 1 | 0 | 0           | 0           |
|                                                                                     |                                                                                                        |                 | 1 | 1 | 1           | 5 V         |
|  | <b>OR GATE</b><br>  | $Y = A + B$     | A | B | Y           | Observation |
|                                                                                     |                                                                                                        |                 | 0 | 0 | 0           | 0           |
|                                                                                     |                                                                                                        |                 | 0 | 1 | 1           | 5 V         |
|                                                                                     |                                                                                                        |                 | 1 | 0 | 1           | 5 V         |
|                                                                                     |                                                                                                        |                 | 1 | 1 | 1           | 5 V         |
|  | <b>NOT GATE</b><br> | $Y = \bar{A}$   | A | Y | Observation |             |
|                                                                                     |                                                                                                        |                 | 0 | 1 | 5 V         |             |
|                                                                                     |                                                                                                        |                 | 1 | 0 | 0           |             |

|                                                                                   |                                                                                                            |                            |          |          |          |                    |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------|----------|----------|----------|--------------------|
|  | <b>NAND GATE</b><br><br>  | $Y = \overline{A \cdot B}$ | <b>A</b> | <b>B</b> | <b>Y</b> | <b>Observation</b> |
|                                                                                   |                                                                                                            |                            | 0        | 0        | 1        | 5 V                |
|                                                                                   |                                                                                                            |                            | 0        | 1        | 1        | 5 V                |
|                                                                                   |                                                                                                            |                            | 1        | 0        | 1        | 5 V                |
|                                                                                   |                                                                                                            |                            | 1        | 1        | 0        | 0                  |
|  | <b>NOR GATE</b><br><br>   | $Y = \overline{A + B}$     | <b>A</b> | <b>B</b> | <b>Y</b> | <b>Observation</b> |
|                                                                                   |                                                                                                            |                            | 0        | 0        | 1        | 5 V                |
|                                                                                   |                                                                                                            |                            | 0        | 1        | 0        | 0                  |
|                                                                                   |                                                                                                            |                            | 1        | 0        | 0        | 0                  |
|                                                                                   |                                                                                                            |                            | 1        | 1        | 0        | 0                  |
|  | <b>EX-OR GATE</b><br><br> | $Y = A \oplus B$           | <b>A</b> | <b>B</b> | <b>Y</b> | <b>Observation</b> |
|                                                                                   |                                                                                                            |                            | 0        | 0        | 0        | 0                  |
|                                                                                   |                                                                                                            |                            | 0        | 1        | 1        | 5 V                |
|                                                                                   |                                                                                                            |                            | 1        | 0        | 1        | 5 V                |
|                                                                                   |                                                                                                            |                            | 1        | 1        | 0        | 0                  |

#### CALCULATION :

- AND gate** :  $Y = A \cdot B = 0 \cdot 0 = 0$  (0 V)  
 $Y = A \cdot B = 0 \cdot 1 = 0$  (0 V)  
 $Y = A \cdot B = 1 \cdot 0 = 0$  (0 V)  
 $Y = A \cdot B = 1 \cdot 1 = 1$  (5 V)
- OR gate** :  $Y = A + B = 0 + 0 = 0$  (0 V)  
 $Y = A + B = 0 + 1 = 1$  (5 V)  
 $Y = A + B = 1 + 0 = 1$  (5 V)  
 $Y = A + B = 1 + 1 = 1$  (5 V)
- NOT gate** :  $Y = \overline{A} = \overline{0} = 1$  (5 V)  
 $Y = \overline{A} = \overline{1} = 0$  (0 V)
- NAND gate** :  $Y = \overline{A \cdot B} = \overline{0 \cdot 0} = \overline{0} = 1$  (5 V)  
 $Y = \overline{A \cdot B} = \overline{0 \cdot 1} = \overline{0} = 1$  (5 V)  
 $Y = \overline{A \cdot B} = \overline{1 \cdot 0} = \overline{0} = 1$  (5 V)  
 $Y = \overline{A \cdot B} = \overline{1 \cdot 1} = \overline{1} = 0$  (0 V)
- NOR gate** :  $Y = \overline{A + B} = \overline{0 + 0} = \overline{0} = 1$  (5 V)  
 $Y = \overline{A + B} = \overline{0 + 1} = \overline{1} = 0$  (0 V)  
 $Y = \overline{A + B} = \overline{1 + 0} = \overline{1} = 0$  (0 V)  
 $Y = \overline{A + B} = \overline{1 + 1} = \overline{1} = 0$  (0 V)
- EX-OR gate** :  $Y = A \oplus B = 0 \oplus 0 = 0$  (0 V)  
 $Y = A \oplus B = 0 \oplus 1 = 1$  (5 V)  
 $Y = A \oplus B = 1 \oplus 0 = 1$  (5 V)  
 $Y = A \oplus B = 1 \oplus 1 = 0$  (0 V)

#### RESULT :

- The truth table of logic gates **AND**, **OR**, **NOT**, **NAND**, **NOR** and **EX-OR** using integrated circuits is verified.

## Experiment - 9

Date :

### VERIFICATION OF DE MORGAN'S THEOREMS

#### AIM :

- To verify De Morgan's first and second theorems.

#### COMPONENTS REQUIRED:

- Power Supply (0 - 5V), IC 7400, 7408, 7432, 7404, and 7402, Digital IC trainer kit, connecting wires.

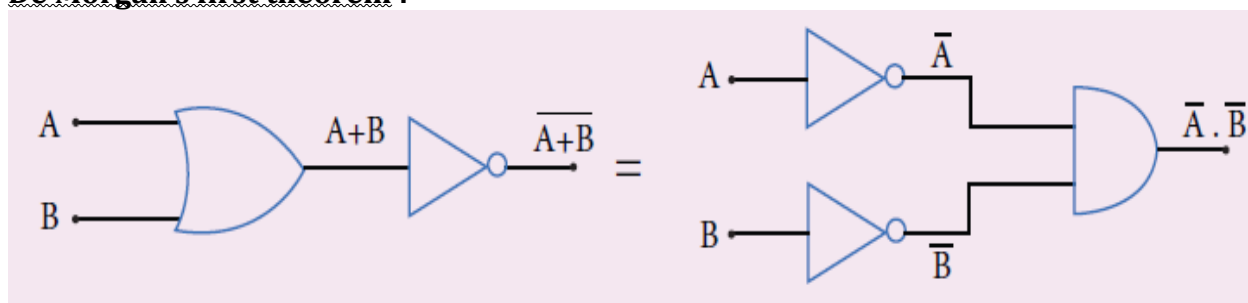
#### FORMULA :

(i) De Morgan's first theorem :  $\overline{A + B} = \bar{A} \cdot \bar{B}$

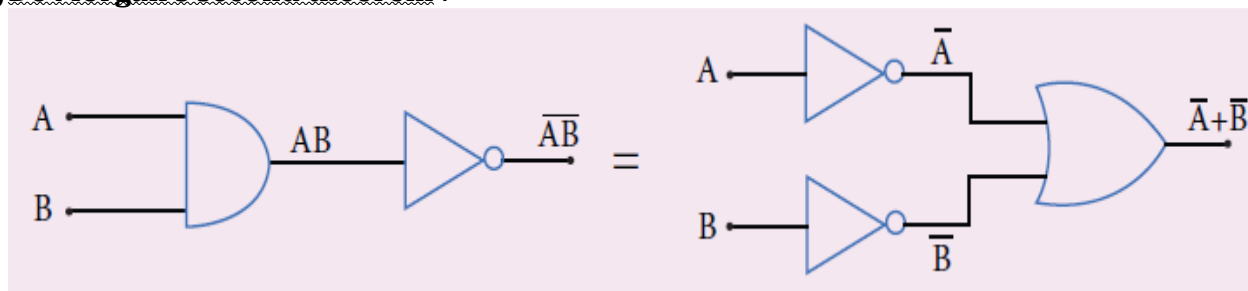
(ii) De Morgan's second theorem :  $\overline{A \cdot B} = \bar{A} + \bar{B}$

#### CIRCUIT DIAGRAM:

##### (i) De Morgan's first theorem :



##### (ii) De Morgan's second theorem :



#### PROCEDURE :

##### (i) Verification of De Morgan's first theorem :

- The connections are made for LHS  $\overline{A + B}$  of the theorem as shown in the circuit diagram using appropriate ICs.
- The output is noted and tabulated for all combinations of logical inputs of the truth table.
- The same procedure is repeated for RHS  $\bar{A} \cdot \bar{B}$  of the theorem.
- From the truth table, it can be shown that  $\overline{A + B} = \bar{A} \cdot \bar{B}$

##### (ii) Verification of De Morgan's second theorem :

- The connections are made for LHS  $\overline{A \cdot B}$  of the theorem as shown in the circuit diagram using appropriate ICs.
- The output is noted and tabulated for all combinations of logical inputs of the truth table.
- The same procedure is repeated for RHS  $\bar{A} + \bar{B}$  of the theorem.
- From the truth table, it can be shown that  $\overline{A \cdot B} = \bar{A} + \bar{B}$

#### TABULATION AND OBSERVATION :

##### (i) De Morgan's first theorem :

| A | B | $\bar{A}$ | $\bar{B}$ | $\overline{A + B}$ | $\bar{A} \cdot \bar{B}$ | Observation        |                         |
|---|---|-----------|-----------|--------------------|-------------------------|--------------------|-------------------------|
|   |   |           |           |                    |                         | $\overline{A + B}$ | $\bar{A} \cdot \bar{B}$ |
| 0 | 0 | 1         | 1         | 1                  | 1                       | 5 V                | 5 V                     |
| 0 | 1 | 1         | 0         | 0                  | 0                       | 0 V                | 0 V                     |
| 1 | 0 | 0         | 1         | 0                  | 0                       | 0 V                | 0 V                     |
| 1 | 1 | 0         | 0         | 0                  | 0                       | 0 V                | 0 V                     |

**(ii) De Morgan's second theorem :**

| A | B | $\bar{A}$ | $\bar{B}$ | $\overline{A \cdot B}$ | $\bar{A} + \bar{B}$ | Observation            |                     |
|---|---|-----------|-----------|------------------------|---------------------|------------------------|---------------------|
|   |   |           |           |                        |                     | $\overline{A \cdot B}$ | $\bar{A} + \bar{B}$ |
| 0 | 0 | 1         | 1         | 1                      | 1                   | 5 V                    | 5 V                 |
| 0 | 1 | 1         | 0         | 1                      | 1                   | 5 V                    | 5 V                 |
| 1 | 0 | 0         | 1         | 1                      | 1                   | 5 V                    | 5 V                 |
| 1 | 1 | 0         | 0         | 0                      | 0                   | 0 V                    | 0 V                 |

**CALCULATION :**

**(i) De Morgan's first theorem :**

| INPUT    | LHS                                                                    | RHS                                                                           |
|----------|------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| CASE - 1 | $\overline{A + B} = \overline{0 + 0} = \overline{0} = 1 \text{ (5 V)}$ | $\bar{A} \cdot \bar{B} = \bar{0} \cdot \bar{0} = 1 \cdot 1 = 1 \text{ (5 V)}$ |
| CASE - 2 | $\overline{A + B} = \overline{0 + 1} = \bar{1} = 0 \text{ (0 V)}$      | $\bar{A} \cdot \bar{B} = \bar{0} \cdot \bar{1} = 1 \cdot 0 = 0 \text{ (0 V)}$ |
| CASE - 3 | $\overline{A + B} = \overline{1 + 0} = \bar{1} = 0 \text{ (0 V)}$      | $\bar{A} \cdot \bar{B} = \bar{1} \cdot \bar{0} = 0 \cdot 1 = 0 \text{ (0 V)}$ |
| CASE - 4 | $\overline{A + B} = \overline{1 + 1} = \bar{1} = 0 \text{ (0 V)}$      | $\bar{A} \cdot \bar{B} = \bar{1} \cdot \bar{1} = 0 \cdot 0 = 0 \text{ (0 V)}$ |

**(ii) De Morgan's second theorem :**

| INPUT    | LHS                                                                       | RHS                                                               |
|----------|---------------------------------------------------------------------------|-------------------------------------------------------------------|
| CASE - 1 | $\overline{A \cdot B} = \overline{0 \cdot 0} = \bar{0} = 1 \text{ (5 V)}$ | $\bar{A} + \bar{B} = \bar{0} + \bar{0} = 1 + 1 = 1 \text{ (5 V)}$ |
| CASE - 2 | $\overline{A \cdot B} = \overline{0 \cdot 1} = \bar{0} = 1 \text{ (5 V)}$ | $\bar{A} + \bar{B} = \bar{0} + \bar{1} = 1 + 0 = 1 \text{ (5 V)}$ |
| CASE - 3 | $\overline{A \cdot B} = \overline{1 \cdot 0} = \bar{0} = 1 \text{ (5 V)}$ | $\bar{A} + \bar{B} = \bar{1} + \bar{0} = 0 + 1 = 1 \text{ (5 V)}$ |
| CASE - 4 | $\overline{A \cdot B} = \overline{1 \cdot 1} = \bar{1} = 0 \text{ (0 V)}$ | $\bar{A} + \bar{B} = \bar{1} + \bar{1} = 0 + 0 = 0 \text{ (0 V)}$ |

**RESULT :**

- De Morgan's first and second theorems are verified.

## **SUGGESTED QUESTIONS FOR THE PRACTICAL EXAMINATION**

1. Determine the resistance of a given wire using metre bridge. Also find the radius of the wire using screw gauge and hence determine the specific resistance of the material of the wire. Take at least 4 readings.
2. Determine the value of the horizontal component of the Earth's magnetic field, using tangent galvanometer. Take at least 4 readings.
3. Compare the emf of two cells using potentiometer.
4. Using the spectrometer, measure the angle of the given prism and angle of minimum deviation. Hence calculate the refractive index of the material of the prism.
5. Adjust the grating for normal incidence using the spectrometer. Determine the wavelength of green, blue, yellow and red lines of mercury spectrum (The number of lines per metre length of the grating can be noted from the grating).
6. Draw the V-I characteristics of PN junction diode and determine its forward resistance and knee voltage from forward characteristics.
7. Draw the V-I characteristics of Zener diode and determine its forward resistance and knee voltage from forward characteristics. Also find break down voltage of the Zener diode from reverse characteristics.
8. (1) Draw the input and transfer characteristic curves of the given NPN junction transistor in CE mode. Find the input impedance from input characteristics and current gain from transfer characteristics.  
  
(2) Draw the output and transfer characteristic curves of the given NPN junction transistor in CE mode. Find the output impedance from output characteristics and current gain from transfer characteristics.
9. (1) Verify the truth table of logic gates AND, NOT, Ex-OR and NOR gates using integrated circuits.  
  
(2) Verify the truth table of logic gates OR, NOT, Ex-OR and NOR gates using integrated circuits.
10. Verify De Morgan's first and second theorems.

**ALL THE BEST**