FEDERAL MINISTRY OF EDUCATION

National Technical Certificate (NTC) Curriculum in

ROBOTICS ENGINEERING CRAFT

February, 2025

NATIONAL BOARD FOR TECHNICAL EDUCATION
NBTE

Innovation Development and Effectiveness in the Acquisition of Skills (IDEAS) Project

NBTE-IDEAS

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Funded by IDEAS project

NATIONAL BOARD FOR TECHNICAL EDUCATION

Plot B, Bida Road, P.M.B. 2239, Kaduna, Nigeria

NATIONAL TECHNICAL CERTIFICATE

CURRICULUM AND MOUDULE SPECIFICATIONS

IN

ROBOTICS ENGINEERING CRAFT

FEBRUARY, 2025

GENERAL INFORMATION

AIM

To provide training and impart the necessary skills to produce skilled personnel capable of integrating into the Robotics and Automation sector as technicians and self-reliant entrepreneurs.

ENTRY QUALIFICATIONS

Craft Programme

Candidates must be at least 14 years old and have successfully completed three years of Junior Secondary Education or its equivalent. Special consideration may be given to candidates with trade test certificates and relevant experience.

Candidates should possess the National Technical Certificate (NTC) or its equivalent and should have a minimum of two years post-qualification cognate industrial experience.

The Curriculum

The curriculum of each programme is divided into three key components:

a. General Education, which accounts for 30% of the total hours required for the programme.

b. Trade Theory, Trade Practice and Related Studies which account for 65% and,

c. Supervised Industrial Training/Work Experience which accounts for about 5% of the total hours required for the programme. This component of the course, which can be completed in industry or within the College production unit, is compulsory for full-time students.

Included in the curriculum are the teacher's activity and learning resources required for the guidance of the teacher.

Unit Course/Modules

A course/module is defined as a body of knowledge and skills capable of being utilized on its own or as a foundation or pre-requisite knowledge for more advanced work in the same or other fields of study. Each trade course/ module when successfully completed can be used for employment purposes.

Behavioural Objectives

These are educational objectives, which identify precisely the type of behaviour a student should exhibit at the end of a course/module or programme. Two types of behavioural objectives have been used in the curriculum. They are:

a. General Objectives
b. Specific Learning Outcomes

General objectives are concise statements of the expected behaviours students should exhibit upon completion of a unit or module, such as understanding the principles and applications of:

a Robotics Fundamentals

b Sensors and Actuators

c Programming and Automation

Specific learning outcomes are statements that detail the precise behaviors and skills students should demonstrate after completing the educational process, expressed through practical tasks and associated knowledge to ascertain that the general objectives of course/ programme have been achieved. They are more discrete and quantitative expressions of the scope of the tasks contained in a teaching unit.

General Education in Technical Colleges

The General Education component of the curriculum aims at providing the trainee with knowledge in critical subjects like English Language, Mathematics, Economics, Physics, Chemistry, Biology, Entrepreneurial Studies and Mathematics, etc. to enhance the understanding of machines, tools and materials of their trades and their application as a foundation for post-secondary technical education for the above average trainee. Hence, it is hoped that trainees who successfully complete their trade and general education may be able to compete with their secondary school counterparts for direct entry into Universities, Polytechnics or Colleges of Education (Technical) for degree, ND or NCE courses respectively.

For the purpose of certification, only the first three courses in mathematics will be required. The remaining modules are optional and are designed for the above average students.

National Certification

The NTC programmes are run by Technical Colleges accredited by NBTE.
NABTEB conducts the final national examination and awards certificates.

Trainees who successfully complete all the specified courses/modules and pass the national examinations in their trade will be awarded the following certificate:

S/NO	LEVEL	CERTIFICATE
	Technical Programme	
1.	NTC	National Technical Certificate

Guidance Notes For Teacher implementing the Curriculum

The number of hours specified in the curriculum table may be adjusted to suit the institution's timetable, provided the course content is fully covered and goals and objectives of each module are achieved at the end of the term.

The maximum duration of any module in the new scheme is 300 hours. This means that for a term of 15 weeks, the course should be offered for 20 hours a week. This can be scheduled in sessions of 4 hours in a day leaving the remaining hours for general education. However, properly organized and if there are adequate resources, most of these courses can be offered in two sessions a day, one in the morning and the other one in the afternoon. In so doing, some of these programmes may be completed in lesser number of years than at present.

The sessions of 4 hours include the trade theory and practice. It is left to the teacher to decide when the class should be held in the workshop or in a lecture room.

Teachers are encouraged to integrate both theoretical and practical aspects of robotics in their lesson plans. A minimum of 30% of the total teaching hours should be allocated for hands-on activities. Teachers should use modern teaching aids and practical tools to ensure students can relate theory to real-world applications.

INTEGRATED APPROACH IN THE TEACHING OF TRADE

Theory, Trade Science and Trade Calculation

The traditional approach of teaching trade science and trade calculation as separate and distinct subjects in Technical College programmes is not relevant to the new programme as it will amount to a duplication of the teaching of mathematics and physical science subjects in the course. The basic concepts and principles in mathematics and physical science are the same as in the trade calculation and trade science. In the new scheme therefore, qualified persons in these fields will teach mathematics and physical science and the instructors will apply the principles and concepts in solving trade science and calculation problems in the trade theory classes. To this end, efforts have been made to ensure that mathematics and science modules required to be able to solve technical problems were taken as pre-requisite

Evaluation of Programme/Module

For the programme to achieve its objectives, any course started at the beginning of a term must terminate at the end of the term. Instructors should therefore device methods of accurately assessing the trainees to enable them give the student's final grades at the end of the term. A national examination will be taken by all students who have successfully completed their modules. The final award will be based on the aggregate of the scores attained in the course work and the national examination.

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ROBOTICS ENGINEERING CRAFT.

GOAL: The Robotics Engineering Craft Programme is designed to equip trainees with the knowledge and skills needed to design, build, maintain, and troubleshoot robotic systems. Graduates of this programme will be capable of integrating mechanical, electronic, and programming principles to create automated solutions for industrial and commercial applications. The program also emphasizes creativity, problem-solving abilities, and entrepreneurship skills to enable graduates to succeed in the evolving robotics field.

CURRICULUM TABLE AND COURSE HOURS/WEEK

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE

Module Code	MODULE	YEAR I						YEAR 2						YEAR 3						TOTAL HOURS
		Term 1		Term 2		Term 3		Term 1		Term 2		Term3		Term 1		Term 2		Term 3		
		T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	
CAM 12 - 15	Mathematics	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	216
CEN 11 - 17	English	2	-	2	-	2	-	3	-	3	-	3	-	3	-	3	-	3	-	288
CPH 10 - 12	Physics	2	-	2	-	2	-	2	1	2	1	2	1	2	1	2	1	2	1	288
CCH 10 - 12	Chemistry	2	-	2	-	2	1	2	1	2	1	2	1	2	1	2	1	2	1	288
CEC 11 - 13	Economics	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	216
CBM 11	Entrepreneurship	-	-	-	-	-	-	2	-	2	-	2	-	-	-	-	-	-	-	72
ICT 11 - 15	Computer Studies	-	-	-	-	-	-	1	2	1	2	1	2	1	2	1	2	-	-	180
CRB 111	Introduction to Robotics	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72
CRB 112	Mathematical Foundation of Robotics	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72
CRB 123	Introduction to Programming (Arduino C++) for Robotics	-	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72
CRB 134	Basic electronics for Robotics	-	-	-	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	72
CRB 215	Basic Sensors and Interfacing for Robotics	-	-	-	-	-	-	2	4	-	-	-	-	-	-	-	-	-	-	72
CRB 226	Introduction to Kinematics	-	-	-	-	-	-	-	-	2	4	-	-	-	-	-	-	-	-	72

CBR 237	Introduction to Robot Control Systems	-	-	-	-	-	-	-	-	-	-	2	4	-	-	-	-	-	-	72
CBR 318	Computer Vision Basics	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	-	-	72
CBR 329	Basics of Motion Planning & Go-To Goal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	72
CBR 330	CAD Design & 3D Printing for Robotics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	72
Total		18	4	7	4	2	5	16	4	16	8	16	8	14	8	16	12	11	2	**4272**

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<tr><td colspan="3">MODULE 1: Introduction to Robotics</td><td>COURSE CODE: CRB111</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 1</td><td>TERM: 1</td><td>PREREQUISITE:</td><td colspan="2">Theoretical: 48 Hours
Practical: 24 Hours</td></tr>
<tr><td colspan="5">GOAL: This module is designed to introduce the trainee to develop basic knowledge of robotics</td></tr>
<tr><td colspan="5">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1.0 Know the history of robots and their application
2.0 Know the classifications of Robots
3.0 Know the Basic components of Robots
4.0 Discuss ethical and societal impacts of robotics.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 1: Introduction to Robotics				**COURSE CODE: CRB111**	**CONTACT HOURS:**	
YEAR: 1	**TERM:** 1		**PREREQUISITE:**		**Theoretical:** 48 Hours **Practical:** 24 Hours	
GOAL: This module is designed to introduce the trainee to develop basic knowledge of Robotics						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Know the history of robots and their application						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-3	1.1 Explain the origins and evolution of robotics. 1.2 Identify key milestones in robotics history (e.g., first industrial robot, modern advancements). 1.3 Define a Robot 1.4 Identify the applications of robots in industries like manufacturing, healthcare, agriculture, and space exploration.	Present a timeline of robotics history using slides or posters. Show videos of early robots (e.g., Unimate) and modern robots (e.g., Boston Dynamics). Assign students to research and present a key milestone in robotics history.	Timeline Posters, Documentary Videos (e.g., "Rise of the Robots"), Books on Robotics History			
GENERAL OBJECTIVE 2.0: Know the classification of Robots						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
4-6	2.1 Differentiate between types of robots: - Industrial robots (e.g., robotic arms). - Service robots (e.g., vacuum cleaners, delivery robots).	Use examples to explain different types of robots (e.g., industrial, service, medical).	Infographics on Robot Types, IEEE Robotics Reports, YouTube			

	- Medical robots (e.g., surgical robots). - Autonomous robots (e.g., self-driving cars). - Humanoid robots (e.g., ASIMO, Sophia). 2.2 Explain the criteria for classification (e.g., mobility, autonomy, application). 2.3 Identify the examples of robots in each category.	Organize a group activity where students classify robots based on their functions.	Videos on Robot Categories			
GENERAL OBJECTIVE 3.0: Know the Basic components of Robots						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
7-9	3.1 Describe the core components of a robot: **- Mechanical**: Chassis, joints, actuators (motors, servos). **- Electrical**: Power supply, sensors (IR, ultrasonic, IMU), microcontrollers (Arduino, Raspberry Pi). **- Software**: Control algorithms, feedback loops, programming languages (C++, Python). 3.2 Discuss the functions of each component of a robot	Show a disassembled robot or robot kit and explain each component (e.g., motors, sensors, microcontrollers). Assign students to label the components of a robot diagram.	3D Diagrams of Robot Parts, Physical Robot Models, Interactive Slides	3.1 Identify the components of Robot 3.2 Assemble a basic robot using these components	Show a disassembled robot or robot kit and explain each component. Assign students to assemble the components of a robot using the provided kit.	Disassembled Robot Kit, Microcontrollers, Motors, Sensors, Actuators

GENERAL OBJECTIVE 4.0: Discuss ethical and societal impacts of robotics.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
10-12	4.1 Discuss the ethical implications of robotics (e.g., job displacement, privacy concerns). 4.2 Explain the concept of robot rights and responsibilities. 4.3 Describe the impacts of robots in agriculture. 4.4 Analyze the societal benefits of robotics (e.g., improved healthcare, disaster response). 4.5 Discuss the future of robotics and its potential impact on humanity	Facilitate a debate on the ethical implications of robotics (e.g., job displacement, privacy concerns). Assign students to write a short essay on the societal benefits of robotics	Debate Topics, Case Studies (e.g., Ethics of AI), Research Papers			

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="3">MODULE 2: Mathematical Foundation of Robotics</td><td>COURSE CODE: CRB112</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 1</td><td>TERM: 1</td><td>PREREQUISITE:</td><td colspan="2">Theoretical: 48 Hours
Practical: 24 Hours</td></tr>
<tr><td colspan="5">GOAL: This module is designed to equip students with the mathematical tools necessary for understanding and designing robotic systems.</td></tr>
<tr><td colspan="5">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1.0 Understand and apply coordinate systems and transformations.
2.0 Learn the basics of linear algebra for robotics.
3.0 Develop skills in kinematics for robot motion.
4.0 Understand the principles of dynamics and control.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 2: Mathematical Foundation of Robotics				**COURSE CODE: CRB112**		**CONTACT HOURS:**
YEAR: 1	**TERM: 1**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours		
GOAL: This module is designed to equip students with the mathematical tools necessary for understanding and designing robotic systems.						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand and Apply Coordinate Systems and Transformations						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-3	1.1 Define 2D and 3D coordinate systems. 1.2 Differentiate between 2D and 3D coordinate systems. 1.3 Relate 2D and 3D coordinate systems to Robotics	Show animations of 2D and 3D frame transformations. Give examples of applications of 2D and 3D coordinate systems to Robotics	Graph Paper, Digital Simulations (GeoGebra), Animated Videos on Transformations	1.1 Identify 2D and 3D coordinate systems 1.2 Demonstrate the use of 2D and 3D coordinate systems in Robotics	Use physical models to demonstrate coordinate systems. Use picking an object to demonstrate how 2D and 3D transformation is carried out	2D and 3D wooden or paper models. Any Objects
GENERAL OBJECTIVE 2.0: Learn the basics of linear algebra for robotics.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
4-6	2.1 Define a vector 2.2 Describe how matrix is formed from vectors 2.3 Explain linear geometry 2.4 Describe robot motion and transformations using linear algebra	Teach vector and matrix operations using simple examples. Discuss linear geometry using examples Provide exercises for	Books (e.g., "Linear Algebra for Robotics"), Examples, Practice Worksheets Calculators			

		students to practice solving linear equations and matrices				
GENERAL OBJECTIVE 3.0: Develop skills in kinematics for robot motion.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
7-9	3.1 Define forward and inverse kinematics. 3.2 Describe body fixed frame and World frame. 3.3 Discuss how forward and inverse kinematics can be achieved using Body fixed frame and World frame.	Walk students through the derivation of forward kinematics for a 2-link planar arm. Assign practice problems for students to solve.	Motion Analysis Videos, Robot Arm Demo Models	3.1 Demonstrate how forward and inverse kinematics can be achieved using Body fixed frame and World frame.	Use physical models to demonstrate forward and inverse kinematics	Robot Arm Demo Models
GENERAL OBJECTIVE 4.0: Understand the principles of dynamics and control.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
10-12	4.1 Understand the basics of Newtonian mechanics (forces, torque, inertia). 4.2 Derive the equations of motion for simple systems. 4.3 Explain the concept of feedback control and its importance in robotics.	Use examples (e.g., a pendulum or rolling ball) to explain dynamics.	Interactive Control System Models, PID Controller Videos, Books on Robotics Control	4.1 Simulate a pendulum or rolling ball to demonstrate dynamics.	Use examples (e.g., a pendulum or rolling ball) to explain dynamics.	Robotic Arm Kit, Protractors, Measuring Tools,

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="3">MODULE 3: Introduction to Programming (Arduino C++) for Robotics</td><td>COURSE CODE: CRB123</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 1</td><td>TERM: 2</td><td>PREREQUISITE:</td><td colspan="2">Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="5">GOAL: This module is designed to equip students with foundational knowledge of the Arduino platform (C++ programming).</td></tr>
<tr><td colspan="5">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1. Understand the basics of the Arduino platform and its components.
2. Learn the fundamentals of C++ programming for Arduino.
3. Develop skills in interfacing sensors and actuators with Arduino.
4. Write and debug code for basic robotic tasks.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 3: Introduction to Programming (Arduino C++) for Robotics				**COURSE CODE: CRB123**		**CONTACT HOURS: 72**
YEAR: 1	**TERM: 2**		**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours	
GOAL: This module is designed to equip students with foundational knowledge of the Arduino platform (C++ programming)						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand the basics of the Arduino platform and its components.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-3	1.1 Explain the Arduino Uno hardware, including the microcontroller, ports, power supply, and other key components. 1.2 Explain the functions of digital and analogue pins, and their role in input/output operations. 1.3 Explain the Arduino IDE software, including its features such as the code editor, serial monitor, and tools for compiling and uploading code. 1.4 Explain the role of libraries in extending Arduino functionality. 1.5 Troubleshoot common hardware and software issues,	Show a physical Arduino board and explain each component. Provide a labelled diagram for students to study.	Arduino Board Diagrams, Introduction to Microcontrollers Video	1.1 Identify the main components of an Arduino board (e.g., microcontroller, pins, power supply). 1.2 Setup (Download and Install) the Arduino IDE. 1.3 Upload a simple sketch (e.g., blink an LED) to the Arduino Board.	Guide the students to be able to identify the parts on Arduino Board. Guide students to download and install Arduino IDE	Arduino Kits, Breadboards, Jumper Wires, Resistors

	including incorrect pin connections, compilation errors, and faulty components.					
GENERAL OBJECTIVE 2.0: Learn and apply the fundamentals of C++ programming to develop and control embedded systems using the Arduino platform						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
4-6	2.1 Explain basic C++ syntax, including variables, data types, and operators, and their purpose in building functional code. 2.2 Write basic C++ syntax by creating simple programs using variables, data types, and operators. 2.3 Explain control structures (e.g., if-else, switch-case, loops) and their role in decision-making and repetition in programming 2.4 Define functions in C++ and explain their importance in creating modular, reusable code. 2.5 Call functions in C++ to modularize and structure code effectively	Discus basic C++ syntax Discuss basic programming concepts using simple examples (e.g., blinking an LED). Discuss control structures Discuss functions and how to modularize code Describe arrays and strings Discuss the basics of object-oriented programming.	Coding Worksheets, Interactive Tutorials (Codecademy, Arduino.cc)	2.1 Design a basic calculator using C++ code 2.2 Write and upload a simple Arduino program (e.g., blink an LED, control a servo). 2.3 Use function to modularize code	Guide students to design a basic calculator using C++ code Guide students to write and upload a simple Arduino program Guide students to use function to modularize code	Laptops, Arduino IDE, Arduino Board Other accessories

	2.6 Explain arrays and strings as data structures used for storage and manipulation of information in C++ programmes 2.7 Explain the basics of object-oriented programming (e.g., classes, objects) and their relevance to organizing code in C++ for Arduino applications.					
GENERAL OBJECTIVE 3.0: Develop skills in interfacing sensors and actuators with Arduino.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
7-9	3.1 Explain the functionality, types, and examples of sensors and actuators used in embedded systems. 3.2 Differentiate between sensors and actuators, focusing on their roles in Arduino-controlled systems (input vs. output). 3.3 Differentiate between digital and analogue sensors, and provide examples of each type in practical applications. 3.4 Explain how sensors are connected and programmed to trigger actuators in an Arduino	Discuss sensors, actuators and differentiate between them. Discuss the wiring diagram of sensors and actuators	Sensor Datasheets, Circuit Connection Posters, Breadboard Wiring Charts	3.1 Read data from digital and analog sensors (e.g., IR sensors, ultrasonic sensors). 3.2 Control actuators (e.g., motors, servos) using PWM signals. 3.3 Interface with common communication protocols (e.g., I2C, SPI). 3.4 Troubleshoot and debug sensor and actuator connections.	Demonstrate how to connect and read data from sensors. Supervise students as they build and test their circuits.	IR Sensors, Ultrasonic Sensors, Servo Motors, LEDs

	system, focusing on signal processing and control flow.					
GENERAL OBJECTIVE 4.0: Write and debug code for basic robotic tasks.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
10-12	4.1 Explain the structure of a basic Arduino sketch. 4.2 Write a simple program to control a motor. 4.3 Write code to process sensor input and make decisions. 4.4 Debug a program using the Arduino IDE serial monitor. 4.5 Write a program to control the movement of a simple robot. 4.6 Test and troubleshoot robotic code.	Provide an overview of the structure of an Arduino sketch, explaining the purpose of the setup() and loop() functions. Create a basic sketch on the Arduino IDE, demonstrating how to use the setup() function to configure input/output pins and the loop() function to repeat actions. Explain how to connect a DC motor to an Arduino board using a motor driver (e.g., L298N) and how to control motor speed and direction using digital output pins. Guide students in writing a simple program to control the	Projector to display Arduino IDE. Pre-made simple Arduino sketch for demonstration. Arduino Uno and laptop for coding demo. motor driver (L298N), DC motor, jumper wires. Step-by-step guide on motor control with Arduino.	4.1 Write code to control a robot's movement (e.g., forward, backward, turn). 4.2 Implement basic feedback control using sensor data (e.g., line-following, obstacle avoidance). 4.3 Debug code using serial monitoring and print statements	Guide students in writing code for tasks (e.g., line-following, obstacle avoidance). Provide feedback on their code and help them debug errors.	Serial Monitor, Arduino IDE

		motor's speed and direction. Provide students with an Arduino board, motor driver, and motor to implement and test their code. Introduce sensors (e.g., light or distance sensors), explaining how to read analog or digital values from the sensors using the Arduino board. Demonstrate how to write code that reads sensor input and uses conditions (e.g., if-else) to make decisions (e.g., turning a motor on or off based on sensor readings). Introduce the serial monitor in the Arduino IDE and explain its importance for debugging programs by printing values to the screen.	Arduino IDE for coding. Light sensor (or distance sensor) Sensor datasheets for reference. Pre-written example code for sensor input processing. Two-wheeled robot kit (Arduino, motor driver, wheels, sensors). Guide on how to assemble the robot. Sample Arduino code for robotic movement.			

		Run a faulty program, demonstrating how to use the serial monitor to print sensor values and diagnose the issue. Introduce the concept of robotic movement (e.g., a two-wheeled robot) and explain how sensors and motors work together to control movement (e.g., obstacle avoidance or line following). Guide students through writing a full programme to control a two-wheeled robot, using sensor input to make the robot move, stop, or change direction. Supervise the testing of each group's robot, providing feedback and asking students to identify any issues with robot behaviour.	Two-wheeled robot kits (Arduino, sensors, motors). Debugging guide for common robotic issues (e.g., wrong sensor readings, motor control problems). Arduino IDE for real-time testing.			

		Demonstrate common troubleshooting techniques, such as checking sensor connections, reviewing motor wiring, and using the serial monitor to debug logic errors.				

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="2">MODULE 4: Basic electronics for Robotics</td><td>COURSE CODE: CRB134</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 1</td><td>TERM: 3</td><td>PREREQUISITE:</td><td>Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="4">GOAL: This module is designed to provide students with a foundational understanding of electronics, enabling them to design, build, and troubleshoot circuits for robotic systems.</td></tr>
<tr><td colspan="4">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1.0 Understand the fundamental concepts of electricity and electronics.
2.0 Learn to use basic electronic components in robotic circuits.
3.0 Develop skills in reading and designing circuit diagrams.
4.0 Understand power management and safety in robotics.
5.0 Build and troubleshoot simple electronic circuits for robotics.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE					
MODULE 4: Basic electronics for Robotics			**COURSE CODE: CRB134**	**CONTACT HOURS:**	
YEAR:	**TERM:**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours	
GOAL: This module is designed to provide students with a foundational understanding of electronics, enabling them to design, build, and troubleshoot circuits for robotic systems.					
Theoretical Content			**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand the Fundamental Concepts of Electricity and Electronics					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-2	1.1 Define voltage, current, resistance, and power, and understand their relationships (Ohm's Law). 1.2 Explain the difference between AC and DC circuits. 1.3 Explain the concept of electrical ground and its importance in circuits. 1.4 Calculate power consumption and heat dissipation in electronic components. 1.5 Describe the role of semiconductors in modern electronics. 1.6 Explain the concept of series and parallel connection of	Use a multimeter to demonstrate how to measure voltage, current, and resistance and the relationship with ohms law. Provide simple circuit examples to explain Ohm's Law. Perform practical experiments to measure power and heat in simple circuits. Explain how semiconductors are used in robotic systems (e.g., microcontrollers,	Books (e.g., "Electronics for Dummies"), Circuit Diagrams, Interactive Physics Simulations	1.1 Build a simple circuit (e.g., LED with a resistor) and measure voltage, current, and resistance using a multimeter. 1.2 Calculate power consumption in a circuit using Ohm's Law	Guide student to use a multimeter to measure voltage, current, and resistance. Guide students on how to calculate voltage, current and resistance using ohms law. Provide simple circuit examples to explain Ohm's Law.	Multimeters, Power Supplies, Circuit Components

	electronic components	sensors). Build simple series and parallel circuits to demonstrate the differences in voltage and current distribution.				
GENERAL OBJECTIVE 2.0: Learn to Use Basic Electronic Components in Robotic Circuits						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
3-5	2.1 Identify and use resistors, capacitors, and inductors in circuits. 2.2 Understand the function and use of diodes and LEDs. 2.3 Work with transistors (e.g., BJT, MOSFET) as switches and amplifiers. 2.4 Use integrated circuits (ICs) such as voltage regulators and motor drivers. 2.5 Understand the role of sensors (e.g., IR, ultrasonic) and actuators (e.g., motors, servos) in robotics.	Show physical components (e.g., resistors, capacitors, LEDs) and explain their functions. Supervise students as they build simple circuits (e.g., LED blink).	Hands-on Circuit Kits, LED Circuit Demonstrations, Online Resistor Calculators	2.1 Build circuits using resistors, capacitors, and LEDs (e.g., LED blink, RC circuit). 2.2 Test the functionality of each component in the circuit.	Show physical components (e.g., resistors, capacitors, LEDs) and explain their functions. Supervise students as they build and test their circuits	Breadboards, Resistors, Capacitors, Transistors, ICs

GENERAL OBJECTIVE 3.0: Develop Skills in Reading and Creating Circuit Diagrams						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
6-8	3.1 Explain schematic diagrams and give examples. 3.2 Explain standard symbols for electronic components. 3.3 Explain the internal array connection of a breadboard.	Discuss diagrams with examples. Discuss standard symbols for electronic components. Discuss the internal array connection of a breadboard.	Circuit Simulation Software Scratch, (Tinkercad, Fritzing), Schematic Posters	3.1 Read and interpret schematic diagrams. 3.2 Identify standard symbols for electronic components in circuit diagrams. 3.3 Create a circuit diagram for a simple robotic system. 3.4 Use breadboards to prototype circuits. 3.5 Transition from a breadboard prototype to a soldered circuit board.	Guide the students to read and interpret schematic diagrams Guide the students to identify standard symbols for electronic components in circuit diagrams. Assign students to draw schematics for simple circuits. Supervise students in soldering operation and handling of soldering iron.	Circuit Simulation Software, Schematic Diagrams, Books
GENERAL OBJECTIVE 4.0: Understand Power Management and Safety in Robotics						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
9	4.1 Explain voltage regulation and current limiting in circuits. 4.2 Explain safety procedure in designing robots 4.3 Explain safety procedures in handling tools.	Discuss voltage regulation and current limiting in circuits. Discuss safety practices (e.g., avoiding short circuits, handling components	Troubleshooting Guide, Component Data Sheets, Videos on Common Circuit Issues	4.1 Select appropriate tools 4.2 Select appropriate power sources (e.g., batteries, power supplies) for robotic systems. 4.3 Use multimetres to	Guide students how to select proper tools to be used. Guide students how to select and use batteries and power supplies.	Soldering Irons, batteries DC power sources. Multimetrer Bread Boards Vero Boards

		safely).		measure voltage, current, and resistance. 4.4 Implement safety practices to prevent short circuits, overheating, and electrical hazards. 4.5 Design power distribution systems for multi-component robots.	Guide students how to design and know the required power for their robotics project. Demonstrate how to select and use batteries and power supplies. Teach safety practices (e.g., avoiding short circuits, handling components safely).	
GENERAL OBJECTIVE 5.0: Build and troubleshoot simple electronic circuits for robotics.						
10-12	5.1 Explain the procedure in designing a circuit 5.2 Explain the components required to perform the task. 5.3 Explain the procedures in diagnosing and optimising a circuit.	Discuss procedures in designing a circuit Discuss the components required in designing a circuit Discuss the procedure in diagnosing and optimising a circuit.	Charts Videos	5.1 Assemble a basic circuit (e.g., LED blink, motor control). 5.2 Diagnose common circuit issues (e.g., open circuits, short circuits). 5.3 Optimize circuits for efficiency and reliability. 5.4 Document and present a functional electronic circuit for a robotic application.	Supervise students as they build and test circuits. Guide them in troubleshooting common issues.	Soldering Irons, Test Benches Multimeter Bread Boards, Vero Boards, Jumper wires LED Motors

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="2">MODULE 5: Basic Sensors and Actuators Interfacing for Robotics</td><td>COURSE CODE:CRB215</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 2</td><td>TERM: 1</td><td>PREREQUISITE:</td><td>Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="4">GOAL: This module is designed to teach students how to select, interface, and use sensors in robotic systems, enabling them to gather data and implement feedback control.</td></tr>
<tr><td colspan="4">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:
1. Understand the role of sensors in robotics and their types.
2. Understand the role of actuators in robotics.
3. Learn to interface analog and digital sensors with microcontrollers.
4. Develop skills in processing and interpreting sensor data.
5. Explore basic sensor fusion techniques (e.g., complementary filter).</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 5: Basic Sensors and Interfacing for Robotics				**COURSE CODE: CRB215**	**CONTACT HOURS:**	
YEAR: 2	**TERM: 1**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours		
GOAL: This module is designed to teach students how to select, interface, and use sensors in robotic systems, enabling them to gather data and implement feedback control.						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand the role of sensors in robotics and their types.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1	1.1 Define what sensors are and why they are important in robotics. 1.2 Classify sensors based on their output (analog vs. digital). 1.3 Explain common sensors used in robotics (e.g., IR, ultrasonic, temperature). 1.4 Explain how sensors help robots interact with their environment. 1.5 Compare sensors based on their applications.	Discuss Sensors, their importance and classes. Show examples of sensors (e.g., IR, ultrasonic) Discuss how sensors help robots interact with their environment.	Sensor Infographics, Books on Sensors (e.g., "Sensors for Mechatronics"), Live Sensor Demos	1.1 Identify common sensors used in robotics (e.g., IR, ultrasonic, temperature). 1.2 Test different sensors (e.g., IR, ultrasonic) and record their outputs. 1.3 Compare the performance of analog vs. digital sensors.	Guide students on how to identify and test sensors Guide students on how to compare the performance of analog and digital sensors	Sensor Kits (Ultrasonic, IR, Temperature, Light)
GENERAL OBJECTIVE 2.0: Understand the roles of actuators in robotics.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
2	2.1 Explain actuators 2.2 Explain types of actuators	Discuss actuators Discuss how actuators	Infographics, Books on Actuators,	2.1 Identify different actuators and their uses	Guide students on how to connect actuators	Actuators, jumper wires, Arduino Uno,

	2.3 Explain how to connect and read data from actuators	can be connected to robots	Videos and slides.	2.2 Connect actuators too perform a specific function 2.3 Write an Arduino code to activate an actuator to perform a function	Guide students on how to read actuator data using serial monitor	Arduino IDE
GENERAL OBJECTIVE 3.0: Learn to interface analog and digital sensors with microcontrollers.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
3-5	3.1 Explain how to read analog sensor data using an Arduino (e.g., potentiometer, light sensor). 3.2 Explain how to Interface digital sensors with Arduino (e.g., buttons, ultrasonic sensors) with Arduino. 3.3 Explain how digital sensors can be connected using interfaces (e.g., I2C, SPI). 3.4 Explain how to troubleshoot common sensor interfacing issues (e.g., incorrect wiring).	Discuss how to connect sensors with interfaces Discuss steps in troubleshooting common issues	Circuit Diagrams, Library Documentation, Interactive Simulations	3.1 Connect digital sensors with Arduino 3.2 Write Arduino code to display sensor data on the serial monitor. 3.3 Read analog sensor data using an Arduino (e.g., potentiometer, light sensor). 2.4 Debug if there is an error.	Demonstrate how to connect and read data from sensors. Provide coding examples for students to practice.	Microcontrollers (Arduino), Jumper Wires Arduino Sensor I2C SPI
GENERAL OBJECTIVE 4.0: Develop skills in processing and interpreting sensor data.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
6-8	4.1 Explain how raw sensor data can be converted into meaningful units	Discuss how raw data can be converted and visualised	Data Logs, Charts, Slides,	4.1 Convert raw sensor data into meaningful units (e.g., distance in cm,	Guide students how to calibrate sensors and filter noisy data.	Serial Monitors Arduino IDE Jumper wires

	(e.g., distance in cm, temperature in °C). 4.2 Explain how to visualize sensor data using serial monitors 4.3 Explain how to make decisions using sensor data	Discuss how decision are made using data.	Videos,	temperature in °C). 4.2 Visualize sensor data using tools like serial monitors or graphs. 4.3 Use sensor data to make decisions (e.g., stop if an obstacle is detected).	Assign exercises to convert raw sensor data into meaningful units.	Arduino Uno
GENERAL OBJECTIVE 5.0: Explore basic sensor fusion techniques (e.g., complementary filter).						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
9-12	5.1 Explain the line of code for a line-following robot using IR sensors. 5.2 Explain the steps involved in developing an obstacle-avoidance robot using ultrasonic sensors. 5.3 Explain the steps in designing circuits using Tinkercad.	Discuss how to build and program robots (e.g., line-following, obstacle avoidance). Discuss how to connect IR and ultrasonic sensors Discuss the steps involved in developing an obstacle-avoidance robot using ultrasonic sensors.	Textbooks, Manuals, Simulation videos,	5.1 Build and program a line-following robot using IR sensors. 5.2 Develop an obstacle-avoidance robot using ultrasonic sensors. 5.3 Simulate a sensor-based control system using software tools (e.g., Tinkercad). 5.4 Present and demonstrate a functional robot that uses sensors for control.	Supervise students as they build and program robots.	IR Sensors, Ultrasonic Sensor, Motors, Motor Drivers, Arduino Uno, Arduino IDE, Jumper wires, Batteries, Chassis, Switch,

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="2">Module 6: Introduction to Kinematics</td><td>COURSE CODE: CRB226</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 2</td><td>TERM: 2</td><td>PREREQUISITE:</td><td>Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="4">GOAL: This module introduces students to the mathematical principles of robot motion, focusing on forward and inverse kinematics, which are essential for controlling robotic arms and mobile robots.</td></tr>
<tr><td colspan="4">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1. Understand what kinematics is and why it’s important in robotics.
2. Learn how robots move and how to describe their motion.
3. Explore basic concepts of forward and inverse kinematics.
4. Understand coordinate systems and how robots use them.
5. Apply kinematic concepts to simple robotic projects.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 6: Introduction to Kinematics			**COURSE CODE:**		**CONTACT HOURS:**	
YEAR: 2	**TERM: 2**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours		
GOAL: This module is designed to provide students with a foundational understanding of kinematics in robotics,						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand what kinematics is and why it's important in robotics.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1	1.1 Define kinematics in simple terms (the study of motion without forces). 1.2 Explain how kinematics helps robots move and perform tasks. 1.3 Describe examples of kinematics in everyday life (e.g., robotic arms, drones). 1.4 Describe the difference between kinematics and dynamics. 1.5 Discuss why kinematics is important for designing robots.	Use animations to explain the difference between kinematics and dynamics. Provide real-world examples (e.g., robotic arm motion).	Robotic Arm Animation, Videos, Books, Slides	1.1 Identify differences between kinematics and dynamics. 1.2 Identify the different kinematic motion performed by a robot arm.	Use animations to explain the difference between kinematics and dynamics. Provide real-world examples (e.g., robotic arm motion).	Robotic Arm Kits, 3D Printed Models.
GENERAL OBJECTIVE 2.0: Learn how robots move and how to describe their motion.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
	2.1 Explain the concept of degrees of freedom (DOF) in robots.	Discuss the derivation of forward kinematics for a 2-link planar arm.	Videos, Simulation, Graphing	2.1 Derive forward kinematics for a 2-link planar arm.	Guide students through the derivation of forward kinematics	Planar arm models, Markers,

	2.2 Describe how joints (e.g., revolute, prismatic) allow robots to move. 2.3 Explain how wheels, legs, or arms enable motion in different robots.	Use simulations to demonstrate forward kinematics for mobile robots.	Exercises	2.2 Build a simple robotic arm and calculate its end-effector position.	for a 2-link planar arm.	Measurement Tools
GENERAL OBJECTIVE 3.0: Explore basic concepts of forward and inverse kinematics.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
	3.1 Define forward kinematics (predicting where the robot will move). 3.2 Define inverse kinematics (finding how to move the robot to a specific position). 3.4 Use hands-on activities to explore forward and inverse kinematics.	Discuss forward and inverse kinematics. Discuss how to achieve forward and inverse kinematics.	Videos, Slides, Posters, textbooks	3.1 Design an inverse kinematics for a 2-link planar arm using geometric methods. 3.2 Design a forward kinematics robot.	Guide students through the steps of designing an inverse kinematics for a 2-link planar arm. Guide students through the steps of designing a forward kinematics robot.	Graph Paper, Robot Kit, Arduino Uno, Ardiono IDE, Jumper wires Batteries 2-Link Planar arms
GENERAL OBJECTIVE 4.0: Understand coordinate systems and how robots use them.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
	4.1 Define a coordinate system (e.g., x, y, z axes). 4.2 Differentiate between the robot's frame and the world frame. 4.3 Describe robot motion	Explain physical models to demonstrate coordinate frames. Discuss steps to achieve transformations.	Virtual Robotics Lab, CAD Models of Robot Joints, Interactive Robot Motion	4.1 Perform 2D transformations (e.g., translation, rotation) on graph paper. 4.2 Apply coordinate systems to plan robot paths.	Guide students through the steps to design physical models. Guide students through the steps to perform 2D	Miniature Robotic Systems, Robotic Arm Kits

	using coordinate systems (e.g., “Move to x=5, y=10”).		Demos		transformation using graph paper.	
GENERAL OBJECTIVE 5.0: Apply kinematic concepts to simple robotic projects.						
	5.1 Explain the codes required to perform a simple robot motion 5.2 Outline steps involved in using Tinkercad for designing a robot. 5.3 Outline the components required to design a simple robot.	Guide students in simulating robot motion using scratch or Tinkercad Provide feedback on their simulations.	Virtual Robotics Lab, CAD Models of Robot Joints, Interactive Robot Motion Demos	5.1 Build and program a simple robotic arm to move to specific positions. 5.2 Use forward kinematics to predict where a robot will move. 5.3 Use inverse kinematics to control a robot arm to reach a target. 5.4 Simulate robot motion using software tools (e.g., Scratch, Tinkercad). 5.5 Present a project demonstrating kinematic principles.	Guide students in simulating robot motion using software. Provide feedback on their simulations.	Miniature Robotic Systems, Robotic Arm Kits, Simulation software

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="2">Module 7: Introduction to Robot Control Systems</td><td>COURSE CODE: CRB237</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 2</td><td>TERM: 3</td><td>PREREQUISITE:</td><td>Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="4">GOAL: This module is designed to equip students with the knowledge of robot control systems</td></tr>
<tr><td colspan="4">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1 Understand what robot control systems are and why they are important.
2 Learn the basics of open-loop and closed-loop control.
3 Explore simple feedback mechanisms for robots.
4 Understand how sensors and actuators work together in control systems.
5 Apply control concepts to build and program a simple robot.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 7: Introduction to Robot Control Systems				**COURSE CODE: CRB237**	**CONTACT HOURS:**	
YEAR: 2	**TERM: 3**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours		
GOAL: This module is designed to introduce the trainee to the						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand what robot control systems are and why they are important.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1	1.1 Define a control system in simple terms (e.g., a system that makes a robot do what you want). 1.2 Explain why control systems are important for robots (e.g., to move accurately, avoid obstacles). 1.3 Outline examples of control systems in everyday life (e.g., thermostats, self-driving cars). 1.4 Describe the difference between manual and automatic control. 1.5 Explain how control systems make robots smarter and more efficient.	Give examples (e.g., thermostat, self-driving car) to explain control systems. Discuss how control systems make robots smarter.	Block Diagram Posters, Control Theory Books, Videos on Open vs Closed-Loop Systems	1.1 Build a simple open-loop control system (e.g., a fan that turns on at a specific time). 1.2 Build a closed-loop control system (e.g., a thermostat). Guide students in designing a simple control system.	Guide students using examples (e.g. thermostat, self-driving car) to explain control systems.	Thermostats, Motor Drivers, Sensors, Control System Kits

GENERAL OBJECTIVE 2.0: Learn the basics of open-loop and closed-loop control.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
2	2.1 Define open-loop control (e.g., robot moves without feedback). 2.2 Define closed-loop control (e.g., robot uses feedback to adjust its actions). 2.3 Compare open-loop and closed-loop control with real-world examples. 2.4 Explain the role of sensors in closed-loop control.	Discuss open-loop and closed-loop control with simple examples (e.g., fan vs. thermostat). Give examples of open and closed loop control in real life.	Block Diagram Posters, Control Theory Books, Videos on Open vs Closed-Loop Systems	2.1 Build and test an open-loop control system (e.g., a robot moving in a straight line). 2.2 Build and test a closed-loop control system (e.g., a line-following robot).	Guide students in designing an open-loop and closed-loop control. Guide students to identify examples of open ad closed loop systems in real life.	DC Motors Microcontrollers, Arduino IDE, Jumper wires
GENERAL OBJECTIVE 3.0: Explore simple feedback mechanisms for robots.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
3-5	3.1 Explain the concept of feedback in control systems. 3.2 Describe the difference between open-loop and closed-loop control systems with examples. 3.3 Explain how feedback mechanisms help improve the accuracy and performance of robots. 3.4 Demonstrate how sensors	Discuss how feedback works in a line-following robot. Discuss the steps in programming a feedback control system. Illustrate the difference between open-loop and closed-loop systems using	Comparison Charts, Practical Examples (e.g., Thermostat, Motor Control)	3.1 Build a line-following robot that uses feedback to adjust its path. 3.2 Test the robot's performance and optimize the feedback algorithm.	Guide students on designing ssa line-following robot. Guide students in programming a feedback control system. Guide students to compare two robotic setups, one using an open-loop system	Feedback Sensor Modules, Line Following Robot Kits

	provide real-time feedback to control robotic movements. 3.5 Program a simple feedback loop using sensors and actuators in a robotic system (e.g., maintaining a robot's balance or adjusting motor speed). 3.6 Troubleshoot common issues in feedback-controlled robotic systems.	diagrams, explaining how each system operates and the absence or presence of feedback. Demonstrate how sensors (e.g., ultrasonic or infrared sensors) collect real-time data and how that data is processed by the control system to adjust the robot's actions. Provide a step-by-step tutorial on how to write a feedback control program using an Arduino or similar platform. Provide students with a troubleshooting guide for common feedback-related issues, such as noisy sensor data, incorrect actuator responses, or delayed feedback.			(e.g., pre-programmed movements) and another using a closed-loop system (e.g., sensor-driven adjustments). Guide students to document how feedback influences performance. Guide students to connect a sensor (e.g., ultrasonic) to an Arduino-controlled robot and write a simple program where the robot responds to real-time sensor input (e.g., avoiding obstacles based on proximity detection). Guide students to write and upload a program to a robot that uses a feedback loop to adjust its movements. (e.g., slowing down or stopping when approaching an	

					obstacle). They will test the robot and observe how the feedback mechanism improves its operation. Guide students by given them a robot with a faulty feedback system and guide them to troubleshoot and fix the issue using the debugging steps provided (e.g., checking sensor connections, calibrating sensors, adjusting code logic).	
GENERAL OBJECTIVE 4.0: Understand how sensors and actuators work together in control systems.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
6-8	4.1 Explain how sensors gather information (e.g., distance, light, sound). 4.2 Describe how actuators perform actions (e.g., move wheels, rotate arms). 4.3 Explain the connection	Discuss how sensors and actuators interact in a robotic system. Explain how to build and test a feedback control system.	Feedback System Simulations, Case Studies (e.g., Line-Following Robots)	4.1 Build a robot that stops when it detects an obstacle using ultrasonic sensors. 4.2 Program the robot to adjust its speed based on sensor feedback. 4.3 Build a simple control	Guide students on how to connect sensors and actuators in a robotic system. Supervise students as they build and test a feedback control system.	Test Benches, sensor kits, jumper wires, Arduin Uno, Motor, motor shield, battery.

	between sensors, controllers, and actuators.			system (e.g., robot that stops when it hears a clap). 4.4 Program a robot to use sensor data to control actuators (e.g., avoid obstacles).		
GENERAL OBJECTIVE 5.0: Apply control concepts to build and program a simple robot.						
9-12	5.1 Explain steps to design a robot that uses open-loop control (e.g., move in a square pattern). 5.2 Explain steps to program a robot to use closed-loop control (e.g., follow a line using sensors). 5.3 Outline steps to improve robot performance (e.g., adjust speed based on sensor data). 5.4 Outline steps in simulating a control system using software tools (e.g., Scratch, Tinkercad).	Discuss how to build and program a robot (e.g., line-following, obstacle avoidance).	Videos on PID Control, Step-by-Step Tutorials, Circuit Simulation Software	5.1 Build and program a robot (e.g. line-following, obstacle avoidance). 5.2 Build a robot that uses open-loop control (e.g., move in a square pattern). 5.3 Program a robot to use closed-loop control (e.g., follow a line using sensors). 5.4 Simulate a control system using software tools (e.g., Scratch, Tinkercad).	Supervise students as they build and program a simple robot. Guide students on how to debug the codes for errors.	Test Benches, Arduini Uno, Arduino IDE, jumper wires, batteries, switch, Tinkercad

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="2">MODULE 8: Computer Vision Basics</td><td>COURSE CODE: CRB318</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 3</td><td>TERM: 1</td><td>PREREQUISITE:</td><td>Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="4">GOAL: This module introduces students to the basics of computer vision and how it can be used in robotics for tasks like object detection, navigation, and manipulation.</td></tr>
<tr><td colspan="4">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1. Understand what computer vision is and its role in robotics.
2. Understand the basics of camera calibration and image transformations.
3. Learn the basics of image processing and object detection.
4. Explore how robots use vision to navigate and interact with their environment.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 8:				**COURSE CODE: CRB318**		**CONTACT HOURS:**
YEAR: 3	**TERM: 1**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours		
GOAL: This module introduces students to the basics of computer vision and how it can be used in robotics for tasks like object detection, navigation, and manipulation.						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: 1. Understand what computer vision is and its role in robotics.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-3	1.1 Define computer vision in simple terms (e.g., teaching robots to "see"). 1.2 Explain how computer vision helps robots perform tasks (e.g., object detection, navigation). 1.3 Outline real-world applications of computer vision in robotics (e.g., self-driving cars, robotic arms). 1.4 Describe the difference between human vision and computer vision. 1.5 Explain why computer vision is important for the future of robotics.	Discuss the relationship between computer vision and human vision. Discuss how computer vision helps robots "see" and interact with their environment	Image Processing Tutorials, Videos, Slides, Textbooks	1.1 Use a camera to capture images and display them on a computer. 1.2 Use any image processing software (e.g. PictoBlox) to process and analyze an image characteristic and improve output.	Guide students on how to use a camera to capture images. Guide students on the use of an image processing software to process image characteristics and improve output.	Cameras, Image Processing Software (PictoBlox). Computer

GENERAL OBJECTIVE 2.0: Understand the basics of camera calibration and image transformations.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
4-6	2.1 Define camera calibration and explain why it's important. 2.2 Explain how simple camera calibration tasks can be done. 2.3 Explain image transformations (e.g., rotation, scaling, translation). 2.4 Explain how to align images (e.g., match a robot's view to a map). 2.5 Outline how calibration and transformations can improve robot vision accuracy.	Discuss how to calibrate a camera and correct lens distortion. Discuss how to perform image transformations (e.g., rotation, scaling).	Hands-on Projects (e.g., Color Object Detection), AI Vision Datasets, Textbooks, Slides.	2.1 Design a code for image transformation. 2.2 Perform image transformations using Image editing software (e.g. PictoBlox).	Guide students on how to calibrate a camera and perform image transformations. Provide exercises for students to practice these tasks.	Camera, Image editing software, Computer, Microcontroller Batteries
GENERAL OBJECTIVE 3.0: Learn the basics of image processing and object detection.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
7-9	3.1 Explain how images are represented digitally (e.g., pixels, grayscale, RGB). 3.2 Outline the steps to perform basic image processing tasks (e.g., resizing, cropping, converting to grayscale). 3.3 Outline simple shapes and	Discuss how to resize, crop, and convert images using software (e.g. Corel draw) Discuss steps in outlining shapes, apply color and isolating images.	Videos on Image Filtering, Hands-on Corel draw, Textbooks Slides.	3.1 Resize, crop, and convert images to grayscale using software (e.g. PictoBlox). 3.2 Detect simple shapes (e.g., circles, squares) in an image.	Guide students on how to perform basic image processing tasks. Guide students on the use of any image processing tool (e.g. PictoBlox)	Image processing software (PictoBlox), Camera.

	objects in images (e.g., circles, squares). 3.4 Outline steps to apply color filtering to isolate objects (e.g., detect a red ball). 3.5 Outline steps to perform edge detection techniques (e.g., Canny edge detection).					
GENERAL OBJECTIVE 4.0: Explore how robots use vision to navigate and interact with their environment.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
10-12	4.1 Explain how mobile robots use vision for navigation (e.g., following a line, avoiding obstacles). 4.2 Explain how robotic arms use vision to pick and place objects. 4.3 Explain how vision detect and track objects in real-time. 4.4 Outline the challenges of using vision in robotics (e.g., lighting, occlusions).	Discuss examples of robots using vision for navigation (e.g., line-following, obstacle avoidance). Discuss the challenges of vision-based navigation (e.g., lighting, occlusions).	Self-Driving Car Simulation, Videos on Object Tracking, Textbooks, Slides.	4.1 Build a robot that uses vision to follow a line or avoid obstacles. 4.2 Design a code to control robotic arm to pick and place objects using camera. 4.3 Design a robot using vision to perform objects tracking task	Guide students on how to design a robot using vision for navigation (e.g., line-following, obstacle avoidance). Guide students on how to program the microcontrollers. Guide students on how to debug the code for errors.	Cameras, LiDAR, Arduino Uno, Arduino IDE, Jumper wires, Batteries, switch

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="3">MODULE 9.0: Basics of Motion Planning and Go-To Goal</td><td>COURSE CODE: CRB329</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 3</td><td>TERM: 2</td><td>PREREQUISITE:</td><td colspan="2">Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="5">GOAL: This module will introduce students to the fundamental concepts of motion planning and how robots navigate to specific locations or follow paths.</td></tr>
<tr><td colspan="5">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1. Understand the basics of motion planning and its importance in robotics.
2. Learn how robots navigate to specific locations (go-to tasks).
3. Explore path planning algorithms (e.g., shortest path, obstacle avoidance).
4. Understand the role of sensors and maps in motion planning.
5. Apply motion planning concepts to simple robotic projects.</td></tr>
</table>

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 9: Basics of Motion Planning and Go-To Goal				**COURSE CODE: CRB329**	**CONTACT HOURS:**	
YEAR: 3	**TERM: 2**		**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours	
GOAL: This module will introduce students to the fundamental concepts of motion planning and how robots navigate to specific locations or follow paths.						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand the Basics of Motion Planning and Its Importance						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1	1.1 Define motion planning and explain its role in robotics. 1.2 Outline real-world applications of motion planning (e.g., self-driving cars, warehouse robots). 1.3 Explain why motion planning is important for autonomous robots. 1.4 Compare manual control vs. autonomous motion planning. 1.5 Outline the challenges of motion planning (e.g., dynamic environments, obstacles).	Discuss how motion planning is used in robotics. Discuss how motion planning is applied to real world applications. Discus manual control and autonomous motion planning.	Videos, Slides, Textbooks, Planning Charts	1.1 Design a simple robot and manually and autonomously controlled. 1.2 Assemble a simple robot.	Guide students on how to design a robot that can be manually and autonomously controlled. Guide students on how to assemble a robot that can be controlled manually and autonomously.	Simulated Path Planning Tools, LiDAR Sensors, Ultrasonic Sensors Microcontroller, Batteries, Arduino IDE, Jumper wires.
GENERAL OBJECTIVE 2.0: Learn How Robots Navigate to Specific Locations (Go-To Tasks)						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
2-3	2.1 Define a go-to task (e.g., moving to a specific location).	Discuss what a go-to task is (e.g., moving to a specific location).	Demonstrati on of GPS and LiDAR in	2.1 Program a robot to move to a specific location using simple commands	Guide students in writing code for go-to tasks.	Obstacle Course, Sensor-Based Navigation Kits,

	2.2 Explain how robots use sensors and maps to navigate. 2.3 Explain how a robot can move to a specific location using simple commands. 2.4 Discuss the importance of accuracy and precision in go-to tasks.	Discuss examples of go-to tasks in real-world robots (e.g., delivery robots). Discuss how sensors (e.g., ultrasonic, IR) and maps help robots navigate.	Robots, Animated Path Planning Examples, Slides	(e.g., move forward, turn left). 2.2 Test the robot's accuracy in reaching the target location. 2.3 Optimize the robot's navigation performance through iterative testing.	Supervise students as they test and adjust their robots. Guide students in the connection of the different sensors.	Micro controller, Battery, Jumper wires.
GENERAL OBJECTIVE 3.0: Understand and Explore Path Planning Algorithms						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
4-6	3.1 Explain path planning and its goals (e.g., shortest path, obstacle avoidance). 3.2 Explain the basics of grid-based path planning. 3.3 Outline the limitations of obstacle avoidance in a robot	Discuss path planning is and its goals (e.g., shortest path, obstacle avoidance). Discuss examples of path planning in real-world robots (e.g., drones, autonomous vehicles). Discuss the basics of grid-based path planning.	Books (e.g., "Principles of Robot Motion"), ROS Tutorials, Algorithm Flowcharts	3.1 Design a simple path planning algorithm using software (e.g., Scratch, PictoBlox, mBlocks, Tinkercad).	Guide students in using software to plan algorithm (eg. mBlock, PictoBlox, Tinkercad)	Tinkercad, Microcontrollers, PictoBlox, mBlocks Jumper wires, Batteries, Arduino IDE, Scratch.
GENERAL OBJECTIVE 4.0: Understand the Role of Sensors and Maps in Motion Planning						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
7-9	4.1 Explain the concept of a map and how robots use it for navigation.	Discuss how sensors (e.g., ultrasonic, IR) detect obstacles.	Mobile Robot Simulations,	4.1 Create a simple map of an environment (e.g., a room or maze).	Demonstrate how to create a map and use it for navigation.	Mobile Robot Kits, GPS, Microcontrollers,

	4.2 Explain how sensors (e.g., ultrasonic, IR, LiDAR) help robots detect obstacles and in mapping. 4.3 Outline the challenges of mapping and localization.	Discuss how sensor data is used to adjust the robot's path. Discuss what a map is and how robots use it for navigation.	Live Demos of Maze-Solving Robots, Videos, Slides.	4.2 Program a robot to navigate the environment using sensor data and the map. 4.3 Test the robot's ability to avoid obstacles using sensor feedback.	Guide students in programming a robot to use sensor data and a map.	Batteries, Arduino IDE, Sensors, LiDAR
GENERAL OBJECTIVE 5.0: Apply motion planning concepts to simple robotic projects.						
10-12	5.1 Outline the steps in designing a robot that has the capability of motion planning. 5.2 Explain the steps in simulating a sensor response and activity. 5.3 Outlie the steps taken to optimize the robot's motion planning performance.	Discuss steps taken to build and program a robot for a go-to task. Discuss how the robot uses sensor data and path planning algorithms. Discuss how software (Tinkercad, Scratch) can help simulate a robot navigating a planned path. Discuss how the simulation helps test and optimize the robot's performance. Discuss the importance of testing and iteration in robotics.	Mobile Robot Simulations, Live Demos of Maze-Solving Robots, Slides.	5.1 Design and program a robot to navigate to a specific location while avoiding obstacles. 5.2 Simulate a motion planning system using software (e.g., Tinkercad, Scratch, mBlock, PictoBlox).	Supervise students as they build and program their robots. Use software to demonstrate motion planning simulations. Guide students in programming a robot to follow a path and avoid obstacles.	Mobile Robot Kits (LAFVIN), GPS Sensors, LiDAR, Battery, Jumper wires, Microcontroller, Scratch, Tinkercad.

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE</td></tr>
<tr><td colspan="2">MODULE 10: CAD Design and 3D Printing for Robotics</td><td>COURSE CODE: CRB 330</td><td>CONTACT HOURS: 72</td></tr>
<tr><td>YEAR: 3</td><td>TERM: 3</td><td>PREREQUISITE:</td><td>Theoretical: 24 Hours
Practical: 48 Hours</td></tr>
<tr><td colspan="4">GOAL: This module will introduce students to the basics of Computer-Aided Design (CAD) and 3D printing, which are essential skills for designing and prototyping robotic components</td></tr>
<tr><td colspan="4">GENERAL OBJECTIVES:

On completion of this module, the trainee should be able to:

1. Understand the basics of CAD design and its importance in robotics.
2. Learn to create 3D models of robotic components using CAD software.
3. Explore the principles of 3D printing and its applications in robotics.</td></tr>
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PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE 10:				**COURSE CODE: CRB 330**		**CONTACT HOURS:**
YEAR: 3	**TERM: 3**	**PREREQUISITE:**		**Theoretical:** 24 Hours **Practical:** 48 Hours		
GOAL: This module will introduce students to the basics of Computer-Aided Design (CAD) and 3D printing, which are essential skills for designing and prototyping robotic components						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand the basics of CAD design and its importance in robotics						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-4	1.1 Define CAD and explain its role in robotics. 1.2 Outline real-world applications of CAD in robotics (e.g., custom parts, prototypes). 1.3 Outline the advantages of using CAD for robotic design (e.g., precision, customization).	Discuss the interface and tools of CAD software. Discuss the steps in creating a 3D model.	CAD Software Tutorials, Slides Videos.	1.1 Create a simple 3D model (e.g., a cube or cylinder).	Demonstrate the interface and tools of CAD software. Guide students in creating their first 3D model.	CAD Software, Computer.
GENERAL OBJECTIVE 2.0: Learn to create 3D models of robotic components using CAD software						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
5-8	2.1 Explain the interface and tools of CAD software (e.g., SolidWorks, Fusion 360). 2.2 Outline the steps in creating basic 3D models (e.g., gears, brackets, chassis). 2.3 Explain the steps in	Discuss how to design basic robotic components using CAD software.	Step-by-Step Guides, Video Tutorials on CAD design, Slides.	2.1 Design a basic robotic component (e.g., a gear or bracket). 2.2 Export the 3D model in STL format for 3D printing.	Guide students on how to design basic robotic components. Supervise students as they export their 3D models.	Digital Callipers, 3D Modelling Tools, Computer.

	exporting 3D models in formats suitable for 3D printing (e.g., STL files					
GENERAL OBJECTIVE 3.0: Explore the principles of 3D printing and its applications in robotics						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
9-12	3.1 Explain how 3D printers work (e.g., FDM, SLA). 3.2 Outline materials used in 3D printing (e.g., PLA, ABS). 3.3 Explain the limitations and challenges of 3D printing (e.g., layer resolution, material strength).	Discuss how to set up and calibrate a 3D printer.	Videos on 3D Printing Process, Infographics on Additive Manufacturing, Slides	3.1 Set up and calibrate a 3D printer. 3.2 Print a simple object (e.g., a keychain or small figurine).	Gude students on how to set up and calibrate a 3D printer. Supervise students as they print their first object.	3D Printers, PLA Filaments, Computer.

LIST OF EQUPMENT

Hardware Required for 60 Students

Computers & Electronics		
SN	Item	Quantity
1	Laptops (for programming, simulations)	30 (shared in pairs)
2	Microcontrollers (Arduino)	60 (1 per student)
3	Breadboards	60
4	Power Supplies (5V, 12V)	30 (shared in pairs)
5	Sensors (Ultrasonic, IR, Temperature, Light)	120 (2 per student)
6	Actuators (Servos, DC Motors)	120 (2 per student)
7	LiDAR Sensors	10 (for demonstrations)
8	Encoders	30 (shared in pairs)
9	Multimeters	30 (shared in pairs)
10	Oscilloscopes	10 (for lab sessions)
11	Soldering Stations	10
12	Resistors, Capacitors, Transistors	600 pieces each
13	Integrated Circuits (ICs)	120 (for circuit experiments)
14	LEDs	600 (10 per student)
Robotic Kits & Components		
1	Robotic Arm Kits	20 (shared in groups of 3)
2	Line Following Robot Kits	20 (shared in groups of 3)
3	Mobile Robot Kit (LAFVIN)	30 (shared in pairs)
4	Coding Box	10
5	Feedback Sensor Modules	30
6	3D Printed Components (for assembly)	As required
Control & Measurement Tools		
1	Digital Calipers	10
2	Protractors	20
3	Graph Paper	60
4	Hand Tools (Screwdrivers, Pliers, Wire Cutters)	30 sets
Networking & Peripherals		

1	WiFi Routers (for IoT applications)	5
2	USB Cables (for microcontroller connection)	60
3	Projectors	5
4	Whiteboards	5
3D Printing & CAD Equipment		
1	3D Printers	10
2	PLA Filaments (for printing)	20 spools
3	Mechanical Assembly Tools (Screw Sets, Bolts)	30 sets

Software Required for 60 Students

SN	Software	Purpose
Programming & Development		
1	Arduino IDE	Coding for microcontrollers
2	Python	Robotics programming & simulations
3	PictoBlox	
4	C++	Embedded systems programming
Simulation & Control		
1	ROS (Robot Operating System)	Robot simulation & motion planning
2	GeoGebra	Mathematical calculations & transformations
3	LabVIEW	Control system simulations
4	Tinkercad	Basic electronic simulations
5	Scratch	Beginner-level coding simulations
Computer Vision & AI		
1	OpenCV	Image processing for robots
2	TensorFlow	Machine learning in robotics
CAD & 3D Printing		
1	SolidWorks	3D modelling of robotic components
2	Fusion 360	CAD design & simulations
3	Cura	3D slicing software for printing
4	AutoCAD	Technical drawings & blueprints

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