AUTONOMOUS MOBILE ROBOTS
23MTOE323

(COURSE HANDBOOK)

DEPARTMENT OF MECHATRONICS

COURSE FACULTY:

Dr. Suraj Bhat

1. GENERAL INFORMATION

Welcome to Autonomous Mobile Robots!

This course introduces the principles, models, and algorithms that enable robots to perceive their environment, move autonomously, and coordinate with other robots. Autonomous mobile robots form the backbone of modern applications such as warehouse automation, self-driving vehicles, service robots, and swarm robotics.

The course is structured into five progressive modules. It begins with an overview of mobile robot types and locomotion mechanisms, followed by sensing and perception systems. The middle modules focus on kinematic modeling and motion control, while the later modules address navigation, path planning, and multi-robot coordination. Emphasis is placed on conceptual understanding, algorithmic thinking, and practical relevance to real-world robotic systems.

Students are encouraged to actively engage with examples, numerical problems, and algorithmic discussions to build strong intuition for autonomous behavior in robots.

1.1. Course Learning Objectives

This course is designed to:

- Introduce the fundamentals of mobile robotics
- Familiarize sensor technologies and perception systems for autonomous mobile robots
- Develop knowledge of the kinematics of mobile robots
- Impart knowledge of navigation and path-planning techniques
- Introduce concepts of multi-robot systems and swarm robot control

1.2. Course Outcomes

- **CO1**: Understand the foundational concepts of mobile robotics
- **CO2**: Explain the working of various sensors for mobile robots
- **CO3**: Apply kinematic principles to model and analyze the motion of mobile robotic systems
- **CO4**: Implement navigation and path planning strategies.
- **CO5**: Understand principles of multi robot systems and swarming

1.3. Set Text and Suggested Sources

Key Text Books:

1. Roland Siegwart, Illah. R Nourbakhsh, and Davide Scaramuzza, “Introduction to autonomous mobile robots”, 2nd Ed., MIT press, 2011.
2. Eugene Kagan , Nir Shvalb, and Irad Ben-Gal, eds., “Autonomous mobile robots and multirobot systems: Motion-planning, communication, and swarming”, 1st Ed., John Wiley & Sons, 2019.

Reference Books:

1. George A. Bekey, “Autonomous Robots: From Biological Inspiration to Implementation and Control”, MIT Press, 2005.
2. G. Dudek and M. Jenkin, “Computational Principles of Mobile Robotics”, 3rd ed., Cambridge University Press, 2024.

2. THE COURSE

2.1. Course Description

Autonomous Mobile Robots			
Semester	**VI**	CIE Marks	**50**
Course Code	**23MTOE323**	SEE Marks	**50**
Teaching Hours/Week (L:T:P)	**4:0:0**	Exam Hrs	**03**
Total Hours	**42**	Credits	**03**

The Autonomous Mobile Robots course is designed to provide students with a strong foundational understanding of the principles, models, and algorithms that enable robots to perceive their environment, move autonomously, and interact intelligently with it. The course will run for 14 weeks during Semester VI and consists of 5 modules that cover essential topics including mobile robot locomotion, sensing and perception, kinematic modeling, navigation and path planning, and multi-robot systems with swarming behavior.

Each week includes 3 lectures, delivered as part of a structured lecture-based format, focusing on theoretical foundations, mathematical modeling, algorithmic approaches, and real-world robotic applications. The course emphasizes conceptual clarity and analytical thinking required to design and evaluate autonomous mobile robotic systems used in domains such as warehouse automation, service robotics, autonomous vehicles, and swarm robotics.

Spanning a total of 42 contact hours, this 3-credit course is assessed through Continuous Internal Evaluation (CIE) for 50 marks and a Semester-End Examination (SEE) for 50 marks, conducted in the form of a 3-hour written examination.

2.2. Initiating Contact with Staff and Other Students

Students are encouraged to maintain professional and proactive communication with course instructors. Academic queries should be raised during lectures, office hours, or via official email. Peer discussions and collaborative learning are strongly encouraged to deepen conceptual understanding.

2.3. Resources

In addition to textbooks, students are encouraged to use:

- Digital libraries and e-learning platforms
- Open-source robotics resources
- Simulation tools and algorithm visualizations

These resources support self-paced learning and deeper exploration of autonomous robotics concepts.

E-learning and digital library can be accessed via the college website https://mite.ac.in/ (Campus Life section > Library > VTU Consortium/e-learning platforms/additional sources).

2.4. Staff

Course Convenor: Dr. Suraj Bhat
Cabin: 2nd floor, Mech Block
Email: surajbhat@mite.ac.in

2.5. Topics and Reading materials for each module

Module 1 *No. of Hours: 08*

- **Topic: Introduction to Mobile Robots**
  - Introduction to mobile and autonomous robots
  - Locomotion mechanisms and design considerations
  - Types of mobile robots: legged, wheeled, and aerial robots
  - Stability, maneuverability, and wheel configurations

- **Essential Readings:**
  - Roland Siegwart, Illah. R Nourbakhsh, and Davide Scaramuzza, "Introduction to autonomous mobile robots", 2nd Ed., MIT press, 2011. (Chapters 1 and 2)

Module 2 *No. of Hours: 08*

- **Topic: Sensors and Perception**
  - Basics of perception and sensor systems
  - Classification and characteristics of sensors
  - Odometry sensors, inertial sensors, GPS
  - Range and vision-based sensors
  - Error propagation in sensing

- **Essential Reading:**
  - Roland Siegwart, Illah. R Nourbakhsh, and Davide Scaramuzza, "Introduction to autonomous mobile robots", 2nd Ed., MIT press, 2011. (Chapters 3 and 4)

Module 3 *No. of Hours: 09*

- **Topic: Kinematics of Mobile Robots**
  - Kinematic models and constraints
  - Robot position and orientation representation
  - Forward kinematics and trajectory tracking
  - Maneuverability, degree of mobility, and steerability
  - Kinematic motion control: open-loop and feedback control

- **Essential Reading:**
  - Roland Siegwart, Illah. R Nourbakhsh, and Davide Scaramuzza, "Introduction to autonomous mobile robots", 2nd Ed., MIT press, 2011. (Chapters 5 and 6)

Module 4 *No. of Hours: 09*

- **Topic: Navigation and Path Planning**
  - Fundamentals of robot navigation
  - Graph-based path planning methods
  - BFS, DFS, Dijkstra, A*, D* algorithms
  - Obstacle avoidance and Bug algorithms
  - Offline planning strategies
- **Essential Reading:**
  - Roland Siegwart, Illah. R Nourbakhsh, and Davide Scaramuzza, "Introduction to autonomous mobile robots", 2nd Ed., MIT press, 2011. (Chapters 7 and 8)

Module 5 *No. of Hours: 08*

- **Topic: Multi-Robot Systems and Swarming**
  - Principles of multi-agent systems
  - Swarming and flocking behavior
  - Aggregation and collision avoidance
  - Communication and coordination in robot swarms
  - Agent-based and probabilistic models

- **Essential Reading:**
  - Eugene Kagan , Nir Shvalb, and Irad Ben-Gal, eds., "Autonomous mobile robots and multirobot systems: Motion-planning, communication, and swarming", 1st Ed., John Wiley & Sons, 2019.

3. ASSESSMENT

The assessment for this course is divided into two components: Continuous Internal Evaluation (CIE) and Semester End Examination (SEE), each accounting for 50% of the total marks.

Continuous Internal Evaluation (CIE) comprises two internal tests, scheduled for 8th and 14th week, which together contribute 30% of the total marks. Additionally, students can earn 20% through the completion of two activity-based assignments (10 marks ach).

Semester End Examination (SEE) constitutes the remaining 50% of the total marks. Key information regarding examination dates and related details can be accessed via the college website.

Rubrics for Other Assessment (Total: 20 Marks / 40% of CIE)

Activity – Based Assignments (10 + 10 Marks)				
Criteria	**10-9 Marks (Excellent)**	**8-7 Marks (Good)**	**6-5 Marks (Fair)**	**4-1 Marks (Poor)**
Completion	Completed all the assignment activity neatly.	Completed most activities.	Completed some activity.	Incomplete or missed activities.
Timeliness	Completed on time.	Completed slightly late.	Completed much later than due.	Missed the deadline.