NATIONAL UNIVERSITY – FAIRVIEW

SCHOOL OF ENGINEERING AND TECHNOLOGY
BACHELOR OF SCIENCE IN COMPUTER ENGINEERING

5 Sensor Non-Programmable Line Following Robot

A Hardware Project presented to the School of Engineering and Technology
In partial fulfillment of the requirements for the subject:

CPLGCT1L
Bachelor of Science in Computer Engineering

Submitted by:
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Instructor

September 24, 2025
Date

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1. Introduction

This project focuses on the development of non-programmable robot powered by basic logic gates. The main goal is to demonstrate how digital logic principles can be applied in robotics without the need for microcontrollers. These designs showcase the practical use of Boolean algebra, logic circuits, and motor drivers to achieve autonomous robotic behavior.

1.1. Line Following Robot

The desired behavior of the design is to autonomously follow a predefined path. Using five IR sensors as input, the robot identifies the presence or absence of a line and, through logic gate combinations, generates the appropriate motor commands to move forward, turn, or stop. This system emphasizes path-tracking accuracy and smooth motion control without programming.

1.2. Logic-Controlled Motor System

The desired behavior of the design is to control motor actions through direct logic gate inputs. Instead of sensors, predefined logic signals dictate whether the motors move forward, left, right, or remain off. This simplified design demonstrates how logic gates and H-Bridge drivers work together.

2. Materials and Components

2.1. Line Following Robot

2.1.1 List of Materials

Table 2.1 Materials

This table lists the essential materials used in building the robot.

Image	Material	Description	Quantity	Cost
	Battery Holder	Holds rechargeable batteries for powering the circuit	1 (2-Series 18650)	23 Php
	3.7V Lithium Battery	Power source for logic circuitry and motors	2-3	147 Php
	Jumper Wires	Provide connections between components	1 Pack	26 Php
	MOBOT Chassis	Frame to hold motors, sensors, and electronics	1	289 (Sold in a kit)
	Wheels	Main drive wheels for robot movement	1	289 (Sold in a kit)
	Caster Wheel	Provides balance and stability	1	289 (Sold in a kit)
	Breadboard	For circuit prototyping	1	74 Php
	P-PCB	Permanent circuit mounting	1	300 Php (4"x6")
	Glue Gun	For assembly and securing parts	1	70 Php
	Glue Stick	For assembly and securing parts	2	12 Php
	Screws	For fastening mechanical parts	8	289 (Sold in a kit)

2.1.2 List of Components

Table 2.2 Components

This table presents the electronic components, with their functions.

Image	Component	Description	Quantity	Cost
	IR Sensor	Detects line (black/white surface contrast)	5	29 Php each
	74LS04 – NOT Gate	Inverts logic signals for control	1 IC – 2 Gates	21 Php
	74LS08 – AND Gate	Outputs 1 only if both inputs are 1	1 IC – 4 Gates	21 Php
	74LS32 – OR Gate	Outputs 1 if at least one input is 1	1 IC – 4 Gates	21 Php
	L293N Motor Driver	H-Bridge IC that powers and controls DC motors	1	85 Php
	DC Motor	Drives the wheels for robot motion	2	289 (Sold in a kit)

2.2. Outer Design

2.2.1 List of Materials

Table 2.3 Materials for Outer Design

This table lists the essential materials used in building the outer design for the robot.

Image	Material	Description	Quantity	Cost
	Popsicle Sticks	Served as the roof for the design	1 Pack	32 Php
	Barbeque Sticks	Used to make the main casing	1 Pack	20 Php
	Glue Gun	For assembly and securing parts	1	70 Php
	Glue Stick	For assembly and securing parts	4	6 Php each
	Crepe Paper	For the flower design	4 Pack	34 Php each
	Drinking Straw	For hexagonal pattern	1 Pack	18 Php

3. Functional Design

3.1. Logic of The Line Following Robot

3.1.1 Block Diagram

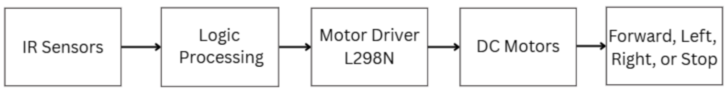

Figure 3.1 Block Diagram

This shows the flow of process from sensors to motors.

3.1.2 Truth Table

Table ***3.1 Truth Table***

This table shows how sensor inputs control the left and right motor outputs.

	SL(A)	SL(B)	SC(C)	SR(D)	SR(E)	ML	MR
0	0	0	0	0	0	0	0
1	0	0	0	0	1	0	1
2	0	0	0	1	0	0	1
3	0	0	0	1	1	0	1
4	0	0	1	0	0	1	1
5	0	0	1	0	1	0	1
6	0	0	1	1	0	0	1
7	0	0	1	1	1	0	1
8	0	1	0	0	0	1	0
9	0	1	0	0	1	0	0
10	0	1	0	1	0	0	0
11	0	1	0	1	1	0	0
12	0	1	1	0	0	1	0
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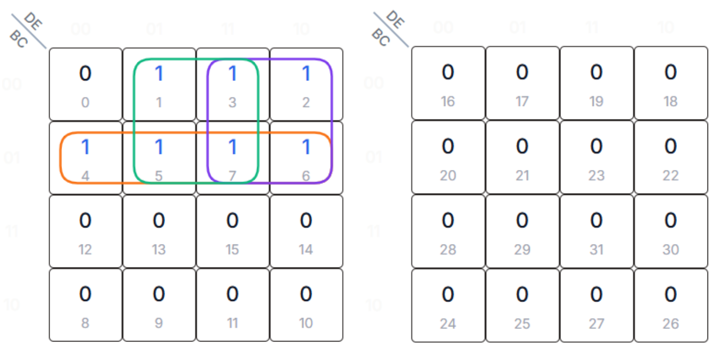
25	1	1	0	0	1	0	0
26	1	1	0	1	0	0	0
27	1	1	0	1	1	0	0
28	1	1	1	0	0	1	0
29	1	1	1	0	1	0	0
30	1	1	1	1	0	0	0
31	1	1	1	1	1	0	0

4. Synthesis Design

4.1. Logic of the Line Following Robot – Left Motor

4.1.1 K-Map



BOOLEAN EXPRESSION:

MOTOR LEFT: $\overline{\mathrm{AB}}\mathrm{C} + \overline{\mathrm{AB}}\mathrm{D} + \overline{\mathrm{AB}}\mathrm{E}$

Figure 4.1 K-Map for Left Motor

This shows the grouped minterms used to simplify the Boolean expression for motor control logic.

4.1.2 Circuit Diagram

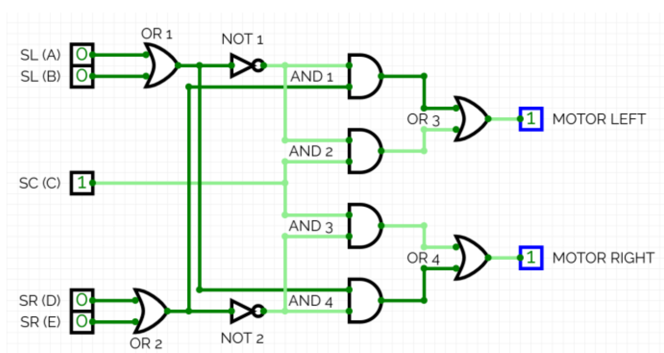


Figure 4.2 Circuit Diagram for Left Motor

This diagram illustrates the motor control circuit using OR, AND, and NOT gates to drive the motors.

4.2. Logic of the Line Following Robot – Right Motor

4.2.1 K-Map

BOOLEAN EXPRESSION:

MOTOR RIGHT: $A\overline{DE} + B\overline{DE} + C\overline{DE}$

Figure 4.3 K-Map for Right Motor

This shows the grouped minterms used to simplify the Boolean expression for motor control logic.

4.2.2 Circuit Diagram

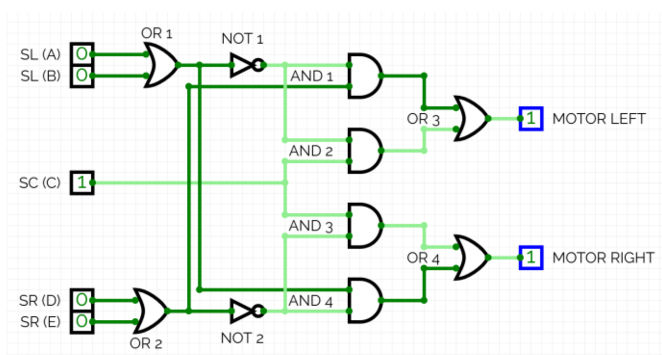


Figure 4.4 Circuit Diagram for Right Motor

This diagram illustrates the motor control circuit using OR, AND, and NOT gates to drive the motors.

5. Simulation

To validate the logic gates before breadboarding, a simulation program called circuitverse.org/simulator was used. The program allowed for the visualization of how the logic gates interact with the input signals and outputs.

5.1. Simulation of Logic Diagram

5.1.1 Functional Simulation

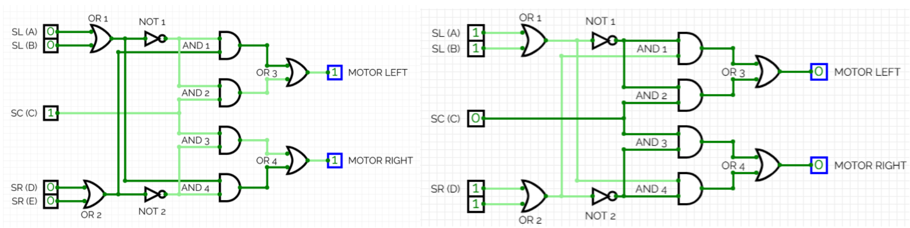


Figure 5.1 Circuit Diagram for the Logic

This diagram illustrates the motor control circuit using OR, AND, and NOT gates to drive the motors.

5.1.2 Simulation Results

The simulation results showed that the provided truth table was showing accuracy. (Refer to Table 3.1)

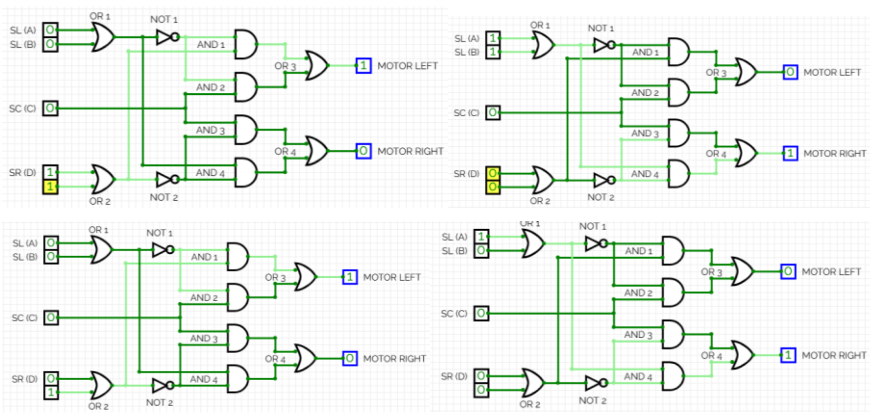


Figure 5.2 Simulation Results

This diagram shows different output results of the motor using the OR, AND, and NOT gates.

6. PCB and Prototype Layout

6.1 Line Following Robot PCB

6.1.1 PCB Layout

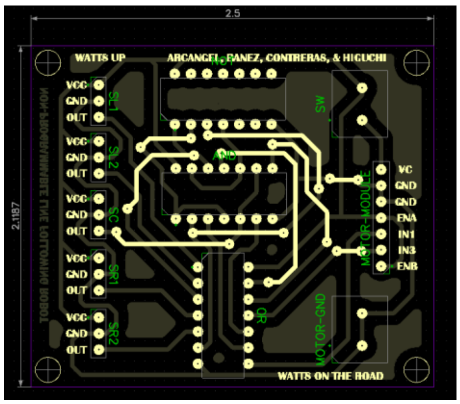


Figure 6.1 PCB Layout

This figure shows the PCB layout of the circuit, displaying the connections and placements of components.

Trace Widths: 0.7mm

Mounting Hole Size: 4mm

Pad Size: 1.7mm

Dimensions: 2.5 in x 2.1187 in

6.1.2 Prototype Layout

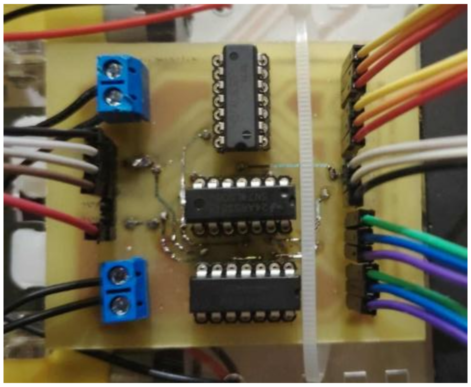


Figure 6.2 Prototype Layout

This is the assembled PCB with ICs and connectors, showing the actual wiring implementation.

7. Results and Performance

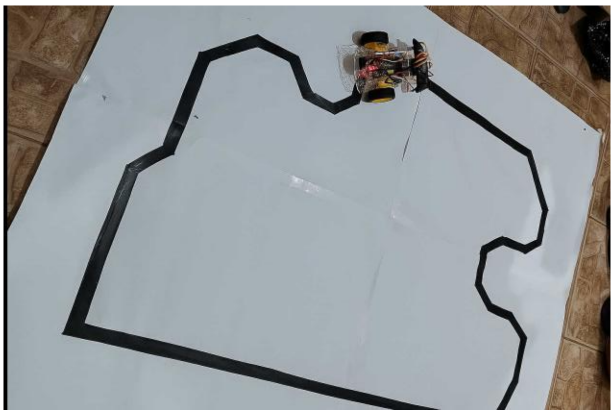


Figure 7.1 Results and Performance

A specified track was used to create and test the prototype line-following robot, with an emphasis on motor driver output stability, logic-gate-based control circuit responsiveness, and sensor detection accuracy.

7.1 **Line Detection Accuracy**

The five sensors were able to detect the contrast between the black line and the white surface during calibrations and testing and the truth table logic matched the expected motor responses.

7.2 **Speed and Stability**

When the robot had a high voltage, it had a more than average forward speed, this means that when detecting the contrast of black lines and white surface, turning at sharp turns and curved sections it overshoots due to its high speed. To resolve this, the group decided to lower the voltage of the robot by taking out one of the rechargeable batteries.

7.3 **Track Following Test**

During trial runs, the robot was able to follow straight lines but at the curved sections and sharp turns of the track, it stalls and overshoots. After lowering the voltage and fixing the placement of each sensor, the robot maintained a consistent speed and did not overshoot or stall.

7.4 Performance Summary

With the use of a logic-gate-based control system, the line-following robot was able to accomplish its goal of tracking its own course. The robot showed steady, precise, and reliable performance on both straight and curved courses after the first overshooting problems were fixed by reducing voltage and repositioning the sensors. These outcomes prove the tested design's reliability and effectiveness under the given testing circumstances.

8. References

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9. Appendices

A. Roles and Responsibilities

Table 9.1 ***Roles and Responsibilities***

The table summarizes each member's roles and responsibilities, highlighting their specific contributions to the project.

Member	Roles and Responsibilities	Description
Arcangel, Ahren Joaquin	3D Design, Etching, Assembly	Created 3D design for robot design and assisted in PCB etching and assembly.
Banez, Mhyca	3D Design, Poster, Documentation, Breadboarding	Contributed to 3D design, prepared documentation and poster, and helped in breadboarding.
Contreras, Jan Elmar	Research, Gathering of components, Documentation, Schematic & PCB Layout, Breadboarding, Troubleshooting.	Conducted research, gathered needed components, helped with the paper documentation, designed the schematic and PCB layout, and supported breadboarding and troubleshooting.
Higuchi, Kenji	Gathering of components, Video, Etching	Collected materials, documented progress through video, and assisted in PCB etching.

B. Picture of Process

1. Breadboarding

Figure 9.1 Breadboarding

This shows the initial circuit setup on a breadboard used for testing and verifying the design before final PCB implementation.

2. PCB Layout Creation

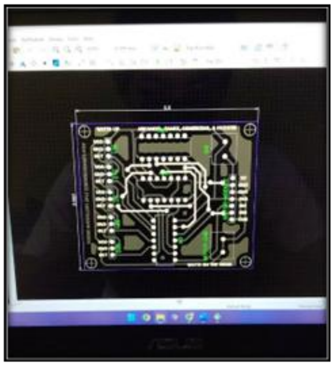

Figure 9.2 PCB Layout Creation

This shows the designed PCB layout showing component placement and circuit connections for implementation using DipTrace.

3. Chasis Assembly

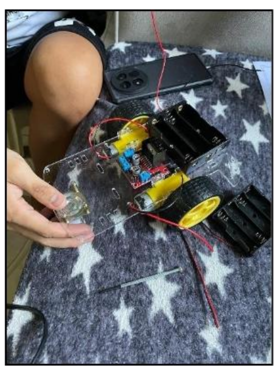

Figure 9.3 Chasis Assembly

This shows the assembly of robot chassis, including the motors, wheels, and base structure.

4. PCB Etching and Developing

Figure 9.4 PCB Etching and Developing

This shows the process of etching and developing the PCB to create the circuit.

5. Design Creation (Logo, Poster, Casing)

Casing:

Figure 9.5 Casing Design

This shows the design of the robot's casing, providing protection and overall design of the robot with a Festival theme.

Logo:

Figure 9.6. Logo Design

This shows the created logo design representing the group's identity.

Poster:

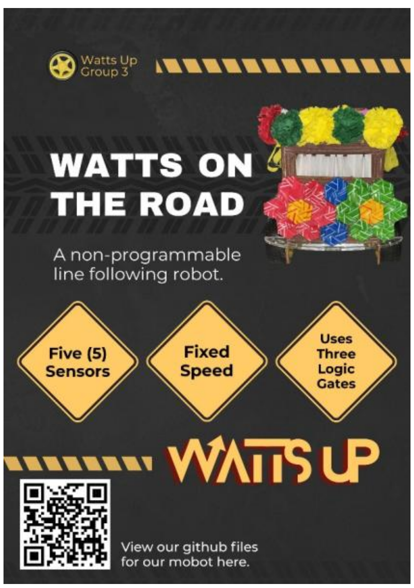

Figure 9.7 Poster Design

This shows the poster created for visual presentation of the project.

6.Calibration and Track Testing

Track Testing Video Link: https://drive.google.com/file/d/1DlnNKhsuoSv9w71YCVWjmwgRN5d0DEg3/view?usp=sharing

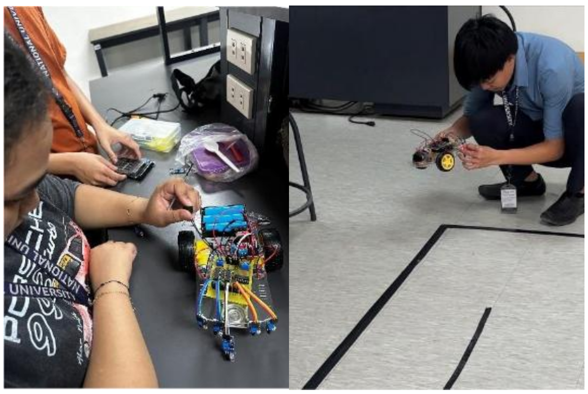

Figure 9.8 Calibration and Track Testing

Shows the robot being calibrated and tested on the track to ensure proper sensor response and movement.

7.Overall Assembly

Figure 9.9 Overall Assembly

This shows the fully assembled robot with all the components and design joined together.

C. Curriculum Vitae

ARCANGEL, Ahren Joaquin
BS Computer Engineering, National University Fairview (NU) 2023-Present

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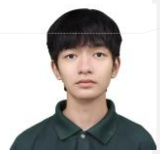
NATIONAL UNIVERSITY – FAIRVIEW
Class 2025



Commented [JC1]: @Arcangel, Ahren Joaquin

OBJECTIVE

Highly reliable and versatile Computer Engineering student with excellent computer literacy, aiming to establish and strengthen my skills through internships, workshops, training, and group projects.

DESIGN PROJECTS COMPLETED/ RESEARCH UNDERTAKEN

Project - Transistor-Based Audio and Bass Amplifier (Electronics)
May 2025
Project - Typing Test (Python Programming)

KNOWLEDGE, SKILLS AND ATTITUDE

- Interpersonal communication
- Computer Literacy
- Fast Learner
- Graphics Design and Video Editing (Canva, Filmora, CapCut)
- Computer-Aided Design (Auto-CAD, Blender, ExpressPCB, DipTrace)

SEMINAR/S AND TRAINING/S ATTENDED

- BYTE (2025)
- ACpES General Assembly (2025)

EXTRA AND CO-CURRICULAR ENGAGEMENTS AND VOLUNTEER WORKS

- NUFV - ACpES (Association of Computer Engineering Students) Member

Training Service) Graduate

BAÑEZ, Mhyca O.
BS Computer Engineering, National University Fairview (NU) 2023-Present

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NATIONAL UNIVERSITY – FAIRVIEW
Class 2025

OBJECTIVE

I aim to gain hands-on experience in Computer Engineering by engaging in internships and team-based projects, where I can contribute meaningfully to a forward-thinking company that prioritizes innovation, ethical practices, and ongoing development.

DESIGN PROJECTS COMPLETED/ RESEARCH UNDERTAKEN

- Electrical: Dancing Lights (Parol) – Using Transistor and sensor to emit lights.
- Electronics: Transistor-Based Audio and Bass Amplifier/Speaker

KNOWLEDGE, SKILLS AND ATTITUDE

- Electronics: Breadboarding, logic circuits, soldering
- Basic PCB Layout
- Dip trace
- Avid multitasker
- Quick learner
- Programming: Python, Iverilog
- Schematic Diagram
- Auto-cad Floor Plan

LEADERSHIP ACTIVITIES

- Creatives Team Graphic Designer, NU Fairview – Association of Computer Engineering Students (ACPES) (2023–2024)
- Active Member, NU Fairview – Association of Computer Engineering Students (ACPES)

SEMINAR/S AND TRAINING/S ATTENDED

- IoT Symposium (2023) - IoT Symposium Seminar Attendee
- BYTE (2025)
- Intro to Drone Simulation (2025)

EXTRA AND CO-CURRICULAR ENGAGEMENTS AND VOLUNTEER WORKS

- Staff - IoT Symposium Seminar (2023)

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Email Address: jancontreras210@gmail.com
Cellular No.: 0915406985

NATIONAL UNIVERSITY – FAIRVIEW
Class 2025

OBJECTIVE

A motivated Computer Engineering student seeking opportunities to apply technical skills in software development and hardware design while gaining practical experience in a dynamic engineering environment.

DESIGN PROJECTS COMPLETED/ RESEARCH UNDERTAKEN

Project - National University Fairview NU-ARF: Automated Room-Reservation Facilitation System
January 2025 - March 2025
NU-ARF: Automated Room-Reserved Facilitation System NU-ARF is an online room reservation application designed for booking process at National University.
Key responsibilities: Designing, Programming
Technologies used: Figma, PyCharm, Google Firebase

Project - Transistor-Based Audio and Bass Amplifier
May 2025
Transistor-Based Audio and Bass Amplifier boost weak audio signals to drive small speakers with improved clarity and bass response..
Key responsibilities: Prototyping, PCB Creation
Technologies used: DipTrace, TinkerCAD

KNOWLEDGE, SKILLS AND ATTITUDE

Programming Languages: Python, C++
Tools & Technologies: AutoCAD, MS Office Tools, Figma, DipTrace, ExpressPCB+, TinkerCAD

SEMINAR/S AND TRAINING/S ATTENDED

- IoT Symposium – AI Applications (2024)

EXTRA AND CO-CURRICULAR ENGAGEMENTS AND VOLUNTEER WORKS

ICPEP.SE (Institute of Computer Engineering of the Philippines, Inc. Students Edition) Member
NUFV ACpES (Association of Computer Engineering Students) Member

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Cellular No.: 09271930478

Commented [JC2]: @Higuchi, Kenji

OBJECTIVE

A driven student of computer engineering is looking for chances to use technical abilities in hardware design and software development while obtaining real-world experience in a fast-paced engineering setting.

DESIGN PROJECTS COMPLETED/ RESEARCH UNDERTAKEN

Project- Quiz Application for Nation University Students
To improve learning through interactive evaluations, the project intends to create a quiz application especially for National University students.
Key responsibilities: Designing and programming
Technologies used: Pycharm, Vscode

Project- Adjustable Power Supply
An **adjustable power supply** is an electronic device that provides a controlled voltage or current to power various electronic circuits or devices.
Key responsibilities: PCB Creation, Chassis Design
Technologies used: TinkerCAD

KNOWLEDGE, SKILLS AND ATTITUDE

Programming Languages: Python, C++
Tools & Technologies: AutoCAD, MS Office Tools, DipTrace, ExpressPCB+, TinkerCAD

SEMINAR/S AND TRAINING/S ATTENDED

BYTE (2025)
IoT Symposium – AI Applications (2024)

EXTRA AND CO-CURRICULAR ENGAGEMENTS AND VOLUNTEER WORKS

NUFV ACpES (Association of Computer Engineering Students) Member