

Industrial Robotics Master Program: **Design, Embedded Systems & ROS2**

Target Audience

This course is designed for engineering students, diploma holders, automation professionals, robotics enthusiasts, mechatronics engineers, embedded systems developers, and industrial automation practitioners seeking comprehensive knowledge of industrial robotics, embedded control systems, ROS2-based robotics. Participants should possess basic knowledge of electrical, electronics, mechanical engineering, or programming concepts. The course prepares learners for careers in robotics, electronics, smart manufacturing, and Industry 4.0 applications.

Course Outcomes

- Understand the fundamentals of industrial robotics and robot architectures.
- Analyze robot kinematics and motion control systems.
- Design and model robotic systems using engineering principles.
- Implement embedded hardware interfaces for robotic applications.
- Configure and control various actuators and motor systems.
- Apply communication protocols in robotic and automation systems.
- Develop robotic applications using ROS2 frameworks.
- Create robot simulations and control systems using Gazebo and ROS2.
- Evaluate and optimize robotic design workflows.

Course Objectives

- Provide a structured understanding of industrial robotics and automation technologies.
- Develop proficiency in robotic manipulator design, modeling, and control.
- Build competency in embedded systems development for robotics applications.
- Enable learners to configure sensors, actuators, and communication systems.
- Introduce ROS2 architecture, simulation, and intelligent robotic applications.
- Reinforce learning through hands-on laboratory exercises and projects.
- Prepare participants for real-world industrial robotics designing and control.

Course Outline

The course comprises **120 hours** of theory and laboratory sessions and is divided into **3 stages**. Each stage will be followed by **hands-on lab exercises** to reinforce learning and gauge understanding of the topics covered.

Table of Content

Stage 1: Industrial Robotics Fundamentals

Robot Fundamentals

- Introduction to Industrial Robotics
- Evolution of Industrial Robotics
- Industrial Robot Classifications
- Structure of Robotic Manipulators
- Robot Joints and Links
- Degrees of Freedom and Robot Mobility
- Robot Workspace and Reachability
- Applications of Industrial Robots

Robot Design & Modeling

- Mechanical Design Considerations
- Components of Robotic Systems
- Robot Structural Design
- Material Selection for Robotics
- Basic CAD for Robotics
- 3D Modeling Concepts
- Coordinate Systems and Transformations
- Position and Orientation Representation

Robot Motion & Control

- Forward Kinematics
- Inverse Kinematics
- Actuators and Sensors in Robotics
- Types of Robotic Actuators
- Position and Feedback Sensors
- Robot Motion Control
- Open-Loop and Closed-Loop Control
- Trajectory Planning and Task Execution

Stage 2: Embedded Robotics Systems Design & Control

Embedded Hardware & Interfacing

- Introduction to Embedded Systems

- Microcontrollers (STM32/ESP32)
- Microcontroller Architecture Overview
- GPIO Configuration
- Digital and Analog Interfacing
- ADC and DAC Fundamentals
- Sensors and Sensor Interfacing
- Signal Conditioning Techniques

Actuation & Control Systems

- Servo Motors
- Stepper Motors
- BLDC Motors
- Motor Selection Criteria
- Motor Drivers and Actuation
- PWM Generation Techniques
- PWM and Motion Control
- Speed and Position Control
- Feedback Control Systems (PID)
- PID Tuning Fundamentals

Communication & Integration

- Communication Protocols (UART, SPI, I2C, CAN, RS485)
- Serial Communication Fundamentals
- Device-to-Device Communication
- Industrial Communication Networks
- Real-Time Robotics
- Embedded System Integration
- Robotic Subsystem Development
- System Testing and Validation

Stage 3: ROS2-Based Robotics

ROS2 Foundations

- Introduction to ROS2
- ROS2 Architecture and Communication
- Nodes, Topics, and Messages
- Services and Actions
- Robot Description
- Robot Modeling Concepts
- TF and Coordinate Frames
- Workspace and Package Management

Simulation & Robot Control

- Introduction to Robot Simulation
- Gazebo Simulation
- Creating Simulation Environments
- Robot Model Integration
- ROS2 Control Framework
- Controllers and Hardware Interfaces
- Joint State Management
- Robot Control Workflows

Robotics Applications

- Vision and Perception
- Camera and Sensor Integration
- Object Detection Concepts
- Sensor Fusion Fundamentals
- Autonomous Robot Behaviors
- Pick-and-Place Applications