Shantilal Shah Engineering College, Bhavnagar

General Department

Practical Journal

Subject: Physics (3110018)

Branches: EC, IT, IC & Electrical (Group-II)

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General Department

Physics (3110018)

List of Experiments

(*Electrical, EC, IC, IT*)

Sr. No.	Code	Objective
1	**P_1**	To study V-I Characteristics of P-N junction diode.
2	**P_2 (VLAB)**	1. To determine the Hall voltage developed across the sample material. 2. To calculate the Hall coefficient and the carrier concentration of the sample material.
3	**P_3**	Measurement of the Numerical Aperture (NA) of the optical fiber.
4	**P_4 (VLAB)**	Determination of Planck's constant
5	**P-5**	Understand the function of CRO and measure the *rms* voltage and frequency of AC signal using CRO.
6	**P_6 (VLAB)**	To calculate the beam divergence and spot size of the given laser beam.
7	**P-7**	To find zener breakdown voltage.

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Physics (Tutorial/Class Test)-3110018

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Physics Laboratory Manual

Experiment-1 (P_1)

❖ **Objective:** To study V-I Characteristics of P N junction Diode

❖ **Instrument Used:** Diode Characteristics Trainer (NV6501)

❖ **Items Required:**
1. Semiconductor Diode, Regulated Power Supply
2. Connecting wire

❖ **Procedure:**

Study of Forward bias characteristics

1. Before switch 'On' the supply rotate potentiometer P1 fully in CCW (counter clockwise direction).
2. Connect Ammeter between **TP4** and **TP10**, to measure diode current I_F (mA) & set Ammeter at **200 mA range** (as shown in fig. 1).
3. Connect Voltmeter across **TP3** and **TP11**, to measure diode voltage V_F & set Voltmeter at **20 V range**.
4. Switch 'On' the power supply.
5. Vary the potentiometer P1 so as to increase the value of diode voltage V_D from 0 to 1 V (0.83 V) in steps and measure the corresponding values of diode current I_D in mA and note down in the Observation Table-(1).
6. Switch 'Off' the supply.

Study of Reverse bias characteristics

7. Before switch 'On' the supply rotate potentiometer P1 fully in CCW (counter clockwise direction).
8. Connect Ammeter between **TP5** and **TP10**, to measure diode current I_R (µA) & set Ammeter at **200 µA** range (as shown in fig. 1).
9. Connect Voltmeter across **TP3** and **TP11**, to measure diode voltage V_R & set Voltmeter at **20 V** range.

10. Switch 'On' the power supply.
11. Vary the potentiometer P1 so as to increase the value of diode voltage V_R from 0 to 15 V in steps and measure the corresponding values of diode current I_R in μA and note down in the Observation Table-(2).
12. Switch 'Off' the supply.
13. Plot a curve between diode voltage V_D/ V_R and diode current I_D/ I_R using suitable scale, with the help of Observation Table. This curve is the required characteristics curve of Si diode.

❖**Circuit Diagram**:

Diode Characteristics Trainer
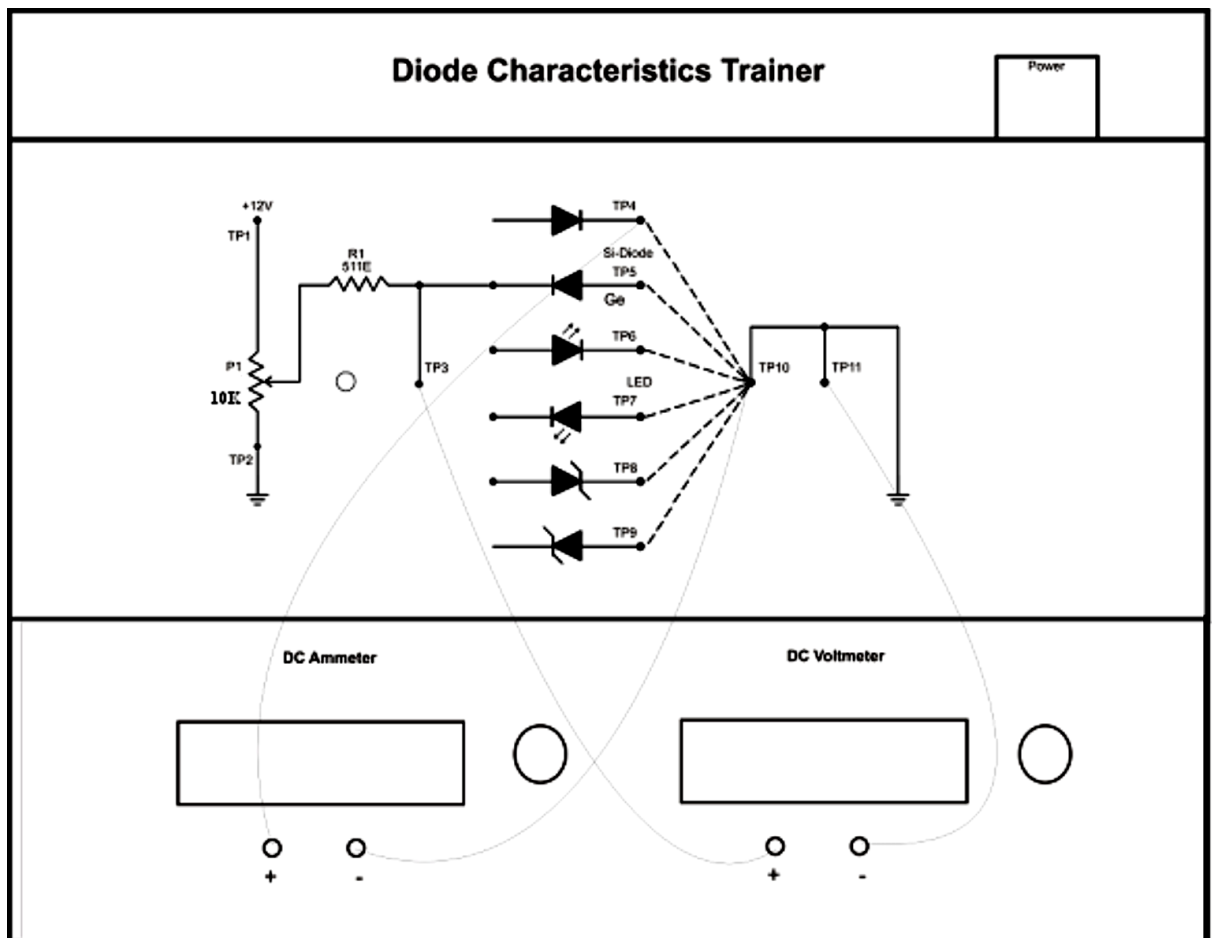
❖ **Observation Table-(1):**

Sr. No.	Forward Bias Voltage, V_F (volt)	Forward Bias Current, I_F (mA)	Static Resistance R = V/I (Ohm)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			

❖ **Calculation:**

➢ From the graph:

Dynamic Resistance of diode is, $R_d = \dfrac{\Delta V_F}{\Delta I_F}$

❖ Observation Table-(2):

Sr. No.	Reverse Bias Voltage, V_R (volt)	Reverse Bias Current, I_R (µA)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

❖ **Graph**: *I* v/s *V* graph is shown on page no_____.

❖ Result:

1) The dynamic resistance of the diode, R_d = ………………….. Ohm.

2) The static resistance of the diode is ……………… ohm with value of current ………………. mA and value of voltage is ………….. volt.

3) Breakdown voltage for the diode is ………….. volt.

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Experiment-2 [P_2 (VLAB)]

⌘   Website link: **http://vlab.amrita.edu/?sub=1**

❖ Objective:

1. To determine the Hall voltage developed across the sample material.
2. To calculate the Hall coefficient and the carrier concentration of the sample material.

❖ Apparatus:

Two solenoids, Constant current supply, four probe, Digital gauss meter, Hall Effect apparatus (which consist of Constant Current Generator (CCG), digital milli voltmeter and Hall probe).

❖ Procedure:

Controls

♦ **Combo box**

   🖉 **Select procedure**: This is used to select the part of the experiment to perform.
   1) Magnetic field Vs Current.
   2) Hall Effect setup.
   🖉 **Select Material**: This slider activate only if Hall Effect setup is selected. And this is used to select the material for finding Hall coefficient and carrier concentration.

♦ **Button**

   🖉 **Insert Probe/ Remove Probe**: This button used to insert/remove the probe in between the solenoid.
   🖉 **Show Voltage/ Current**: This will activate only if Hall Effect setup selected and it used to display the Hall voltage/ current in the digital meter.
   🖉 **Reset**: This button is used to repeat the experiment.

♦ **Slider**

   🖉 **Current:** This slider used to vary the current flowing through the Solenoid.
   🖉 **Hall Current:** This slider used to change the hall current
   🖉 **Thickness:** This slider used to change the thickness of the material selected.

❖ Procedure for doing the simulation:

♦ To measure the magnetic field generated in the solenoid

- Select **Magnetic field Vs Current from** the procedure combo-box.

- Click **Insert Probe** button

- Placing the probe in between the solenoid by clicking the wooden stand in the simulator.

- Using Current slider, varying the current through the solenoid and corresponding magnetic field is to be noted from Gauss meter.

♦ Hall Effect apparatus

- Select **Hall Effect Setup** from the **Select the procedure** combo box
- Click **Insert Hall Probe** button
- Placing the probe in between the solenoid by clicking the wooden stand in the simulator.
- Set "**current slider**" value to minimum.
- Select the material from "Select Material" combo-box.
- Select the Thickness of the material using the slider **Thickness**.
- Vary the Hall current using the sllider **Hall current**.
- Note down the corresponding Hall voltage by clicking "show voltage" button.
- Then calculate Hall coefficient and carrier concentration of that material using the equation

$$R_H = V_H t/(I*B) \quad ....(4)$$

Where R_H is the Hall coefficient

$$R_H = 1/ne \quad ....(5)$$

And n is the carrier concentration

- Repeat the experiment with different magnetic file.

❖ Observation Table-(1):

Trial No:	Current through solenoid	Magnetic field generated
1		
2		

❖ Observation Table-(2): Material: _____

Trial No:	Magnetic Field (Tesla T)	Thickness (t) (m)	Hall current, (mA)	Hall Voltage (mV)	R_H
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

❖ Calculation:

1) For Magnetic Field =........................ and thickness =....................................

2) For Magnetic Field =........................ and thickness =....................................

❖ Result:

(1) Hall Coefficient of the material, R_H = ... m^3/C

(2) Carrier concentration of the material, n = ... m^{-3}

❖ Theory:

♦ If a current carrying conductor placed in a perpendicular magnetic field, a potential difference will generate in the conductor which is perpendicular to both magnetic field and current. This phenomenon is called Hall Effect. In solid state physics, Hall Effect is an important tool to characterize the materials especially semiconductors. It directly determines both the sign and density of charge carriers in a given sample.

♦ Consider a rectangular conductor of thickness t kept in XY plane. An electric field is applied in X-direction using Constant Current Generator (CCG), so that current I flow through the sample. If w is the width of the sample and t is the thickness. There for current density is given by,

$$J_x = I / wt \qquad \text{.......(1)}$$

♦ If the magnetic field is applied along negative z-axis, the Lorentz force moves the charge carriers (say electrons) toward the y-direction. This results in accumulation of charge carriers at the top edge of the sample. This set up a transverse electric field E_y in the sample. This develop a potential difference along y-axis is known as Hall voltage V_H and this effect is called Hall Effect.

♦ A current is made to flow through the sample material and the voltage difference between its top and bottom is measured using a volt-meter. When the applied magnetic field B=0, the voltage difference will be zero.

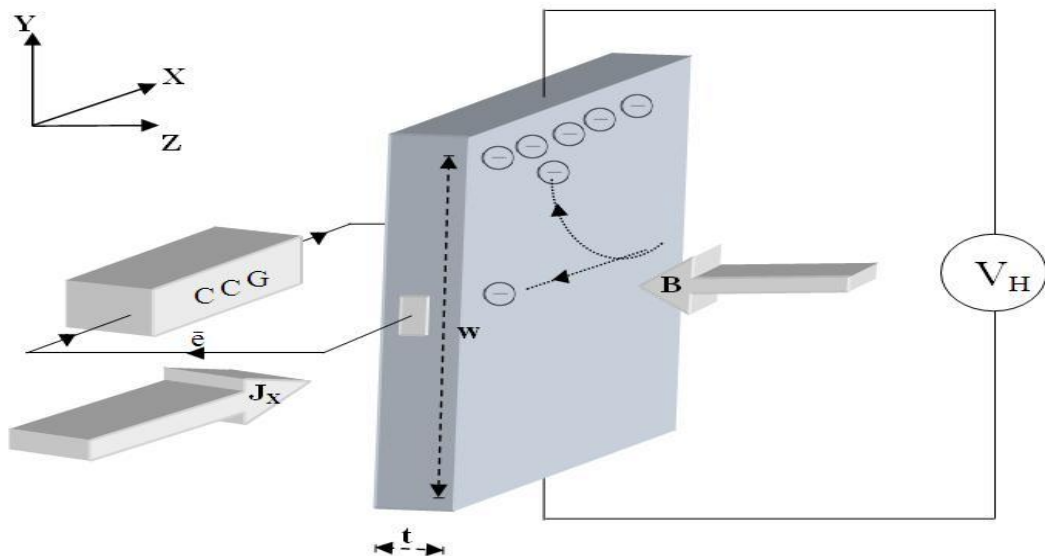
Fig.1 Schematic representation of Hall Effect in a conductor.
CCG – Constant Current Generator, *Jx* – current density
ē – electron, *B* – applied magnetic field
t – thickness, *w* – width, *VH* – Hall voltage

- We know that a current flows in response to an applied electric field with its direction as conventional and it is either due to the flow of holes in the direction of current or the movement of electrons backward. In both cases, under the application of magnetic field the magnetic Lorentz force, $\vec{F}_m = q\,(\vec{v} \times \vec{B})$ causes the carriers to curve upwards. Since the charges cannot escape from the material, a vertical charge imbalance builds up. This charge imbalance produces an electric field which counteracts with the magnetic force and a steady state is established. The vertical electric field can be measured as a transverse voltage difference using a voltmeter.

- In steady state condition, the magnetic force is balanced by the electric force. Mathematically we can express it as:

$$eE = evB \qquad ....(2)$$

Where 'e' the electric charge,

'E' the hall electric field developed,

'B' the applied magnetic field and

'v' is the drift velocity of charge carriers.

- And the current 'I' can be expressed as, $I = neAv$ ....(3)

Where 'n' is the number density of electrons in the conductor of length l, breadth 'w' and thickness 't'.

- Using (1) and (2) the Hall voltage V_H can be written as,

$$V_H = E_w = vB_w = \frac{I\,B}{n\,e\,t}$$

$$\therefore V_H = R_H\,\frac{I\,B}{t}$$

$$\therefore R_H = \frac{V_H\,t}{I\,B}$$

Where R_H is called the Hall coefficient = $\dfrac{1}{n\,e}$

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Experiment-3 (P_3)

❖ **<u>Objective</u>:** Measurement of the Numerical Aperture (NA) of the fiber.

❖ **<u>Instrument Used</u>** : Fiber Optics Trainer (Scientech 2502)

❖ **<u>Items Required</u>:**

1. ST2502 trainer with power supply cord
2. Optical Fiber cable.
3. Numerical Aperture measurement Jig/Paper & Scale

❖ **<u>Procedure</u>:**

1. Connect the Power supply cord to mains supply and to the trainer ST2502.
2. Connect the frequency generator's 1 KHz sine wave output to input of emitter 1 circuit. Adjust its amplitude at 5 V pp.
3. Connect one end of fiber cable to the output socket of emitter 1 circuit and the other end to the numerical aperture measurement jig. Hold the white screen facing the fiber such that its cut face is perpendicular to the axis of the fiber.
4. Hold the white screen with 4 concentric circles (10, 15, 20 & 25 mm diameter) vertically at a suitable distance to make the red spot from the fiber coincide with 10 mm circle.
5. Record the distance of screen from the fiber end **L** and note the diameter **W** of the spot.
6. Compute the numerical aperture from the formula given below:

$$NA = \frac{W}{\sqrt{4L^2 + W^2}} = \sin\theta_{max}$$

❖ Diagram:
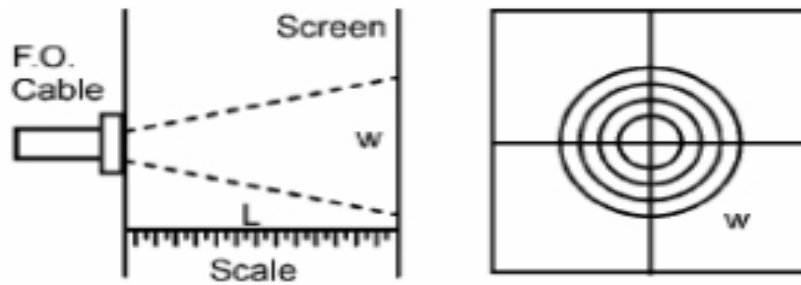
Numerical Aperture measurement Jig/Paper & Scale

❖ Observation Table:

Sr. No.	Diameter of the spot (W)	Distance between screen and fibre (L)	Numerical Aperture (NA)
1.	10 mm		
2.	15 mm		
3.	20 mm		
4.	25 mm		

❖ Calculations:

(1) NA $= \dfrac{W}{\sqrt{4L^2 + W^2}}$

(2) NA $= \dfrac{W}{\sqrt{4L^2 + W^2}}$

(3) NA $= \dfrac{W}{\sqrt{4L^2 + W^2}}$

(4) NA $= \dfrac{W}{\sqrt{4L^2 + W^2}}$

❖ **Result**: The N.A. of fiber measured is ………………… using trigonometric formula.

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Experiment-4 [P_4 (VLAB)]

⌘ Website link: **http://vlab.amrita.edu/?sub=1**

❖ **Objective:** Determination of Planck's constant.

❖ **Apparatus:**

0-10 V power supply, a one way key, a rheostat, a digital milliammeter, a digital voltmeter, a 1 K resistor and different known wavelength LED's (Light-Emitting Diodes)

❖ **Procedure:**

1. After the connections are completed, click on 'Insert Key' button.

2. Click on the combo box under 'Select LED' button.

3. Click on the 'Rheostat Value' to adjust the value of rheostat to 500 Ω.

4. Corresponding voltage across the LED is measured using a voltmeter, which is the knee voltage.

5. Repeat, by changing the LED and note down the corresponding knee voltage.

6. Calculate h using formula, $h = \dfrac{e \lambda V}{c}$

❖ **Observation Table:**

Sr. No.	Colour of LED	Wavelength, λ (nm)	Knee Voltage, V (V)	λV (nm · V)	Average λV
1	Red				
2	Green				
3	Yellow				
4	Blue				

❖ **Calculation:**

(e = 1.6 × 10⁻¹⁹ C, c = 3 × 10⁸ m/s)

➢ Plank's Constant, $h = \dfrac{e}{c}$ (average λV) = …………………… J s.

❖ **Result:**

Value of Plank's constant is .... J s.

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Experiment-5 (P_5)

❖ **Objective:** Understand the function of CRO and measure the *rms* voltage and Frequency of AC signal using CRO.

❖ **Components:** CRO, Function Generator

❖ **Procedure:**

➢ Switch on the CRO and Function Generator.
➢ Study and understand the function of every knob on CRO and function generator.
➢ Set function generator to any frequency with a particular peak to peak voltage (V_P)
➢ Connect the output of function generator to any channel of CRO.
➢ Adjust CRO so that stable and full signal is viewed.
➢ Measure V_P using formula-(1). Determine V_P & V_{rms}.
➢ Determine the frequency of the same signal.
➢ Repeat for different signals.

❖ **Observation Table:**

1. **Measurement of AC voltage:**

Sr. No.	Signal no.	Division on Y-axis	Volt/div.	V_P	V_{rms}
1	Signal-1				
2	Signal-2				
3	Signal-3				

2. Measurement of AC frequency:

Sr. No.	Signal no.	Division on X-axis	Time/div.	Time Period (*T*)	Frequency (*f*)
1	Signal-1				
2	Signal-2				
3	Signal-3				

❖ Calculation:

1. **Signal-1**

   ➢ Voltage (V_P) = (Division on Y-axis) (volt/division) = ...

   ➢ V_{rms} = 0.707 V_P =......................

   ➢ Time period (*T*) = (Division on X-axis) (time/division) = ...

   ➢ Frequency (*f*) =.....................

2. **Signal-1**

   ➢ Voltage (V_P) = (Division on Y-axis) (volt/division) = ...

   ➢ V_{rms} = 0.707 V_P =......................

   ➢ Time period (*T*) = (Division on X-axis) (time/division) = ...

   ➢ Frequency (*f*) =.....................

3. **Signal-1**

   ➢ Voltage (V_P) = (Division on Y-axis) (volt/division) = ...

   ➢ V_{rms} = 0.707 V_P =......................

   ➢ Time period (*T*) = (Division on X-axis) (time/division) = ...

   ➢ Frequency (*f*) =....................

❖ Result:

With the help of CRO one can determine the *rms* voltage and frequency of AC signal.

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Experiment-6 [P_6 (VLAB)]

⌘ Website link: **http://vlab.amrita.edu/?sub=1**

❖ **<u>Objective</u>:** To calculate the beam divergence and spot size of the given laser beam.

❖ **<u>Apparatus</u>:**

A laser source, An ammeter, Micrometer Screw gauge

❖ **<u>Procedure</u>:**

1. The experimental arrangement is shown in the simulator. A side view and top view of the setup is given in the inset.

2. The start button enables the user to start the experiment.

3. From the combo box, select the desired laser source.

4. Then fix a detector distance, say 100 cm, using the slider Detector distance, z. The z distance can be varied from 50 cm to 200 cm.

5. For a particular z distance, change the detector distance x, from minimum to maximum. Using the slider detector distance, x, The micrometer distances and the corresponding output currents are noted. The x distances can be read from the zoomed view of the micrometer and the current can be note from the digital display of the output device.

6. Draw the graph and calculate the beam divergence and spot size using the steps given above.

❖ **<u>Observations</u>:**

<u>To find the Least Count of Screw gauge:</u>

➢ One pitchscale division (*n*) = ... mm

➢ Number of divisions on head scale (*m*) = ...

➢ Least Count (L.C) = n/m = ... mm

❖ Observation Table:

Sr. No.	For Z_1 = ... cm Distance, x (mm)	Current, I (mA)	Sr. No.	For Z_2 = ... cm Distance, x (mm)	Current, I (mA)
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		

❖ Calculation:

From Graph-1

➢ $1/e^2$ of maximum intensity (Current), I_e = ... mA

➢ Diameter of the beam corresponds to I_e, d_1 = ...mm

From Graph-2

➢ $1/e^2$ of maximum intensity (Current), I_e = ... mA

➢ Diameter of the beam corresponds to I_e, d_2 = ...mm

Divergence angle (θ)

$$\theta = \frac{d_2 - d_1}{z_2 - z_1} = \ldots\ldots\ldots\ldots\text{m rad}$$

❖ **Result:**

Beam divergence of the given laser beam is .... m rad.

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Experiment-7 (P_7)

❖ **<u>Objective</u>:** To find zener breakdown voltage.

❖ **<u>Instrument Used</u>:** Diode Characteristics Trainer (NV6501)

❖ **<u>Items Required</u>:**
   1. Zener Diode, Regulated Power Supply
   2. Connecting wire

❖ **<u>Procedure</u>:**

<u>Study of Reverse bias characteristics</u>

1. Before switch 'On' the supply rotate potentiometer P1 fully in CCW (counter clockwise direction).
2. Connect Ammeter between **TP9** and **TP10**, to measure Zener current I_Z (mA) & set Ammeter at **20 mA** range (as shown in fig. 1).
3. Connect Voltmeter across **TP3** and **TP11**, to measure Zener voltage V_Z & set Voltmeter at **20 V** range.
4. Switch 'On' the power supply.
5. Vary the potentiometer P1 so as to increase the value of zener voltage V_Z from 0 to 15 V in steps and measure the corresponding values of zener current I_Z and note down in the Observation Table.
6. Switch 'Off' the supply.
7. Plot a curve between diode voltage V_Z and diode current I_Z using suitable scale, with the help of Observation Table and find breakdown voltage.

❖Circuit Diagram:

Diode Characteristics Trainer
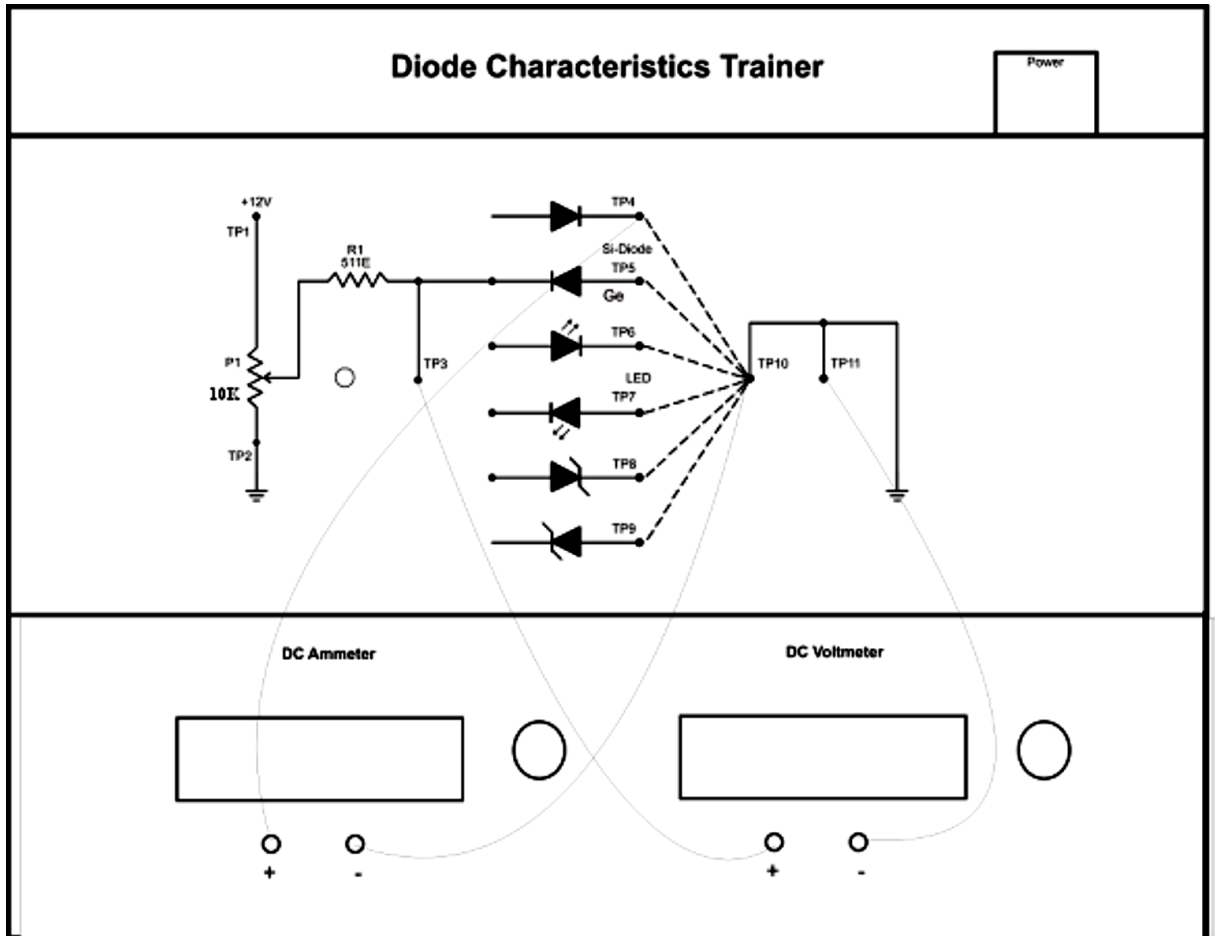
❖ **Observation Table:**

Sr. No.	Zener Voltage, V_Z (volt)	Zener Current, I_Z (mA)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

❖ **Graph:** *I* v/s *V* graph is shown on page no_____.

❖ **Result:**

Zener Breakdown voltage for given zener diode is ………….. volt.

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