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(शिक्षा मंत्रालय, भारत सरकार के अधीन एक राष्ट्रीय महत्व का संस्थान / An Institute of National Importance under Ministry of Education, Gov. of India)
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# *CSXX0258* : Autonomous Navigation

**L-T-P-Cr: 3-0-0-3**

**Prerequisite:** Fundamentals of Machine Learning, Robotics and Sensors

**Course Objectives:**

- Understand the core concepts of autonomous navigation in robotic systems.
- Learn sensor integration, localization, path planning, and control for autonomous systems.
- Apply machine learning and AI techniques to perception and decision-making tasks in navigation.
- Analyze and simulate autonomous navigation pipelines in simulated environments.

**Course Outcomes:** At the end of the course, students will be able to:

**CO1:** Understand the architecture and components of autonomous systems.

**CO2**: Apply techniques for localization and mapping using sensor data.

**CO3**: Implement path planning and obstacle avoidance algorithms.

**CO4**: Integrate perception and control modules for autonomous decision making.

**CO5**: Design and simulate a basic autonomous navigation pipeline using AI techniques.

**CO-PO Mapping**

| PO/PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | | | | | 1 | | 3 | 3 | 2 | |
| CO2 | 3 | 3 | 2 | 2 | 3 | | | | | 1 | | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | | | | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 3 | | | | 2 | 2 | 2 | 3 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

**Syllabus**

**Unit I – Introduction to Autonomous Navigation** ***Lectures: 08***

Overview of Autonomous Systems and Applications, Components of Navigation Systems, Types of Navigation (Global, Local, Reactive, Deliberative), Basic Kinematics of Robots, Introduction to ROS (Robot Operating System)

**Unit II – Sensors and Perception** ***Lectures: 08***

Sensor Technologies: LiDAR, GPS, IMU, Cameras, Ultrasonics, Sensor Fusion Basics, Noise Models and Filtering (Kalman Filter, Particle Filter), Vision-based Perception: Object Detection, Depth Estimation, Data Preprocessing and Feature Extraction

**Unit III – Simultaneous Localization and Mapping** ***Lectures:08***

Localization Techniques (Dead Reckoning, Odometry, GPS-based), Mapping Techniques (Grid Maps, Topological Maps), SLAM Algorithms (EKF-SLAM, FastSLAM), Real-time SLAM using ROS, Introduction to Visual SLAM.

**Unit IV – Path Planning and Control** ***Lectures: 07***

Graph-based Planning, Sampling-based Planning, Motion Planning in Dynamic Environments, Trajectory Generation and Tracking, Control Strategies

**Unit V – Autonomous Navigation and AI** ***Lectures: 09***

AI for Decision Making: Rule-based vs Learning-based, Reinforcement Learning for Navigation (Q-learning, DDPG), Neural Network Architectures for Path Prediction, Imitation Learning and Behavior Cloning, Case Studies: Self-driving Cars, Drone Navigation

**Textbook/Reference Books:**


1. Probabilistic Robotics by Sebastian Thrun, Wolfram Burgard, Dieter Fox, MIT Press
2. Introduction to Autonomous Mobile Robots by Roland Siegwart, Illah R. Nourbakhsh, Davide Scaramuzza, MIT Press
3. Planning Algorithms by Steven M. LaValle, Cambridge University Press
4. Modern Robotics: Mechanics, Planning, and Control by Kevin M. Lynch, Frank C. Park, Cambridge University Press

Deep Learning for Autonomous Vehicles by Rajesh Singh, Anita Gehlot, Akshay Kumar, CRC Press (Taylor & Francis Group)