



COMPETENCY BASED CURRICULUM (ROBOTICS)

BQF CERTIFICATE 3



Published by Technical Trainers Training and Resource Center
Department of Workforce Planning and Skills Development
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FOREWORD

Bhutan has seen a gradual increase in the requirement of skilled workers in recent years due to growth of industries. However, supply of skilled workforce that are responsive to the needs of the industry has not been able to keep in pace with the industry demand. Since the skilled workers are crucial ingredient for socio-economic development of the country, it is important to have adequate number of trained and certified workers. With growing industries, the “Robotics Technician” is not only the most significant occupation but also have high demand in the labour market. In an effort to meet the skilled human resources requirement in the area of power sector, it is imperative to deliver training based on Competency Based Training system in Robotics BQF Certificate-3 to ensure quality and adequate number of work force in this sector.

To this end, the Department of Workforce Planning and Skills Development (DWPSD) is pleased to present first edition of Competency Based Curriculum for Robotics Certificate-3 course developed based on national competency standard. Since it is an outcome of a more participatory process of curriculum development, it is expected to provide training delivery with reformed approaches having its content being directly related to labour market needs, focusing on imparting of skills and assessment based on industry work standards. We believe that the Competency Based Curriculum will help in bridging the skill gap between industry’s needs and training institutes thereby enhance the employability of the technical graduates.

The Department acknowledges the valuable contributions made by institutes, officials, and experts from relevant industries who were involved in the design and development of this curriculum. As it is a dynamic document which may require revision based on the needs of the changing labour market, the Department look forward to receiving valuable feedbacks from the institutes and the industries to further improve and refine the curriculum

The Department hope that this document will help advance Competency Based Learning in most of the TVET Institutions.



(Sangay Dorji)

Officiating Director

Department of Workforce Planning and Skills Development

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Experts involved in the development of Robotics Certificate-3 curriculum:

1. Mr. Kamal Kumar Chapagai, Lecturer, College of Science and Technology
2. Mr. Mani Kumar Basnet, Associate Analyst, DHI
3. Mr. Cheche, Analyst, DHI
4. Mr. Darshan Subedi, Network Engineer, Bhutan Telecom
5. Ms. Pema Wangmo, Freelancer, Thimphu
6. Ms. Srijana Gajmer, Lecturer, Jigme Namgyal Engineering College
7. Mr. Yeshi Rigsel Wangchuk, Local Master Trainer, JWPTI

Experts involved in the validation of Robotics Certificate-3 curriculum:

1. Mr. Manish Rai, Analyst, DHI (**Chair Person**)
2. Mr. Tshering Phuntsho, Trainer, Robotics and IoT Training Institute
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6. Mr. Anith Ghalley, Teacher, Druk Gyalpo's Institute, Paro
7. Mr. Yeshi Rigsel Wangchuk, Local Master Trainer, JWPTI

Facilitators for development and validation of Mobile Robotics BQF Certificate 3 curriculum

1. Ms. Karma Dema, Program Officer, TTTRC, DWPSD, MoESD

Chief editor

1. Mr. Karma Dorji, Offtg. Chief Program Officer, TTTRC, DWPSD, MoESD

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COMPETENCY PROFILE

Trade: Robotics BQF Certificate Level 3

Competency Area	Sub- Competency Area	Competencies/Tasks 			
A: Apply fundamentals of electrical and electronics theory	A1: Apply basic electrical theory	A1.01 Perform instrument reading	A1.02 Test conductor and insulator	A1.03 Measure resistance	A1.04 Measure voltage
		A1.05 Measure current	A1.06 Measure frequency		
	A2: Verify DC circuits	A2.01 Verify Ohm's law	A2.02 Verify characteristics of series circuit	A2.03 Verify characteristics of parallel circuits	A2.04 Verify characteristics of series-parallel combined circuit
	A3: Apply basic electronics theory	A3.01 Perform soldering	A3.02 Test inductor	A3.03 Test capacitor	A3.04 Verify V-I characteristics of diode
		A3.05 Verify V-I characteristics of Zener diode	A3.06 Test transistors	A3.07 Simulate VI characteristics of diode	
B: Carry out development and integration of MCU based robotic system	B1: Install Operating system and application Software	B1.01 Install Ubuntu on computer	B1.02 Configure required software using command line tool	B1.03 Store code in collaborative version control platform	B1.04 Install microcontroller libraries
	B2: Program microcontroller to communicate with robotic components	B2.01 Create a program to blink a LED	B2.02 Create a program to toggle a buzzer using push button	B2.03 Create a program to run a motor	B2.04 Create a program for LCD
		B2.05 Create a program to read distance with sensors	B2.06 Simulate distance measurement using US sensors in design software	B2.07 Create a program to read angles from an inertial measurement unit (IMU) sensor	

	B3: Design robotics components	B3.01 Install designing software	B3.02 Create 2D sketch	B3.03 Design 3D model	B3.04 Assemble 3D models
	B4: Develop motion programs using microcontroller	B4.01 Develop a motion program without sensors	B4.02 Develop a motion program with an ultrasonic sensor	B4.03 Develop a motion program with IMU sensor	B4.04 Develop a Program to drive on a test track with multiple sensors
C: Carry out implementation of robotic system with ROS	C1: Install Operating system and application Software on the Single Board Computer (SBC)	C1.01 Install Ubuntu on SBC	C1.02 Configure required software using command line tool	C1.03 Configure communication network between PC and SBC	
	C2: Program microcontroller and SBC to communicate with one another	C2.01 Create a communication program over serial	C2.02 Create a communication program over SPI	C2.03 Create a communication program over i2c	
	C3: Program SBC to use ROS2 and sensors	C3.01 Install ROS2	C3.02 Echo a topic from ROS2	C3.03 Publish a topic in ROS2	C3.04 Visualize topics using simulation tools
		C3.05 Plot a Lidar point cloud with ROS2	C3.06 Plot a Depth Camera image with ROS2		
	C4. Interface SBC hardware to ROS2 framework	C4.01 Maneuver robot with ros2_control	C4.02 Publish Ultrasonic data with ros2_control	C4.03 Publish IMU data with ros2_control	C4.04 Publish Lidar data with ros2_control
		C4.05 Publish Depth Camera image data with ros2_control			

	C5. Program a robot using SBC - microcontroller and ROS2	C5.01 Implement a motion program using motor encoders	C5.02 Implement sensor fusion between motor encoders and IMU	C5.03 Implement robot control remotely using teleop_twist_joy	C5.04 Implement a motion program for localization with Lidar (SLAM)
D: Troubleshoot Robotics system	D1: Troubleshoot malfunctions	D1.01 Perform physical inspection	D1.02 Troubleshoot electrical faults	D1.03 Troubleshoot mechanical faults	
	D2: Debug robotic scripts	D2.01 Monitor variable values and states	D2.02 Interpret sensor and actuator data	D2.03 Rectify errors in robotics script	
	D3: Perform maintenance of robotic system	D3.01 Update software and firmware	D3.02 Perform schedule maintenance of robotic system components	D3.03 Maintain logs and documentation	

COURSE INFORMATION

COURSE TITLE	Robotics
LEVEL	BQF Certificate Level 3
COURSE OBJECTIVE	Upon completion of this training program, the trainees will be able to: • Apply fundamentals of electrical and electronics theory • Carry out development and integration of MCU based robotic system • Carry out implementation of robotic system with ROS • Troubleshoot robotics system
COURSE DESCRIPTION	This course is designed to provide trainees with the knowledge, skills and attitudes required to be competent Robotics Technician. This course will prepare the trainees to exhibit professionalism, teamwork, adaptability, and safety practices as per the requirement of the workplace. To obtain certification of this course, all learning outcomes prescribed must be achieved.
COURSE DURATION	1461 Hours
TRAINER AND TRAINEE RATIO	1:12 (Practical) 1:20 (Theory)
ENTRY REQUIREMENT	Completed class X
TVET TRAINER REQUIREMENTS	• Must have a minimum qualification of Diploma in relevant field (or) Certificate 3 with minimum of 5 years of working experience; • Must have undergone Training of Trainers-Technical Instruction and Andragogy; • Must have at least 5 years job/industry experience if institute hires instructor or guest lecturer from industry

COURSE OUTLINE

Sl. No	Subject /Module	Duration (Hours)	Content Competencies (Mapped)
1.	Core modules	571	CC
2.	OJT	420 (3 months)	CC
Total hours for Core Competencies (CC)		986	
1.	Applied Dzongkha	42	SS
2.	ICT	48	SS
3.	Engineering drawing	34	SS
4.	OHS	34	SS
5.	Ethics and integrity	68	SS
6.	Applied Mathematics	53	SS
7.	Technical English	51	SS
8.	Entrepreneurship	70	SS
Total hours for Soft Skills (SS)		400	
1.	Assessment	70	
Entire Course Duration		1461	

Note: (*) This curriculum contains core modules which cover main competencies of Robotics BQF Certificate level 3 and OJT component. There are separate curricula for subjects/modules for delivery of soft skills, professional development & values and environmental concern & safety. In order to achieve the qualification of Robotics BQF Certificate level 3, the subjects and modules listed must be accomplished as per the credit hours provided.

Content Competencies:

CC-Core Competencies

SS-Soft Skills

PD-Professional Development and Values

ES-Environmental concern and Safety

COURSE STRUCTURE FOR CORE COMPETENCIES

Training Modality	Module Title	Learning outcomes	Nominal Duration (Hour)
1. Institute Training	A. Apply fundamentals of electrical and electronics theory	A1. Apply basic electrical theory A2. Verify DC circuits A3. Apply basic electronics theory	98.5
	B. Carry out development and integration of MCU based robotic system	B1. Install Operating system and application Software B2. Program microcontroller to communicate with robotic components B3. Design robotics components B4. Develop motion programs using microcontroller	165.5
	C. Carry out implementation of robotic system with ROS	C1. Install Operating system and application Software on the Single Board Computer (SBC) C2. Program microcontroller and SBC to communicate with one another C3. Program SBC to use ROS2 and sensors C4. Interface SBC hardware to ROS2 framework C5. Program a robot using SBC - microcontroller and ROS2	252
	D. Troubleshoot Robotics system	D1: Troubleshoot malfunctions D2: Debug robotic scripts D3: Perform maintenance of robotic system	55
2. On the Job Training	A. Carry out development and integration of MCU based robotic system	A1. Install Operating system and application Software A2. Program microcontroller to communicate with robotic components A3. Design robotics components A4. Develop motion programs using microcontroller	420 (3 months)
	B. Carry out implementation of robotic system with ROS	B1. Install Operating system and application Software on the Single Board Computer (SBC) B2. Program microcontroller and SBC to communicate with one another B3. Program SBC to use ROS2 and sensors B4. Interface SBC hardware to ROS2 framework B5. Program a robot using SBC - microcontroller and ROS2	
	C. Troubleshoot Robotics system	C1: Troubleshoot malfunctions C2: Debug robotic scripts C3: Perform maintenance of robotic system	
Total CC Duration:			991

ASSESSMENT AND CERTIFICATION SYSTEM

ASSESSMENT	Diagnostic assessment of each skill will be conducted to identify areas where trainees may require additional support or intervention. This assessment will also evaluate their existing knowledge, skills, and understanding prior to a specific learning experience or unit of study. Methods such as pre-tests, concept mapping, KWL charts, and observations of student work will be utilized. Formative assessment for every module and learning outcome will be conducted through assignments, project works, continuous assessment, demonstration of practical skills/observations, oral questioning and written test. Summative assessment after completion of each national certificate level will be conducted by TVET Quality Council, Bhutan Qualifications and professional certification authority, MoESD as per the National Competency Standards and Guidelines for National Assessment and Certification System, provided the course is accredited with TVET Quality Council, Bhutan Qualifications and professional certification authority, MoESD.
CERTIFICATION	On successful completion of every module, the institute will award a certificate of achievement to the trainees. The TVET Quality Council, Bhutan Qualifications and professional certification authority, MoESD will award a National Certificate to the trainees upon the successful completion of NC level assessment.
COURSE DELIVERY	1. Modular 2. Demonstration 3. Lecture 4. Industrial training/attachment 5. Project work 6. Problem-based learning 7. Project-based learning
RESOURCES	Materials • Pen, paper, wire/metal, plastic/rubber/wood, connectors, resistors, wires, loads, insulation tape, probe, alligator clip, crocodile clip, graph sheet, soldering flux, soldering lead, solder wick, inductor, capacitor, load, diode, Zener diode, transistor, buzzer, push button, DC-DC converter, potentiometer, LED, display devices, distance sensors, IMU sensor, LiDAR sensor & accessories, ultrasonic sensor, double sided tape, inspection log, microfiber cloth, cleaning agent and lubricants Tools • Plier, screwdriver set, wire strippers, tweezer, desoldering pump, US drive, micro-SD card, SD card reader, torque wrench, Allen key set, wrench set, oil can and magnifying lens Instruments • Ohm meter, voltmeter, ammeter, multimeter, LCR meter, ruler, oscilloscope, measuring tape and vernier caliper

	Software • Tinker CAD, excel, Git, IDE, version control platform, libraries, Fusion360, Command Line Tools, camera package, Rviz2, turtle Sim, rqt, LiDAR driver package, ROS2 bag, ROS2, ros2_control, Nav2, SLAM_toolbox, Micro-ROS and ros2doctor Equipment • AC/DC source, adjustable DC power supply, breadboard, soldering iron set, soldering mat, exhaust fan, breadboard, variable, computer with internet connectivity & accessories, microcontroller board and accessories, motor, motor drives, robotic kits, test track, SBC board, logic level shifter, camera stand, depth camera, battery pack, small chassis with motors and wheel, joystick and voltage regulator PPE • Workshop dress, safety goggles, safety mask, safety boots Learning Materials • Competency Based Learning Materials (CBLM) • Reference books • Hand-outs • Audio visuals Infrastructure and training facilities • <i>Theory classroom size:</i> Minimum of 1 m² per trainee; • <i>Practical Workshop size:</i> Minimum of 2.25 m² per trainee. Variables must be considered depending upon type of skills being taught and the number of trainees participating at a time.
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MODULE 1: APPLYING FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS THEORY

MODULE INFORMATION

Occupation	Robotics Technician
Competency Area	Apply fundamentals of electrical and electronics theory
Module Title	Applying fundamentals of electrical and electronics theory
Module Code	3119-L3-M1
Module Description	This module is structured to provide learners with the knowledge, skills and right attitude required to apply basic electrical theory, electronics theory and verify DC circuits
Nominal Duration	98.5 Hours
Certificate Level	BQF Certificate Level 3
Pre-requisite	Class X passed
Learning Outcome	1. Apply basic electrical theory 2. Verify DC circuits 3. Apply basic electronics theory

Module Title	Applying fundamentals of electrical and electronics theory		
Module Code	3119- L3-M1		
Learning Outcome 1	Apply basic electrical theory		
Duration	Theory:11.5 hours	Practical:17 hours	Total:28.5 hours
Assessment Criteria	• Instrument reading is performed as per the standard procedure • Conductor and insulator is tested as per the standard procedure • Resistance is measured as per the job requirement following standard procedure • Voltage is measured as per the job requirement following standard procedure • Current is measured as per the job requirement following standard procedure • Frequency is measured as per the job requirement following standard procedure		
Content	A1.00 Introductory knowledge • Introduction to robotics • Types of robots and their applications • Components of robotic system • Introduction to robotic safety and ethics • Scope of robotics technician A1.01 Performing instrument reading Knowledge • Definition of instruments • Types of scale • Types of electrical measuring instruments • Signs & symbols of electrical measuring instruments • Working principle of instruments • Functions of instruments • Types of instrument error Skills • Instrument reading skills • Analytical skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Having work ethics and integrity • Proper handling of instruments • Ensuring correct use of PPE • Ensuring to follow OHS rules and regulation A1.02 Testing conductor and insulator Knowledge • Types of conductors, insulator and semiconductor • Properties of conductor, insulator and semiconductor		

	<i>Skills</i> • Using multimeter • Analytical skills <i>Attitude, safety, and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring to follow OHS rules and regulation A1.03 Measuring resistance <i>Knowledge</i> • Definition of resistance, resistor and resistivity • Unit and symbol of resistance • Factors affecting resistance • Types of resistor • Application of resistors • Colour coding of resistor • Selection of meter range • Polar and non-polar components • Active and passive components <i>Skills</i> • Interpreting datasheet • Using multimeter • Analytical skills • Numeracy skills <i>Attitude, safety, and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring to follow OHS rules and regulation • Ensuring proper selection of meter range A1.04 Measuring voltage <i>Knowledge</i> • Definition of voltage • AC and DC source • Unit and symbol of voltage • Types of voltmeter • Types of power sources • Concept of open circuit and closed circuit
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	Skills • Interpreting circuit diagram • Using multimeter • Analytical skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring to follow OHS rules and regulation • Ensuring proper meter range selection A1.05 Measuring current Knowledge • Definition of current • Unit and symbols of current • Types of current • Effects of electric current • Selection of ammeter range • Types of ammeter Skills • Interpreting circuit diagram • Using ammeter • Using multimeter • Analytical skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring to follow OHS rules and regulation • Ensuring to make a circuit connection following a circuit diagram A1.06 Measuring frequency Knowledge • Definition of frequency • Unit and symbol of frequency • Relation between time and frequency • Operating principle of oscilloscope Skills • Using oscilloscope
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	• Interpreting graph • Analytical skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • Competency-Based Learning Materials (CBLM)/reference materials • Hand-outs • Audio Visuals • Manuals Learning facilities and infrastructure • Classroom with adequate facilities • Information Technology (IT) lab • Library • Practical lab Materials • Pen, paper, wire/metal, plastic/rubber/wood, connectors, resistors, wires, loads, insulation tape, probe, alligator clip and crocodile clip Tools • Plier and wire strippers Instruments • Ohm meter, voltmeter, ammeter, multimeter and oscilloscope Equipment • AC/DC source and breadboard PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning

Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment
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Module Title	Applying fundamentals of electrical and electronics theory		
Module Code	3119- L3-M1		
Learning Outcome 2	Verify DC circuits		
Duration	Theory:8 hours	Practical:20 hours	Total:28 hours
Assessment Criteria	• Ohm's law is verified as per the standard procedure • Characteristics of series circuit is verified as per the job requirement following standard procedure • Characteristics of parallel circuit is verified per the job requirement following standard procedure • Characteristics of series-parallel combined circuit is verified per the job requirement following standard procedure		
Content	A2.01 Verifying ohms law Knowledge • Ohm's law • Calculations based on Ohms law • Application of Ohms's law • Limitation of Ohm's law Skills • Using multimeter • Interpreting circuit diagram • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation A2.02 Verifying characteristics of series circuit Knowledge • Characteristics of series circuit • Advantages and disadvantages of series circuit • Applications of series circuit • Kirchoff's voltage law Skills • Interpreting circuit diagram • Using multimeter • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources		

	• Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation A2.03 Verifying characteristics of parallel circuit <i>Knowledge</i> • Characteristics of parallel circuit • Advantages and disadvantages of parallel circuit • Applications of parallel circuit • Kirchoff's current law <i>Skills</i> • Interpreting circuit diagram • Using multimeter • Analytical skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation A2.04 Verifying characteristics of series-parallel combined circuit <i>Knowledge</i> • Characteristics of series-parallel combined circuit • Advantages and disadvantages of series-parallel combined circuit • Applications of series-parallel combined circuit • Comparison of series and parallel circuit <i>Skills</i> • Interpreting circuit diagram • Using multimeter • Analytical skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste
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	Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials - CBLM/Reference materials - Hand-outs - Audio Visuals - Manuals Learning Facilities and infrastructure - Classroom with adequate facilities - Information Technology (IT) lab - Library - Practical Lab Materials - Pen, paper, graph sheet, resistors and wires Tools - Pliers, screwdriver and wire strippers Instruments - Multimeter Equipment - Adjustable DC power supply and breadboard PPE - Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: - Lecture - Interactive discussion - Demonstration - Guided practice - Group practice with project-based learning - Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: - Practical observation - Oral/viva-voce - Written test - Assignment

Module Title	Applying fundamentals of electrical and electronics theory		
Module Code	3119- L3-M1		
Learning Outcome 3	Apply basic electronics theory		
Duration	Theory:11 hours	Practical:31 hours	Total:42 hours
Assessment Criteria	- Soldering is performed as per the job requirement following standard procedure - Inductor is tested as per the job requirement following standard procedure - Capacitor is tested as per the job requirement following standard procedure - V-I characteristics of diode is verified as per the job requirement following standard procedure - V-I characteristics of Zener diode is verified as per the job requirement following standard procedure - Transistor is tested as per the job requirement following standard procedure - V-I characteristics of diode is simulated as per the job requirement following standard procedure		
Content	A3.01 Performing soldering Knowledge - Purpose of soldering and desoldering - Purpose of flux - Types of soldering lead and its sizes - Methods of desoldering Skills - Using soldering iron - Perceptual-motor skills - Analytical skills - Observation skills Attitude, safety, and environmental concern - Effective time management - Being efficient in using resources - Being vigilant and patient - Having work ethics and integrity - Proper handling of tools, materials and equipment - Ensuring correct use of PPE - Ensuring proper disposal of waste - Ensuring to follow OHS rules and regulation - Ensuring to follow 5S A3.02 Testing inductor Knowledge - Definition of inductor and inductance - Symbol of inductor - Unit of inductance - Factors affecting inductance		

	• Characteristics of inductor • Types of inductor • Applications of inductor Skills • Interpreting datasheet • Using LCR meter • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation • Ensuring to follow 5S A3.03 Testing capacitor Knowledge • Definition of capacitor and capacitance • Symbol of capacitor • Unit of capacitance • Factors affecting capacitance • Characteristics of capacitor • Types of capacitor • Application of capacitor Skills • Interpreting datasheet • Using LCR meter • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation • Ensuring to follow 5S A3.04 Verifying V-I characteristics of diode Knowledge • Working principle of diode
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	• Types of diodes • V-I Characteristics of diode • Applications of diode Skills • Interpreting datasheet • Using multimeter • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation • Ensuring to follow 5S A3.05 Verifying V-I characteristics of Zener diode Knowledge • Working principle of Zener diode • V-I characteristics of Zener diode • Applications of Zener diode Skills • Interpreting datasheet • Using multimeter • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation • Ensuring to follow 5S A3.06 Testing transistor Knowledge • Working principle of transistor • Transistor configuration • Transistor biasing • Types of transistors • Characteristics of transistors
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	• Transistor symbols • Application of transistor • Introduction to thyristor • Difference between transistor, diode and thyristor Skills • Interpreting datasheet • Using multimeter • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation • Ensuring to follow 5S A3.07 Simulating V-I characteristics of diode Knowledge • Introduction to Simulation platforms • Advantages and disadvantages of simulation platforms Skills • Interpreting circuit diagram • Observation skills • ICT skills • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference materials • Hand-outs • Audio Visuals • Manuals Learning Facilities and infrastructure • Classroom with adequate facilities

	• Information Technology (IT) lab • Library • Practical lab Materials • Pen, pencil, paper, soldering flux, soldering lead, solder wick, wire, inductor, capacitor, load, graph sheet, diode, Zener diode, resistor and transistor Tools • Tweezers, wire strippers and desoldering pump Software • Tinker CAD and excel Instrument • LCR meter, ruler and multimeter Equipment • Soldering iron set, soldering mat, exhaust fan, breadboard, variable DC power supply, computer and accessories PPE • Workshop dress, safety boots, safety goggles and safety mask
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work

MODULE 2: CARRYING OUT DEVELOPMENT AND INTEGRATION OF MCU BASED ROBOTIC SYSTEM

MODULE INFORMATION

Occupation	Robotics Technician
Competency Area	Carry out development and integration of MCU based robotic system
Module Title	Carrying out development and integration of MCU based robotic system
Module Code	3119- L3-M2
Module Description	This module is structured to provide the learners with knowledge, skills and right attitude to install operating system & application software, program microcontrollers to communicate with robotic components, design mobile robotic components and develop motion programs using microcontrollers.
Nominal Duration	165.5 Hours
Qualification Level	BQF Certificate Level 3
Pre-requisite	Completed Module: 3119-L3-M1
Learning Outcome	1. Install operating system and application software 2. Program microcontroller to communicate with robotic components 3. Design robotics components 4. Develop motion programs using microcontroller

Module Title	Carrying out development and integration of MCU based robotic system		
Module Code	3119- L3-M2		
Learning Outcome 1	Install operating system and application software		
Duration	Theory:4.5 hours	Practical:11 hours	Total:15.5 hours
Assessment Criteria	• Ubuntu was installed on computer as per the job requirement following standard procedure • Software is configured using command line tools as per the job requirement following standard procedure • Codes are stored in collaborative version control platform as per the job requirement following standard procedure • Libraries are installed as per the job requirement following standard procedure		
Content	B1.01 Installing Ubuntu in computer Knowledge • Introduction to operating system • Types of operating systems • Introduction to Ubuntu • Advantages and disadvantages of Ubuntu • Introduction to BIOS setup • Introduction to Disk Management Tools Skills • ICT skills • Analytical skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B1.02 Configuring required software using Command Line tools Knowledge • Introduction to command line tools • Basic commands in command line tool • Introduction to bash script • File permissions • File formats Skills • Using command line tools • Analytical skills • ICT skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources		

	• Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B1.03 Storing code in collaborative version control platform <i>Knowledge</i> • Introduction to version control platform • Introduction to Git • Introduction to SSH • Basic commands in Git • Concepts of repository • Introduction to remote and local repositories • Introduction to branching and merging <i>Skills</i> • Using Git commands • Using command line tools • File management skills • Observation skills • Analytical skills • ICT skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B1.04 Installing microcontroller libraries <i>Knowledge</i> • Introduction to IDE • Libraries and their usage • Role of header files(extension) in libraries <i>Skills</i> • File management skills • Observation skills • Analytical skills • ICT Skills <i>Attitude, safety, and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment
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	• Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM • Hand-outs • Audio Visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Information Technology (IT) lab • Library Materials • Pen and paper Tools • USB drive Software • Git and IDE Equipment • Computer with internet connectivity and accessories PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment

Module Title	Carrying out development and integration of MCU based robotic system		
Module Code	3119- L3-M2		
Learning Outcome 2	Program microcontroller to communicate with robotic components		
Duration	Theory:12 hours	Practical:38 hours	Total:50 hours
Assessment Criteria	• Program to blink LED was created as per job requirement following standard procedure • Program to toggle a buzzer using push button is created as per job requirement following standard procedure • Program to run a motor is created as per job requirement following standard procedure • Program for LCD is created as per job requirement following standard procedure • Program to read distance with sensors is created as per job requirement following standard procedure • Distance measurement using Ultrasonic Sensor (US) in design software is simulated as per job requirement following standard procedure • Program to read angles from an Inertial Measurement Unit (IMU) sensor is created as per job requirement following standard procedure		
Contents	B2.01 Creating a program to blink a LED Knowledge • Introduction to microcontroller board and circuit connection • Introduction to C++ Programming ✓ Syntax and data types ✓ Functions ✓ Flow control ✓ Conditionals and loops • Basic microcontroller functions and commands • Components of microcontroller board and its function • Introduction to LED and its polarity • Types of data signals • Introduction to input and output devices Skills • Basic C++ programming skills • Interpreting datasheet • Interpreting circuit diagram • Using collaborative version control platform • Observation skills • Analytical skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation		

	B2.02 Creating a program to toggle a buzzer using push button Knowledge • Working principle of buzzer • Types of buzzer • Application of buzzer • Working principle of push button switch • Types of push button • Concept of pull-up and pull-down resistor • Introduction to push button bouncing Skills • Basic C++ programming skills • Interpreting circuit diagram • Interpreting datasheet • Using version control platform • Observation skills • Analytical skills • ICT skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B2.03 Creating a program to run a motor Knowledge • Definition of actuator • Types of actuator • Working principle of a Motor • Types and application of motors • Type of motor drivers • Motor control libraries • Types of voltage converters and its applications • Introduction to Pulse Width Modulation (PWM) Skills • Basic C++ programming skills • Interpreting circuit diagram • Using version control platform • Interpreting datasheet • Using basic hand tools • Observation skills • Analytical skills • ICT skills Attitude, safety and environmental concern • Effective time management
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	• Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B2.04 Creating a program for LCD <i>Knowledge</i> • Introduction to LCD • Types of display devices • LCD pins and its functions • LCD libraries • Introduction to I2C protocol <i>Skills</i> • Interpreting datasheet • Interpreting circuit diagram • C++ programming skills • Using version control platform • Observation skills • Analytical skills • ICT skills • Numeracy skills <i>Attitude, safety, and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B2.05 Creating a program to read distance with sensors <i>Knowledge</i> • Definition of sensor • Sensor specifications • Accuracy vs precision • Working principle of distance sensor • Types of distance sensors; its advantages and disadvantages • Application of distance sensor • Distance sensor libraries • Introduction to serial monitor and baud rate <i>Skills</i> • Interpreting datasheet • Interpreting circuit diagram • C++ programming skills • Using version control platform
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	• Analytical skills • ICT skills • Numeracy skills <i>Attitude, safety, and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B2.06 Simulating distance measurement using Ultrasonic Sensor (US) in design software <i>Knowledge</i> • Introduction to simulation IDE <i>Skills</i> • Basic C++ Programming • Interpreting circuit diagram • Using version control platform • ICT skills • Analytical skills • Numeracy skills <i>Attitude, safety, and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B2.07 Creating a program to read an angle from IMU sensor <i>Knowledge</i> • Concept of inertia • Working principle of Accelerometer and Gyroscope • Function of IMU sensor • Concept of degrees of freedom and coordinate systems • Working principle of IMU sensor • Types of IMU sensors • Applications of IMU sensors • IMU sensor libraries <i>Skills</i> • Interpreting datasheet • C++ programming skills • Using version control platform • Analytical skills
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	• ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference materials • Hand outs • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • IT lab • Library • Robotics Lab Materials • Pen, paper, resistors, buzzer, push button, wires, DC-DC converter, potentiometer, LED, display devices, distance sensors and IMU sensor Tools • Wire strippers Instruments • Multimeter Software • IDE, version control platform, tinker CAD and libraries Equipment • Computer & accessories, breadboard, microcontroller board and accessories, motor, variable power supply and motor drivers PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning

Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work
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Module Title	Carrying out development and integration of MCU based robotic system		
Module Code	3119-L3-M2		
Learning Outcome 3	Design robotics components		
Duration	Theory:9 hours	Practical:37 hours	Total:46 hours
Assessment Criteria	- Designing software is installed as per job requirement following standard procedure 2D sketch is created as per job requirement following standard procedure 3D model is designed as per job requirement following standard procedure 3D models are assembled as per job requirement following standard procedure		
Contents	B3.01 Installing designing software Knowledge - Basics of CAD software - License types and management - System requirements Skills - ICT skills - Analytical skills Attitude, safety, and environmental concern - Effective time management - Being efficient in using resources - Being vigilant and patient - Having work ethics and integrity - Proper handling of tools, materials, and equipment - Ensuring correct use of PPE - Ensuring proper disposal of waste - Ensuring to follow OHS rules and regulation B3.02 Creating 2D sketch Knowledge - Introduction to coordinate systems and planes - Units and measurements - CAD flow - Introduction to parametric design - Sketch constraints - Dimensioning and control of size - Geometric relationships (edges, vertices, faces) 2D file formats Skills - Analytical skills - ICT skills - Numeracy skills - Using CAD software - Creativity - Using measuring tools Attitude, safety, and environmental concern - Effective time management		

	• Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B3.04 Designing 3D model Knowledge • Importance of 3D modeling in robotics design • Difference between 2D sketch and 3D model • Difference between sketch and body • Features of 3D design software (sketching, modeling and modifying) • 3D file formats Skills • Using CAD software • ICT skills • Spatial visualization • Creativity • Analytical skills • Problem-solving skills • Numeracy skills • Using measuring tools Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B3.05 Assemble 3D models Knowledge • Introduction to components, links and joints in CAD • Types of joints • Mechanism of simple machines (wheel & axle, lever, pulley, wedge, screw and inclined plane) • Gear ✓ Types ✓ Working principle ✓ Application • Material rendering in CAD • Fits and Tolerances in CAD Skills • Using CAD software • Spatial visualization
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	- Analytical skills - Observation skills - ICT skills - Numeracy skills - Creativity - Problem solving skills Attitude, safety, and environmental concern - Effective time management - Being efficient in using resources - Being vigilant and patient - Having work ethics and integrity - Proper handling of tools, materials and equipment - Ensuring correct use of PPE - Ensuring proper disposal of waste - Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials - CBLM/reference materials - Handouts - Audio-visuals - Manuals Learning Facilities and Infrastructure - Classroom with adequate facilities - Library - IT lab - Robotics Lab Materials - Pen and paper Instrument - Measuring tape and vernier caliper (if replicating a real object) Software - Fusion360 Equipment - Computer with internet connectivity and accessories PPE - Workshop dress and safety boot
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: - Lecture - Interactive discussion - Demonstration - Guided practice - Group practice with project-based learning - Individual practice with problem-based learning

Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work
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Module Title	Carrying out development and integration of MCU based robotic system		
Module Code	3119- L3-M2		
Learning Outcome 4	Develop motion programs using microcontroller		
Duration	Theory:9 hours	Practical:45 hours	Total:54 hours
Assessment Criteria	• Motion program without sensors is developed as per job requirement following standard procedure • Motion program with an ultrasonic sensor is developed as per job requirement following standard procedure • Motion program with IMU sensor is developed as per job requirement following standard procedure • Program to drive on a test track with multiple sensors are developed as per job requirement following standard procedure		
Contents	B4.01 Developing a motion program without sensors Knowledge • Kinematic constraints • Speed, velocity and acceleration • Newton's laws of motion • Types of wheels • Introduction to open loop system • Types of robot drive system Skills • C++ programming skills • Circuit design and wiring skills • Debugging skills • Problem solving skills • Using version control platform • Interpreting datasheet • Using multi-meter • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B4.02 Develop a motion program with an ultrasonic sensor Knowledge • Introduction to closed loop system • Concept of interrupt • Introduction to system integration		

	• Introduction to obstacle avoidance Skills • C++ programming skills • Interpreting circuit diagram • Using version control platform • Interpreting datasheet • Using multimeter • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B4.03 Developing a motion program with a IMU sensor Knowledge • Concept of dead reckoning • Concept of noise in communication Skills • C++ programming skills • Interpreting datasheet • Using multimeter • Using version control platform • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation B4.04 Developing a Program to drive on a test track with multiple sensors Knowledge • Importance of using test tracks • Sensor fusion algorithms
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	• Process of autonomous navigation • Robot performance optimization Skills • C++ programming skills • Interpreting data sheet • Using version control platform • Interpreting circuit diagram • Using multi-meter • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference materials • Handouts • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics lab Materials • Pen, pencil and notebook Tools • Screwdriver and wire strippers Instruments • Multimeter Software • IDE and version control platform Equipment • Power supply, computer & accessories, robotic kits, microcontroller board, test track and breadboard PPE • Workshop dress and safety boot

Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work

MODULE 3: CARRYING OUT IMPLEMENTATION OF ROBOTIC SYSTEM WITH ROS

MODULE INFORMATION

Occupation	Robotics Technician
Competency Area	Carry out implementation of robotic system with ROS
Module Title	Carrying out implementation of robotic system with ROS
Module Code	3119- L3-M3
Module Description	This module is structured to provide the learners with knowledge, skills and right attitude required to install operating system and application software on SBC, Program microcontroller and SBC to communicate with one another, program SBC to use ROS2 and sensors, Interface SBC hardware to ROS2 framework and program a robot using SBC microcontroller and ROS2.
Nominal Duration	252 Hours
Qualification Level	BQF Certificate Level 3
Pre-requisite	Completed Module 3119-L3-M2
Learning Outcome	1. Install operating system and application software on SBC 2. Program microcontroller and SBC to communicate with one another 3. Program SBC to use ROS2 and sensors 4. Interface SBC hardware to ROS2 framework 5. Program a robot using SBC - microcontroller and ROS2

Module Title	Carrying out implementation of robotic system with ROS		
Module Code	7412- L3-M3		
Learning Outcome 1	Install Operating system and application Software on the Single Board Computer (SBC)		
Duration	Theory: 6 hours	Practical:15 hours	Total: 21 hours
Assessment Criteria	• Ubuntu is installed on SBC as per the standard procedure • Required software is configured using CLI as per the standard procedure • Communication network is configured between PC and RPi as per job requirement following the standard procedure		
Content	C1.01 Installing Ubuntu on SBC Knowledge • Introduction to Single Board Computer (SBC) • Introduction to RPi • Types of Single Board Computers • Specifications of the SBC • Advantages and disadvantages of Ubuntu on the SBC • Applications of SBC • Difference between SBC and microcontroller • Difference between Linux desktop and Linux server Skills • Using command line interface • Observation skills • Analytical skills • ICT skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C1.02 Configuring required software using command line tool Knowledge • Introduction to file compressor and extractors • Types of file compressor and extractor Skills • Using command line tools • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety, and environmental concern • Effective time management • Being a team player • Being efficient in using resources		

	• Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Having a sense of ownership and accountability • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C1.03 Configuring communication network between PC and SBC Knowledge • Introduction to network • Types of communication protocols • Wireless and Wired communication • Advantages and disadvantages of Ethernet communication • Network commands in Command Line Tools Skills • Using Command line tools • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being a team player • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Having a sense of ownership and accountability • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow environmental rules and regulations • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference materials • Hand-outs • Audio Visuals • Manuals Learning Facilities and infrastructure • Classroom with adequate facilities • Information Technology (IT) lab • Library • Robotics lab Materials • Pen and paper Tools • Micro-SD card and micro-SD card reader

	Software • Command Line tools Equipment • Computer with internet connectivity, display cable, SBC board, keyboard, mouse and monitor/LCD with power cable PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment

Module Title	Carrying out implementation of robotic system with ROS		
Module Code	3119- L3-M3		
Learning Outcome 2	Program microcontroller and SBC to communicate with one another		
Duration	Theory:6 hours	Practical:15 hours	Total:21 hours
Assessment Criteria	• Communication program over serial is created as per the job requirement following standard procedure • Communication program over SPI is created as per the job requirement following standard procedure • Communication program over i2c is created as per the job requirement following standard procedure		
Contents	C2.01 Creating communication program over serial Knowledge • Introduction to Serial Communication • Introduction to communication protocol • Synchronous and asynchronous communication • Python programming syntax • Modes of communication Skills • Using command line tools • Python and C++ programming skills • Interpreting datasheet • Using version control platform • Using multimeter • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C2.02 Creating a communication program over SPI Knowledge • Introduction to SPI communication • Advantage and disadvantages of SPI • Application of SPI • SPI pins and its usage • Concept of Master and Slave • Logic level shifter Skills • Using command line tools		

	• C++ and python programming skills • Interpreting circuit diagram • Interpreting datasheet • Using multi-meter • Using version control platform • Observation skills • Analytical skills • ICT skill • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C2.03 Creating a communication program over I2C <i>Knowledge</i> • Introduction to I2C communication protocol • Advantages and disadvantages of I2C • Application of I2C • I2C pins and its usage • Difference between serial, SPI and I2C <i>Skills</i> • Using command line tools • Interpreting circuit diagram • Python and C++ programming skills • Interpreting datasheet • Using multi-meter • Using version control platform • Analytical skills • ICT skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference material • Hand-outs

	• Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics lab Materials • Pen, paper and jumper wire Software • IDE, version control platform and command line tools Instrument • Multimeter Equipment • Computer with internet connectivity, microcontroller Board, USB cable, SBC board, HDMI Cable, Keyboard, logic level shifter, Mouse and Monitor/LCD with power cable PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work

Module Title	Carrying out implementation of robotic system with ROS		
Module Code	7112- L3-M3		
Learning Outcome 3	Program SBC to use ROS2 and sensors		
Duration	Theory:11 hours	Practical:45 hours	Total:56 hours
Assessment Criteria	• A ROS2 program is installed as per job requirement following the standard procedure • Topics from ROS2 is echoed as per job requirement following the standard procedure • Topics in ROS2 is published as per job requirement, following the standard procedure • Visualize topics using simulation tools as per job requirement, following the standard procedure • LiDAR cloud point is plotted in RViz as per job requirement following the standard procedure • Depth Camera image is plotted with ROS2 as per job requirement following the standard procedure		
Contents	C3.01 Installing ROS2 Knowledge • Introduction to ROS • Application of ROS • Advantages and Limitation of ROS • Introduction to ROS tools and concepts • ROS workspace organization and build system Skills • Using command line tools • ICT skills • Observation skills • Analytical skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being a team player • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Having a sense of ownership and accountability • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C3.02 Echo a topic from ROS2 Knowledge • Introduction to Echo in ROS2 • Introduction to Topic in ROS2 • Introduction to node and subscriber		

	Skills • Using command line tools • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C3.03 Publish a topic in ROS2 Knowledge • Introduction to publisher node • Introduction to broadcasting message using ROS Skills • Using command line tools • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C3.04 Visualize topics using simulation tools Knowledge • Introduction to remapping messages • Introduction to rqt • Introduction to turtlesim • Types of ROS simulation software • Introduction to ROS services • Essential file format in ROS • Packages in ROS Skills • Using command line tools • Observation skills • Analytical skills
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	• ICT skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C3.05 Plotting a LiDAR point cloud with ROS2 <i>Knowledge</i> • Working principle of LiDAR technology • Application of LiDAR technology • Sensor data processing • Concept of point cloud data (2D vs. 3D) • Introduction to Rviz2 • Recording and analyzing sensor data with ros2 bag <i>Skills</i> • Using command line tools • C++ programming skills • ROS2 workspace management skills • Using version control platform • Observation skills • Analytical skills • ICT skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C3.06 Plotting a Depth Camera image with ROS2 <i>Knowledge</i> • Introduction to Depth Camera and its working principle • Applications of depth camera • Introduction to camera calibration <i>Skills</i> • Using command line tools • Interpreting data sheet • Using version control platform • Observation skills
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	- Analytical skills - ICT skills - Numeracy skills Attitude, safety and environmental concern - Effective time management - Being efficient in using resources - Being vigilant and patient - Having work ethics and integrity - Proper handling of tools, materials and equipment - Ensuring correct use of PPE - Ensuring proper disposal of waste - Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials - CBLM/reference material - Hand-outs - Audio-visuals - Manuals Learning Facilities and Infrastructure - Classroom with adequate facilities - Library - IT lab - Robotics Lab Materials - Pen, paper, notebook and LiDAR sensor & accessories Software - Command line tools, camera package, Rviz2, turtlesim, rqt, LiDAR driver package, ROS2 bag and ROS2 Equipment - Computer with accessories, camera stand, depth camera and SBC board PPE - Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: - Lecture - Interactive discussion - Demonstration - Industrial visit/training - Guided practice - Group practice with project-based learning - Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: - Practical observation - Oral/viva-voce - Written test - Assignment

Module Title	Carrying out implementation of robotic system with ROS		
Module Code	7112- L3-M3		
Learning Outcome 4	Interface SBC hardware to ROS2 framework		
Duration	Theory:10 hours	Practical:67 hours	Total:77 hours
Assessment Criteria	• Robot is maneuvered with ros2_control as per job requirement following the standard procedure • Ultrasonic data is published with ros2_control as per job requirement following the standard procedure • IMU data is published with ros2_control as per job requirement, following the standard procedure • LiDAR data is published with ros2_control as per job requirement, following the standard procedure • Depth camera image data is published with ros2_control as per job requirement following the standard procedure		
Contents	C4.01 Maneuvering robot with ros2_control Knowledge • Introduction to ros2_control • Introduction to unified robot description format Skills • C++ and python programming skills • Observation skills • Using Command line tools • Using version control platform • Communication skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C4.02 Publishing Ultrasonic data with ros2_control Knowledge • Introduction to Cmake and compilation process in ROS2 • Applications of Cmake • Sensor_msgs message types and structures Skills • C++ and python programming skills • Interpreting circuit diagrams • Using command line tools		

	• Using version control platform • Observation skills • Analytical skills • ICT skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C4.03 Publishing IMU data with ros2_control <i>Knowledge</i> • Difference between ultrasonic and IMU data <i>Skills</i> • C++ and python programming skills • Interpreting circuit diagram • Using Command Line tools • Using version control platform • Observation skills • Analytical skills • ICT skills • Numeracy skills <i>Attitude, safety and environmental concern</i> • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C4.04 Publishing LiDAR data with ros2_control <i>Knowledge</i> • Data formats and conversion for LiDAR sensor • Introduction to LiDAR data filtering <i>Skills</i> • C++ and python programming skills • Interpreting circuit diagram • Using version control platform • Using Command Line tools • Observation skills • Analytical skills
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	• ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C4.05 Publishing Depth Camera image data with ros2_control Knowledge • Introduction to depth camera data configuration • Introduction to TF2 library • Introduction to depth to point cloud conversion Skills • C++ and python programming skills • Interpreting circuit diagram • Using command line tools • Using version control platform • Observation skills • Communication skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference material • Hand-outs • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics Lab

	Materials • Pen, pencil, notebook, double sided tape, fasteners, jumper wire, IMU sensor, ultrasonic sensor and LiDAR Tools • Screwdriver set and wire strippers Software • IDE, Command Line tool, ROS2, ros2_control and version control platform Equipment • Computer with accessories, SBC, microcontroller Board, USB Cable, Breadboard, motor driver, battery pack, voltage regulator and small chassis with motors and wheel PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work

Module Title	Carrying out implementation of robotic system with ROS		
Module Code	7112- L3-M3		
Learning Outcome 5	Program a robot using SBC-microcontroller and ROS2		
Duration	Theory:14 hours	Practical:63 hours	Total:77 hours
Assessment Criteria	• Motion program using motor encoder is implemented as per job requirement following the standard procedure • Sensor fusion between motor encoders and IMU is implemented as per job requirement following the standard procedure • Robot control remotely using telop_twist_joy is implemented as per job requirement, following the standard procedure • Motion program for localization with LiDAR is implemented as per job requirement, following the standard procedure		
Contents	C5.01 Implementing a motion program using motor encoders Knowledge • Introduction to Encoders • Working principle of Encoders • Types of Encoders • Application of Encoders • Odometry vs dead reckoning • Micro-ROS • Introduction to PID controller Skills • Using command line tools • Using version control platform • Interpreting data sheet • Interpreting circuit diagram • C++ and python programming skills • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C5.02 Implementing sensor fusion between motor encoder and IMU Knowledge • Concept of sensor fusion • Advantages of sensor fusion • Types of filters		

	• Introduction to Kalman filter Skills • Using command line tools • Interpreting data sheet • Interpreting circuit diagram • Using version control platform • C++ and python programming skills • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation C5.03 Implementing robot control remotely using teleop_twist_joy Knowledge • Introduction to teleoperations • Advantages and disadvantages of teleoperations • Introduction to joystick /controller interface • Importance of Joystick configuration • Introduction to teleop_twist_joy package Skills • Using version control platform • Using command line interface • Interpreting C++ and python programming languages • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
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	C5.04 Implementing a motion program for localization with LiDAR (SLAM) Knowledge • Introduction to localization and mapping • Simultaneous Localization and Mapping (SLAM) • Introduction to path planning • Path planning algorithms Skills • Using command line tools • Using version control platform • Interpreting circuit diagram • Interpreting datasheet • Interpreting C++ and python programming languages • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference material • Hand-outs • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics lab Materials • Pen, notebook, fasteners, LiDAR sensor and wire Tools • Screwdriver set and wire strippers Instrument • Multimeter Software • IDE, Command Line Tool, Nav2, SLAM_toolbox, version control platform,

	Micro-ROS and ROS2 Equipment • Computer with accessories, SBC board, microcontroller board, robot, joystick, voltage regulator, small chassis, motors with encoders, wheel, USB cable, motor driver and power supply PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment • Project work

MODULE 4: TROUBLESHOOTING MOBILE ROBOTICS SYSTEM

MODULE INFORMATION	
Occupation	Robotics Technician
Competency Area	Troubleshoot Robotics System
Module Title	Troubleshooting Robotics System
Module Code	3119- L3-M4
Module Description	This module is structured to provide the learners with knowledge, skills and right attitude required to troubleshoot malfunctions, debug robotic scripts and perform maintenance of robotic system.
Nominal Duration	55 Hours
Qualification Level	BQF Certificate Level 3
Pre-requisite	Completed Module 3119-L3-M3
Learning Outcome	1. Troubleshoot malfunctions 2. Debug Robotic scripts 3. Perform maintenance of robotic system

Module Title	Troubleshooting robotics system		
Module Code	7112- L3-M3		
Learning Outcome 1	Troubleshoot malfunctions		
Duration	Theory:4 hours	Practical:13 hours	Total:17 hours
Assessment Criteria	- Physical inspection is performed as per job requirement following the standard procedure - Electrical fault is troubleshot as per job requirement following the standard procedure - Mechanical fault is troubleshot as per job requirement, following the standard procedure		
Contents	D1.01 Performing physical inspection Knowledge - Importance of maintaining inspection checklist Skills - Observation skills - Analytical skills Attitude, safety and environmental concern - Effective time management - Being efficient in using resources - Being vigilant and patient - Having work ethics and integrity - Proper handling of tools, materials and equipment - Ensuring correct use of PPE - Ensuring proper disposal of waste - Ensuring to follow OHS rules and regulation D1.02 Troubleshooting electrical fault Knowledge - Common electrical faults and its causes - PCB construction and trace layouts - Fault Diagnosis Methodologies Skills - Using multimeter - Observation skills - Perceptual motor skills - Analytical skills - Interpreting circuit diagram - Problem solving skills - Soldering and desoldering skills - Interpreting Datasheet Attitude, safety and environmental concern - Effective time management - Being efficient in using resources - Being vigilant and patient - Having work ethics and integrity - Proper handling of tools, materials and equipment		

	• Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation D1.03 Troubleshooting mechanical faults Knowledge • Materials and Tribology • Common mechanical faults and its causes Skills • Perceptual motor skills • Observation skills • Interpreting datasheet • Problem solving skills • Analytical skills • Numeracy skills • Using measuring tools Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference material • Hand-outs • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics Lab Materials • Pen, inspection log, microfiber cloth, cleaning agent, soldering flux, soldering lead, solder wick, wires, replacement components, lubricants and notebook Tools • Screwdriver set, tweezers, wire stripper, desoldering pump, torque wrench, allen key set, wrench set, oil can and magnifying lens Instrument • Multimeter

	Equipment • Soldering iron set, soldering mat and exhaust fan PPE • Workshop dress, safety goggles, safety mask, safety gloves and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment

Module Title	Troubleshooting mobile robotics system		
Module Code	7112- L3-M3		
Learning Outcome 2	Debugging robotic scripts		
Duration	Theory:3 hours	Practical:18 hours	Total:21 hours
Assessment Criteria	• Variable values and states are monitored as per job requirement following the standard procedure • Sensors and actuator data are interpreted as per job requirement following the standard procedure • Error in robotic script is rectified as per job requirement, following the standard procedure		
Contents	D2.01 Monitoring variable values and states Knowledge • Noise, latency and jitter in data Skills • Using Command Line Tools • C++ Programming skills • Observation skills • Analytical skills • ICT skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation D2.02 Interpreting sensor and actuator data Knowledge • Concept of data trends • Data conversion • Data consistency check Skills • Using command line tools • C++ programming skills • Interpreting datasheet • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient		

	• Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation D2.03 Rectifying errors in robotic scripts Knowledge • Introduction to Debugging tools • Usage of ros2doctor tool • QoS in ros2 Skills • Using Command Line Tools • Programming skills • Observation skills • Analytical skills • ICT skills • Numeracy skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials, and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference material • Hand-outs • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics lab Materials • Pen, pencil and notebook Instrument • Multimeter Software • Command line tools, ROS2, version control platform, ros2doctor and IDE Equipment • SBC board, computer with accessories, oscilloscope and robot

	PPE • Workshop dress and safety boots
Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment

Module Title	Troubleshooting mobile robotics system		
Module Code	7112- L3-M3		
Learning Outcome 3	Perform maintenance of robotic system		
Duration	Theory:3 hours	Practical:14 hours	Total:17 hours
Assessment Criteria	• Software and firmware are updated as per job requirement following the standard procedure • Schedule maintenance of robotic system components is performed as per job requirement following the standard procedure • Logs and documentation are maintained as per job requirement, following the standard procedure		
Contents	D3.01 Updating software and firmware Knowledge • Difference between software and firmware • Software and firmware updating processes • Purpose of updating software and firmware Skills • Using Command Line Tools • Using ROS2 • Observation skills • Analytical skills • ICT skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation D3.02 Performing scheduled maintenance of robotic system components Knowledge • Types of maintenance • Importance of scheduled maintenance procedures Skills • Interpreting datasheet • Observation skills • Analytical skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE		

	• Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation D3.03 Maintaining logs and documentations Knowledge • Purpose of maintaining logs and documentation • Key data to be recorded Skills • Record keeping skills • Observation skills • Analytical skills Attitude, safety and environmental concern • Effective time management • Being efficient in using resources • Being vigilant and patient • Having work ethics and integrity • Proper handling of tools, materials and equipment • Ensuring correct use of PPE • Ensuring proper disposal of waste • Ensuring to follow OHS rules and regulation
Learning Conditions	Learning Materials • CBLM/reference material • Hand-outs • Audio-visuals • Manuals Learning Facilities and Infrastructure • Classroom with adequate facilities • Library • IT lab • Robotics lab Materials • Pen, notebook, lubricants, cleaning tools & agents, log format and maintenance log book Tools • Screwdriver set, tweezers, wire strippers, torque wrench, allen key set, wrench set and oil can Instrument • Multimeter Equipment • Computer with accessories and robot PPE • Workshop dress and safety boots

Instructional Methodologies	The trainer shall use <i>inter alia</i>, the following instructional methods: • Lecture • Interactive discussion • Demonstration • Industrial visit/training • Guided practice • Group practice with project-based learning • Individual practice with problem-based learning
Method of Assessment	The trainer shall use <i>inter alia</i>, the following assessment methods: • Practical observation • Oral/viva-voce • Written test • Assignment

ANNEXURE

Annex I: Time Distribution

Time Distribution (Regular course)					
Robotics Technician Certificate 3					
Module Title	Learning outcomes	Tasks	Theory	Practical	Total
			(Hours)	(Hours)	(hours)
A: Apply fundamentals of electrical and electronics theory	A1: Apply basic electrical theory	A1.00 Introductory knowledge	2.5	0	2.5
		A1.01 Perform instrument reading	2	3	5
		A1.02 Test conductor and insulator	1	2	3
		A1.03 Measure resistance	2	2	4
		A1.04 Measure voltage	1	2	3
		A1.05 Measure current	1	3	4
		A1.06 Measure frequency	2	5	7
	Sub Total		11.5	17	28.5
	A2: Verify DC circuits	A2.01 Verify Ohm's law	2	5	7
		A2.02 Verify characteristics of series circuit	2	5	7
		A2.03 Verify characteristics of parallel circuits	2	5	7
		A2.04 Verify characteristics of series-parallel combined circuit	2	5	7
	Sub Total		8	20	28
	A3: Apply basic electronics theory	A3.01 Perform soldering	1	6	7
		A3.02 Test inductor	1	2	3
		A3.03 Test capacitor	1	3	4
		A3.04 Verify V-I characteristics of diode	2	5	7
		A3.05 Verify V-I characteristics of Zener diode	2	5	7
		A3.06 Test transistors	3	4	7
		A3.07 Simulate VI characteristics of diode	1	6	7
	Sub Total		11	31	42
	Total Duration (A)		30.5	68	98.5
B: Carry out development and integration	B1: Install Operating system	B1.01 Install Ubuntu on computer	1	3	4
		B1.02 Configure required software using command line tool	1	3	4

of MCU based robotic system	and application Software	B1.03 Store code in collaborative version control platform	1.5	3	4.5
		B1.04 Install libraries	1	2	3
	Sub Total		4.5	11	15.5
	B2: Program microcontroller to communicate with robotic components	B2.01 Create a program to blink a LED	2	12	14
		B2.02 Create a program to toggle a buzzer using push button	2	3	5
		B2.03 Create a program to run a motor	2	7	9
		B2.04 Create a program for LCD	1	3	4
		B2.05 Create a program to read distance with sensors	2	2	4
		B2.06 Simulate distance measurement using US sensors in design software	1	6	7
		B2.07 Create a program to read angles from an Inertial Measurement Unit (IMU) sensor	2	5	7
	Sub Total		12	38	50
	B3: Design mobile robotics components	B3.01 Install designing software	1	3	4
		B3.02 Create 2D sketch	2	12	14
		B3.03 Design 3D model	2	12	14
		B3.04 Assemble 3D models	4	10	14
	Sub Total		9	37	46
	B4: Develop motion programs using microcontroller	B4.01 Develop a motion program without sensors	3	7	10
		B4.02 Develop a motion program with an ultrasonic sensor	2	7	9
		B4.03 Develop a motion program with IMU sensor	2	12	14
		B4.04 Develop a Program to drive on a test track with multiple sensors	2	19	21
	Sub Total		9	45	54
	Total Duration (B)		34.5	131	165.5
C: Carry out implementation of robotic system with ROS	C1: Install Operating system and application Software on the Single Board Computer (SBC)	C1.01 Install Ubuntu on SBC	2	5	7
		C1.02 Configure required software using command line tool	2	5	7
		C1.03 Configure communication network between PC and SBC	2	5	7
	Sub Total		6	15	21
	C2: Program microcontroller and SBC to communicate with one another	C2.01 Create a communication program over serial	2	5	7
		C2.02 Create a communication program over SPI	2	5	7
		C2.03 Create a communication program over i2c	2	5	7

	Sub Total		6	15	21
	C3: Program SBC to use ROS2 and sensors	C3.01 Install ROS2	2	5	7
		C3.02 Echo a topic from ROS2	1	6	7
		C3.03 Publish a topic in ROS2	1	6	7
		C3.04 Visualize topics using simulation tools	2	5	7
		C3.05 Plot a Lidar point cloud with ROS2	3	11	14
		C3.06 Plot a Depth Camera image with ROS2	2	12	14
	Sub Total		11	45	56
	C4: Interface SBC hardware to ROS2 framework	C4.01 Maneuver robot with ros2_control	2	19	21
		C4.02 Publish Ultrasonic data with ros2_control	2	12	14
		C4.03 Publish IMU data with ros2_control	2	12	14
		C4.04 Publish Lidar data with ros2_control	2	12	14
		C4.05 Publish Depth Camera image data with ros2_control	2	12	14
	Sub Total		10	67	77
	C5: Program a robot using SBC - microcontroller and ROS2	C5.01 Implement a motion program using motor encoders	4	17	21
		C5.02 Implement sensor fusion between motor encoders and IMU	3	18	21
		C5.03 Implement robot control remotely using teleop_twist_joy	2	12	14
		C5.04 Implement a motion program for localization with Lidar (SLAM)	5	16	21
	Sub Total		14	63	77
	Total Duration (C)		47	205	252
D: Troubleshoot Mobile Robotics system	D1: Troubleshoot malfunctions	D1.01 Perform physical inspection	1	2	3
		D1.02 Troubleshoot electrical faults	1	6	7
		D1.03 Troubleshoot mechanical faults	2	5	7
	Sub Total		4	13	17
	D2: Debug robotic scripts	D2.01 Monitor variable values and states	1	6	7
		D2.02 Interpret sensor and actuator data	1	6	7
		D2.03 Rectify errors in robotics script	1	6	7
	Sub Total		3	18	21
	D3: Perform maintenance of robotic system	D3.01 Update software and firmware	1	6	7
		D3.02 Perform schedule maintenance of robotic system components	1	6	7
		D3.03 Maintain logs and documentation	1	2	3

	Sub Total	3	14	17
Total Duration(D)		10	45	55
Total Duration		122	449	571

Annex II: Module Recognition

This is to verify that

Mr/Ms.....

has completed module on

.....

Covering following learning outcomes:

1.
2.
3.

Instructor:

Head of the Department:

.....

.....

Signature:

Signature:

Date: / / (dd/mm/yyyy)
.....(dd/mm/yyyy)

Date: / /

Head of the Institute:

Trained Assessor (Institute)/Exam OC:

.....

.....

Signature:

Signature:

Date: / ... / (dd/mm/yyyy)

Date: / /(dd/mm/yyyy)

Annex IV: Lesson Plan
Lesson Plan

Course Title:		NC Level:
Module Code:		Duration:
Module Title:		
Learning Outcome:		
Skill/Task/Topic:		
Terminal Performance Objective:		
<i>(Note: Write narrative statement extracted from TPO of Task Sheet)</i>		
Enabling Objectives (Related knowledge):		
<i>By the end of the lesson learners will be able to:</i>		
- i) - ii) - iii)		
What (Content/Activity)	Who (T/L)	How (Methods/ Media)
Duration (Min.)	Questions	
<i>Introduction:</i>		
<i>Main body</i>		
<i>Conclusion</i>		
Projects/Problems:		

Instructional Resources Plan				
Skills/Task/Topic:				
No. of Trainees:				
Sl. No.:	Instructional materials/resources	Specifications	Qty.	Remarks
Prepared by :		Signature	Date:	
Revised by:		Signature	Date:	
Approved by:		Signature	Date:	

Task sheet

TS-1/4: Practical Plan			
Course Title:		N C Level:	
Module code:		Duration:	
Module Title			
Learning outcome			
Skills/Task Title:		Task no:	
Terminal Performance Objective: <i>Given:</i> <i>Cue:</i> <i>Who:</i> <i>What:</i> <i>Within:</i> <i>How well:</i> - - -			
Enabling Objectives (Related Skills): <i>By the end of a lesson, the learners will be able to:</i> i) ii) iii) iv)			
Activities	Who (T/L)	How (methods/ media)	Duration
Project/Assignment: 			

TS-2/4: Tool and Equipment required:							
<i>Sl no.</i>	<i>Particulars</i>	<i>Specifications</i>	<i>Qty.</i>	<i>Remarks</i>			
Training Materials required:							
<i>Sl no.</i>	<i>Particulars</i>	<i>Specifications</i>	<i>Qty.</i>	<i>Rate</i>	<i>Amount</i>	<i>Remarks</i>	
TS-3/4: Performance Guide							
Skill/Task:					Date:		
Directions: Use the following performance criteria to rate the learner. Check YES/NO to indicate whether the learner performed each step as indicated or not?							
Sl. No:	Steps					Yes	No
Note: Critical steps: All * marked steps should be carried out very carefully. For a quality performance guide, all items should be checked "YES"							

TS-4/4: Instruction and Drawing***General Instructions for Trainees***

- i)
- ii)
- iii)
- iv)

Drawing (if any)**Safety Precaution**

- i)
- ii)
- iii)

Prepared by:**Signature****Date:****Revised By:****Signature****Date:****Approved by:****Signature****Date:**

Annex V: Course Plan
Institutes letter head and Logo

(Trade)YEAR PLAN- _____ **Semester** _____ **(Year)**

Trade: NC Level:			Schedule																																Total Hours												
Module Code	Module Title	Learning Outcome	Feb.				March				April				May				June				July				Aug.				Sept					Oct.				Nov.							
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		1	2	3	4								
OJT																																															
Assessment and Certification																																															

Prepared by:

Verified & Approved by:

Date:

Monthly/Weekly Plan

Month:

Trade:

Trainer:

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 01							
Week 02							
Week 03							
Week 04							
Week 05							

Developed by:

Approved by:

Date _____



For more information please contact:

Technical Trainers Training and Resource Center (TTTRC), DWPSD

Email ID: tttrd@moesd.gov.bt/dwpsd@moesd.gov.bt