



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Electronics & Communication Engineering /
Information & Communication Technology

Subject Code : DI05000031

Subject Name : Robotics

w. e. f. Academic Year:	2026-27
Semester:	5 th
Category of the Course:	PEC-03 / 04

Prerequisite:	Basic Electronics and Circuit Theory Fundamentals of Programming (C / Python) Electric Circuits and Measurements Microcontrollers and Embedded Systems
Rationale:	This course introduces students to the principles, design, and programming of robotic systems. It bridges electronics, communication, control systems, and software to equip students with skills to design, build, and program robots for industrial and service applications. The course emphasizes both theoretical understanding and hands-on laboratory practice.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Describe the structure, classification, types of joints, end-effectors, and real-world applications of robotic systems.	R, U, A
02	Apply homogeneous transformation matrices and Denavit-Hartenberg convention to solve forward and inverse kinematics of robot manipulators.	R, U, A
03	Select, interface, and configure appropriate sensors and actuators (motors, encoders, IMU) for a given robotic task.	R, U, A
04	Design and tune a PID control algorithm for robot motion and implement trajectory planning in joint and Cartesian space.	R, U, A
05	Program robots using Arduino/Python and ROS to perform specified autonomous or semi-autonomous tasks.	R, U, A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction to Robotics 1.1 History and evolution of robotics; generations of robots; key milestones (UNIMATE, PUMA, ASIMO, collaborative robots) 1.2 Definition of a ROBOT, Laws of robotics. 1.3 Classification: by structure (Cartesian, Cylindrical, Spherical, SCARA, Articulated, Delta); by application (industrial, service, medical, agricultural); by control type 1.4 Robot anatomy: links, joints, manipulator arm, wrist, end-effectors (grippers, tools) 1.5 Degrees of Freedom (DOF), workspace, and reach envelope 1.6 Applications: manufacturing, welding, painting, healthcare, agriculture, and ICT automation	09	20%
2.	Robot Mechanics & Kinematics 2.1 Coordinate frames: Cartesian, cylindrical, and spherical systems 2.2 Homogeneous transformation matrices (translation + rotation); Denavit-Hartenberg (D-H) convention 2.3 Forward kinematics: D-H parameter table; equations for 2-DOF and 3-DOF robots 2.4 Inverse kinematics: geometric and algebraic methods; multiple solutions and singularities 2.5 Introduction to robot dynamics: Newton-Euler formulation overview; torque and inertia concepts	09	20%
3.	Actuators and Sensors 3.1 DC motors (brushed, BLDC), servo motors, stepper motors (full/half-step, microstepping); driver ICs: L293D, L298N, TB6600 3.2 Hydraulic, pneumatic actuators; linear actuators, solenoids 3.3 Proximity sensors: IR, ultrasonic (HC-SR04), capacitive, inductive 3.4 Encoders (incremental, absolute); IMU (MPU-6050, BNO055): accelerometer, gyroscope, magnetometer 3.5 Force/torque sensors, vision sensors (camera, LiDAR); signal conditioning: amplification, filtering 3.6 Interfacing sensors and actuators with Arduino and Raspberry Pi; ADC/DAC conversion	12	25%
4.	Robot Control Systems 4.1 Open-loop vs. closed-loop control; feedback and feedforward;	8	20%



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	block diagrams and signal flow 4.2 PID control: proportional, integral, derivative actions; Ziegler-Nichols tuning; digital PID implementation; anti-windup 4.3 Trajectory planning: point-to-point (PTP) and continuous path (CP) control 4.4 Velocity and acceleration profiles: trapezoidal and S-curve; interpolation methods: linear, circular, spline 4.5 Introduction to adaptive control, fuzzy logic control, and force/impedance control (overview)		
5.	Robot Programming 5.1 Programming approaches: teach pendant, lead-through, textual languages (RAPID, KRL, VAL) 5.2 Arduino C/C++ for robot control; Python with Raspberry Pi, GPIO and OpenCV for vision-based tasks 5.3 Robot Operating System (ROS): architecture (nodes, topics, services, actions); writing publisher/subscriber nodes 5.4 URDF robot description, RViz visualization, Gazebo simulation environment 5.5 Path planning algorithms: Dijkstra, A*; sampling-based methods (RRT overview); obstacle avoidance strategies	7	15%
	Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
30	35	35	-	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Niku S. B. — Introduction to Robotics: Analysis, Control, Applications, Wiley, 3rd ed.
2. Fu K. S., Gonzalez R. C., Lee C. S. G. — Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill.
3. Craig J. J. — Introduction to Robotics: Mechanics and Control, Pearson, 3rd ed.
4. Spong M. W., Hutchinson S., Vidyasagar M. — Robot Modeling and Control, Wiley.
5. Quigley M., Gerkey B., Smart W. D. — Programming Robots with ROS, O'Reilly.



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(b) Open source software and website:

1. ROS Wiki — <https://wiki.ros.org>
2. Arduino Tutorials — <https://www.arduino.cc/en/Tutorial>
3. NPTEL Robotics Course — <https://nptel.ac.in> Robotics by Prof D K Pratihara, IIT Kharagpur
4. Gazebo Simulator — <https://gazebo.org>

Suggested Course Practical List: If any

Sr. No.	Practical Title	Approx. Hrs. required
01	Arduino IDE setup and GPIO programming — blinking LED, push button input, and analog read using potentiometer	2 Hrs
02	DC motor speed and direction control using L293/L298 with PWM signal from Arduino	2 Hrs
03	Stepper motor interfacing with Arduino — full-step, half-step, and microstepping modes using ULN2003 driver	2 Hrs
04	Servo motor position control using Arduino — sweeping angles via Serial input/ potentiometer	2 Hrs
05	Ultrasonic sensor (HC-SR04) with Arduino — distance measurement on Serial display/LCD	2 Hrs
06	IR sensor array interfacing with Arduino — line-follower robot with 3-sensor or 5-sensor array	2 Hrs
07	Obstacle-avoiding robot using Arduino and HC-SR04 ultrasonic sensor with motor driver	2 Hrs
08	IMU (MPU-6050) interfacing with Arduino via I2C — reading roll, pitch, and yaw angles	2 Hrs
09	LDR based light tracking — Robot Direction Control	2 Hrs
10	Encoder-based DC motor speed measurement with Arduino — RPM calculation and Serial Monitor display	2 Hrs
11	Trapezoidal pattern using arduino for stepper motor	2 Hrs
12	PID motor speed control using Arduino — implementation of P, I, D terms with encoder feedback	2 Hrs
13	PIR Motion Sensor Interface to detect human motion and trigger alarm/LED	2 Hrs



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14	Joystick Module to control servo motors or robot direction using joystick	2 Hrs
15	2-DOF robotic arm control— servo position control and forward kinematics verification	2 Hrs
16	3-DOF robotic arm— pick-and-place path with angle presets	2 Hrs
17	Temperature sensor (LM35 / DHT11) interfacing with Arduino — environment-aware robot trigger	2 Hrs
18	Bluetooth-controlled differential drive robot using HC-05 and Arduino with Android / serial terminal	2 Hrs
19	RF remote-controlled robot using nRF24L01 transceiver module and Arduino (transmitter + receiver pair)	2 Hrs
20	Fire-detecting robot using flame sensor and Arduino — autonomous stop-and-alert on fire detection	2 Hrs
Total:		40 Min. 30 Hrs

List of Laboratory/Learning Resources Required:

Sr.	Resource / Equipment	Specification	Qty (per batch)
01	Arduino Uno / Mega Microcontroller Board	ATmega328P / ATmega2560	1
02	Raspberry Pi 4 / ESP32	Quad-core, Wi-Fi/BT	1
03	DC Motor + L298N Driver Module	6V–12V, dual-channel	1
04	Stepper Motor + ULN2003 Driver	28BYJ-48, 5V	1
05	Servo Motor	SG90 / MG995	2
06	Ultrasonic Sensor	HC-SR04	1
07	IR Sensor Module	3-pin digital	2
08	IMU Module	MPU-6050 or BNO055	1



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09	2-DOF Robotic Arm Kit	With servo mounts	1 per group
10	Wheeled Robot Chassis	2WD / 4WD with encoders	1 per group
11	Bluetooth Module	HC-05	1
12	Rotary Encoder Module (600 PPR)	5V, A/B channel output	2
13	LDR (Light Dependent Resistor) Module	Analog + digital output	2
14	Flame Sensor Module, LM35 / DHT11 Temperature Sensor, PIR Motion Sensor	Analog / digital, 5V	2
15	nRF24L01 Transceiver Module	2.4 GHz, SPI interface	2 pairs
16	Breadboard, jumper wires, resistors kit	Full-size, tie-points	1 per student

Suggested Project List:

1. Line-following and obstacle-avoiding autonomous robot using IR and ultrasonic sensors.
2. Bluetooth / Wi-Fi controlled robotic arm (3-DOF) with Android / web interface.
3. PID-controlled self-balancing robot using MPU-6050 IMU.
4. Pick-and-place robot with servo gripper, programmed for a predefined trajectory.
5. IoT-enabled robot with MQTT telemetry dashboard (sensor data logging on cloud).
6. ROS-based differential drive robot simulation with obstacle avoidance in Gazebo.
7. Gesture-controlled robot using MPU-6050 glove— tilt-based direction commands via RF/BT
8. DTMF-controlled robot using Arduino and MT8870 decoder — mobile phone keypad commands
9. Voice-controlled robot using Arduino and HC-05 with voice recognition app on Android
10. Automated Sorting Robot using TCS3200 color sensor
11. 2D CNC Plotter using stepper motors
12. Haptic feedback robotic gripper using FSR-402
13. Wi-Fi controlled robot / ROS simulation — ESP32 web-server teleoperation or Turtlesim publisher-subscriber nodes



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Suggested Activities for Students: If any

1. Participate in robotics competitions (e.g., Robocon, line follower events, hackathons).
2. Complete online certifications: NPTEL Robotics, Coursera Modern Robotics.
3. Build a robot using a low-cost platform (Arduino + chassis) as a self-study exercise.
4. Explore simulation on free tools: Tinkercad, Webots, or Gazebo.
5. Prepare a technical report or presentation on an emerging robotic application.

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