NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	M.Tech. in Electronics & Instrumentation Engineering (Robotics and Artificial Intelligence)
Semester:	I
Course Code:	6EI802CC25
Course Title:	Sensors and Actuators
Course Type:	Core
Year of introduction:	2025 - 26

L	T	Practical component				C
		LPW	PW	W	S	
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Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to –

1. demonstrate the working principles and applications of sensors and actuators used in robotics (BL2)
2. analyze the selection criteria for sensors and actuators in robotic arm and mobile robot applications (BL4)
3. develop a real-time control system by integrating sensors and actuators to optimize robotic performance (BL6)
4. design and implement sensor-actuator systems for advanced robotic applications. (BL6)

Unit	Contents	Teaching Hours (Total 30)
Unit I	**Introduction to sensors and actuators** Overview of sensors and actuators in robotics, classification and characteristics of sensors and actuators, role of sensors in perception and actuators in motion control, interfacing and integration in robotic systems, challenges in sensor-actuator integration for robotic arms and mobile robot.	04
Unit II	**Sensors for robot** Position and displacement sensors: Potentiometers, encoders, and resolvers, force and torque sensors for manipulator joints, tactile and proximity sensors for gripper feedback, vision sensors: 2D and 3D cameras for object recognition and manipulation, visual servoing methods, integration of multi-sensor data for robotic arm applications, case study: sensor configuration for a robotic pick-and-place system. Proprioceptive sensors: Gyroscopes, accelerometers, and IMUs, exteroceptive sensors: LIDAR, ultrasonic sensors, and RADAR, GPS and localization sensors for outdoor navigation, vision sensors for SLAM and path planning, sensor fusion techniques for autonomous navigation, case study: sensor configuration for obstacle avoidance in mobile robots.	10

Unit III	**Actuators for robots** Types of actuators: DC motors, stepper motors, and servo motors. hydraulic and pneumatic actuators for heavy payloads, motor controllers and drive systems, force and torque control in actuators, case study: actuator selection and control for a robotic arm in industrial applications. Overview of motor drives and their role in mobile robotics, types of motors used in mobile robots: DC motors, brushless DC motors, stepper motors, and servo motors, introduction to motor drivers: Functionality and importance in motor control, motor drivers for DC motors: H-bridge drivers and their integration with microcontrollers, stepper motor drivers: Micro-stepping, pulse generation, and current control techniques, selecting motor drivers based on robot specifications and operational requirements, case study: Implementation of motor drivers and robot controllers for a differential drive mobile robot.	10
Unit IV	**Integration and applications** Real-time integration of sensors and actuators. communication protocols: I2C, SPI, and Ethernet in robotic systems, troubleshooting of sensor-actuator systems, selection of sensor-actuator pair for robotic applications, advanced applications: Haptics in robotic arms and collaborative robots. case study: complete sensor-actuator integration for an autonomous robotic.	06

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Suggested Readings/References:

1. Robert H. Bishop, Mechatronics: An Introduction, CRC Press.
2. John J. Craig, Introduction to Robotics: Mechanics and Control, Pearson.
3. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley.
4. R Shrinivasan, Hydraulic and Pneumatic Controls, Vijay Nicole Imprints.
5. Roland Siegwart, Introduction to Autonomous Mobile Robots, MIT Press.

Suggested List of Experiments:

Sr. No.	Title	Hours
1.	To calibrate position sensors for robotic arms.	02
2.	To integrate force sensors in a gripper mechanism.	02
3.	To implement IMU-based orientation tracking.	02
4.	To configure LIDAR for mobile robot navigation.	02
5.	To control actuator for joint movements in a robotic arm.	02
6.	To demonstrate differential drive actuation for a mobile robot.	02
7.	To carry out sensor fusion for autonomous navigation.	02

8.	To demonstrate vision-based object recognition and manipulation using a robotic arm.	02
9.	To implement obstacle avoidance algorithms using ultrasonic sensors.	02
10.	To integrate a complete sensor-actuator system in a mobile robot.	02
11.	To implement DC motor speed control using encoder as feedback	02
12.	To implement robotic arm and mobile robot speed control	02

L = Lecture, T = Tutorial, P = Practical, C = Credit

w.e.f. the academic year 2025 - 26 and onwards