Training Course on Robotics and Mechatronics Control Systems

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

Step into the dynamic world of advanced automation with our comprehensive training course on Robotics and Mechatronics Control Systems. Training Course on Robotics and Mechatronics Control Systems offers an in-depth exploration of the synergistic integration of mechanical engineering, electronics, computer science, and control theory, which forms the bedrock of modern robotic and mechatronic systems. Participants will gain a robust understanding of robot kinematics, dynamics, sensor fusion, and actuator control, crucial for designing, analyzing, and deploying intelligent, high-performance automated solutions. This course emphasizes practical application, equipping attendees with the skills to tackle complex real-world challenges in industrial automation, autonomous systems, and advanced manufacturing.

This intensive course is designed to empower engineers, researchers, and technical professionals with the cutting-edge knowledge required to innovate in the rapidly evolving fields of robotics and mechatronics. We will cover trending topics such as ROS (Robot Operating System) development, collaborative robotics (cobots), machine learning for robot perception, force/impedance control, and advanced motion planning. Join us to master the core competencies for developing the next generation of smart machines, autonomous vehicles, and intelligent robotic manipulators, driving efficiency, precision, and safety across various industries.

Programme Curriculum

Training Course on Robotics and Mechatronics Control Systems

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Course Objectives

1. Master the fundamental principles of robot kinematics and dynamics for various manipulator configurations.
2. Design and implement robust feedback control systems for robotic manipulators and mechatronic devices.
3. Utilize ROS (Robot Operating System) for developing and integrating complex robotic applications.
4. Program and interface with collaborative robots (cobots) for safe human-robot interaction.
5. Apply sensor fusion techniques (e.g., LiDAR, cameras, IMUs) for enhanced robot perception and navigation.
6. Implement machine learning algorithms for object recognition, pose estimation, and intelligent decision-making in robots.
7. Develop advanced motion planning and trajectory generation algorithms for efficient and collision-free robot movement.
8. Understand and apply principles of force and impedance control for sensitive manipulation tasks.
9. Configure and tune various actuators and servo drives for precise robot motion control.
10. Analyze the stability and performance of robotic control systems using classical and modern control theories.
11. Design and integrate embedded control systems for real-time mechatronic applications.
12. Explore emerging trends in human-robot collaboration, autonomous navigation, and mobile robotics.
13. Contribute to the development of sophisticated smart machines and intelligent autonomous systems across diverse industries.

Organizational Benefits

1. Accelerated Automation Adoption: Faster deployment of advanced robotic solutions.
2. Enhanced Operational Efficiency: Optimized robotic workflows and reduced cycle times.
3. Improved Precision and Quality: Robotics leading to higher manufacturing standards.
4. Increased Safety in Workflows: Effective implementation of collaborative robotics.

5. Reduced Labor Costs: Automation of repetitive and hazardous tasks.
6. Competitive Advantage: Leveraging cutting-edge robotic and mechatronic capabilities.
7. Innovative Product Development: Ability to create more sophisticated intelligent machines.
8. Skilled Workforce: Empowered employees proficient in modern robotics technologies.
9. Proactive Maintenance: Utilizing data from mechatronic systems for predictive insights.
10. Scalability and Flexibility: Adapting production lines and processes with advanced automation.

Target Participants

- Robotics Engineers
- Mechatronics Engineers
- Automation Engineers
- Control Systems Engineers
- R&D Engineers
- Software Developers (with an interest in robotics)
- Electrical and Mechanical Engineers
- Researchers and Academics in robotics and automation.
- Technical Managers overseeing robotics or automation projects.

Course Outline

Module 1: Fundamentals of Robotics and Mechatronics Systems

- **Defining Robotics and Mechatronics:** Interdisciplinary nature and key components.
- **Types of Robots:** Industrial manipulators, mobile robots, collaborative robots.
- **Mechatronic System Design Principles:** Integration of mechanics, electronics, and control.
- **Sensors and Actuators in Robotics:** Selection and application.
- **Case Study:** Dissecting a simple mechatronic system like a pick-and-place robot.

Module 2: Robot Kinematics: Understanding Robot Motion

- **Forward Kinematics:** Calculating end-effector position from joint angles (DH Parameters).
- **Inverse Kinematics:** Determining joint angles for a desired end-effector pose.
- **Workspace Analysis:** Defining the reachable area of a robot.
- **Singularities:** Understanding and avoiding kinematic singularities.
- **Case Study:** Kinematic analysis of a 6-DOF industrial robot arm.

Module 3: Robot Dynamics: Forces and Motion

- **Lagrangian and Newton-Euler Formulations:** Deriving robot equations of motion.
- **Robot Inertia and Mass Properties:** Impact on control.
- **Gravity Compensation and Friction Modeling:** Practical considerations.
- **Dynamic Performance Metrics:** Bandwidth, response time, overshoot.
- **Case Study:** Dynamic modeling of a two-link planar manipulator for control.

Module 4: Classical Control Theory for Robotic Systems

- **PID Control Review and Tuning:** Advanced tuning techniques for robotic joints.
- **Frequency Domain Analysis:** Bode plots, Nyquist plots for stability analysis.

- **Root Locus Analysis:** Designing controllers for desired response.
- **Lead-Lag Compensators:** Improving transient response and steady-state error.
- **Case Study:** Designing and tuning a PID controller for a single robot joint.

Module 5: Modern Control Theory & State-Space Control

- **State-Space Representation of Robotic Systems:** From dynamic equations to state variables.
- **Controllability and Observability:** Assessing system properties.
- **LQR (Linear Quadratic Regulator) Design:** Optimal control for robotic systems.
- **Kalman Filters:** State estimation in noisy environments.
- **Case Study:** Implementing an LQR controller for a simple robotic system.

Module 6: Robot Operating System (ROS) Fundamentals

- **ROS Architecture:** Nodes, topics, services, messages, actions.
- **ROS Workspace Setup and Package Creation:** Getting started with ROS development.
- **ROS Communication Mechanisms:** Publishers, subscribers, service servers/clients.
- **URDF (Unified Robot Description Format):** Describing robot kinematics and visual properties.
- **Case Study:** Building a simple ROS package to control a simulated mobile robot.

Module 7: Robot Perception and Sensor Fusion

- **Vision Systems in Robotics:** Cameras, image processing, object detection.
- **Lidar and Radar for Ranging:** Environmental mapping and obstacle avoidance.
- **IMUs (Inertial Measurement Units) and Encoders:** Pose and motion estimation.
- **Kalman Filters and Particle Filters for Sensor Fusion:** Combining disparate sensor data.
- **Case Study:** Integrating LiDAR and IMU data for improved mobile robot localization.

Module 8: Advanced Motion Planning and Trajectory Generation

- **Joint Space vs. Task Space Trajectories:** Different approaches to motion.
- **Path Planning Algorithms:** RRT, PRM, A* for collision avoidance.
- **Collision Detection and Avoidance:** Ensuring safe robot operation.
- **Smooth Trajectory Generation:** Splines and polynomials for continuous motion.
- **Case Study:** Implementing a motion planning algorithm for a robot navigating obstacles in a warehouse.

Module 9: Collaborative Robotics (Cobots) and Human-Robot Interaction

- **Principles of Human-Robot Collaboration:** Safety standards and collaborative modes.
- **Force and Torque Sensing for Collaboration:** Detecting contact and ensuring safety.
- **Intuitive Programming for Cobots:** Lead-through programming, visual interfaces.
- **Applications of Cobots:** Assembly, material handling, quality inspection.
- **Case Study:** Programming a cobot for a pick-and-place task alongside a human operator.

Module 10: Force Control and Impedance Control

- **Force Control Strategies:** Direct force control, hybrid force/position control.
- **Impedance Control:** Regulating robot interaction with the environment.
- **Stiffness and Damping Control:** Adjusting robot compliance.
- **Applications:** Grinding, polishing, assembly with tight tolerances.
- **Case Study:** Implementing impedance control for a robot performing a peg-in-hole assembly task.

Module 11: Machine Learning for Robot Perception and Control

- **Reinforcement Learning for Robot Control:** Learning optimal policies through trial and error.
- **Deep Learning for Object Recognition and Grasping:** Training neural networks for robotic vision.
- **Sim-to-Real Transfer Learning:** Bridging the gap between simulation and physical robots.
- **Robot Learning from Demonstration:** Teaching robots new skills.
- **Case Study:** Training a robot to recognize and pick up irregularly shaped objects using deep learning.

Module 12: Mobile Robotics and Autonomous Navigation

- **Localization Techniques:** GPS, SLAM (Simultaneous Localization and Mapping).
- **Mapping Algorithms:** Occupancy grids, feature-based maps.
- **Path Planning for Mobile Robots:** Global and local planners.
- **Obstacle Avoidance Strategies:** Reactive and predictive approaches.
- **Case Study:** Programming an autonomous mobile robot to navigate an indoor environment.

Module 13: Actuators, Drivers, and Power Electronics for Robotics

- **DC Motors, Stepper Motors, and Servo Motors:** Characteristics and selection.
- **Motor Control Techniques:** PWM, current loops, velocity loops.
- **Servo Drives and Amplifiers:** Interfacing with motion controllers.
- **Power Supply and Energy Management in Robots:** Efficiency and reliability.
- **Case Study:** Selecting and sizing motors and drives for a multi-axis robotic system.

Module 14: Embedded Control Systems and Real-time Implementation

- **Microcontrollers and DSPs for Robotic Control:** Hardware selection.
- **Real-time Operating Systems (RTOS):**Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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