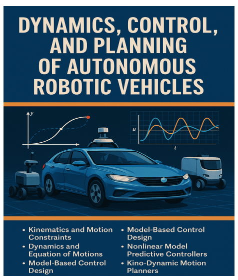
NYU
TANDON SCHOOL OF ENGINEERING

ME-GY 7863 or ROB-GY 7863

Autonomous Mobile Robots & Vehicles

Introduction to Dynamics, Control and Planning

Fall-2025. Tuesday 11:00AM-01:00PM



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Office Location: TBD
Office Hours: TBD
Class Location: Join Online Class Room Here

A statement about the changeable nature of this syllabus.

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Text Books: There is no formal textbook for this course. The Canvas site will refer to a number of books, online texts, and research papers relevant to the material for each week. At least once during the course of the semester, each student must choose one research article and post or present a brief summary on the class discussion forums. A separate thread on research reading will track which students have 'claimed' which readings, to avoid any overlap.

Simulations and Homework: This course will regularly use MATLAB, Python, ROS, Gazebo for both in-class examples and homework. With prior approval from the instructor, students may choose to prepare their assignments using an alternative programming language of their choice.

Course Description: This course offers a rigorous introduction to the dynamics, control, and motion planning of mobile robotic systems and autonomous vehicles—key pillars driving the next wave of industrial and technological transformation. It is designed to equip students with foundational knowledge in analyzing and controlling the motion of mobile platforms, including both holonomic and nonholonomic systems, such as wheeled robots and autonomous vehicles. Throughout the course, students will study the physical principles that govern the motion of particles and rigid bodies, along with the roles of actuators and control architectures. The curriculum emphasizes a modern approach to mobile autonomy, extending beyond traditional control and robotics courses to include topics like underactuated and overactuated systems, nonlinear control design, feedback linearization, Lyapunov-based methods, and Model Predictive Control (MPC).Advanced topics such as control barrier functions, kinodynamic planning such RRT and RRT*, uncertainty modeling, system identification, and learning-based control strategies—including reinforcement learning—will be explored. Real-world industrial case studies and emerging applications will be used to contextualize the theory, helping students develop skills for designing safe, reliable, and intelligent autonomous robotic vehicles in dynamic nvironments.

<u>Note that the lectures may not be covered in the reference books.</u>
<u>Lecture notes are strongly recommended in class.</u>

Prerequisites: Functional skills in MATLAB, Python, or another programming language and basic knowledge of the following subjects:

- Controls or Robotics (e.g. MAE xxxx, or equivalent)
- Linear Algebra (MATH xxx or equivalent)
- Dynamics (MAE xxx or equivalent)

Course objectives: At the end of this course, students will be able to deal with autonomous mobile robotic problems such as:

1. Kinematics and Motion Constraints (Holonomic vs Nonholonomic)
2. Dynamics and Equation of Motions (Newton and Lagrange Methods)
3. Control Design for Trajectory Following (Feedback Liberalizations)
4. Nonlinear Model Predictive Controllers
5. Kino-Dynamic Motion Planners
6. Learning Based Control Design and Planning with Uncertainty Effects

Grade Distribution:

- Homework: 30%
- Midterm: 30%
- Final Project: 35%
- Participation: 5%

Course Policies:

- **General**
  - Quizzes and exams are closed-book, closed notes.
  - **No makeup quizzes or exams will be given.**
- **Grades**
  - **C** range represent performance that **meets expectations**;
    B range represent performance that is **substantially better** than the expectations;
    A range represent work that is **excellent**.
- **Attendance and Absences**
  - Attendance is expected and will be taken each class. You are allowed to miss **1** class during the semester without penalty. Any further absences will result in point and/or grade deductions.
  - Students are responsible for all missed work, regardless of the reason for absence. It is also the absentee's responsibility to get all missing notes or materials.

Academic Honesty Policy Summary:

Introduction

In addition to skills and knowledge, NYU aims to teach students appropriate ethical and professional standards of conduct, especially using AI and rapid advances in large language models. All student work is subject to the Academic Honesty Policy and transparent use of AI.

Unauthorized/Excessive Assistance

The student may not give or receive any unauthorized or excessive assistance in the preparation of any work.

Declaration Online submission of, or placing one's name on an exam, assignment, or any course document, is a statement of academic honor that the student has not received or given inappropriate assistance in completing it and that the student has complied with the Academic Honesty Policy in that work.

Consequences

An instructor may impose a sanction on the student that varies depending upon the instructor's evaluation of the nature and gravity of the offense. Possible sanctions include but are not limited to, the following: (1) Require the student to redo the assignment; (2) Require the student to complete another assignment; (3) Assign a grade of zero to the assignment; (4) Assign a final grade of "F" for the course. A student may appeal these decisions according to the Academic Grievance Procedure. (See the relevant section in the Student Handbook.) Multiple violations of this policy will result in a referral to the Conduct Review Board for possible additional sanctions.

The full text of the Academic Honesty Policy is available in *Student Handbook*.

Course Outline (Tentative)

Week of	Topics
1	Introduction to Mobility and Locomotion
2	Kinematics - Nonholonomic vs Holonomic Constraints
3	Understanding Dynamics and Equation of Motions
4	Underactuated and Overactuated Mobility Platforms
5	Control Architecture for Mobile Robots
6	Taking Perception and Localizations into Account
7	Model Linearization and LQR
8	Nonlinear Feedback Linearizaiton
9	Lyapunov Stability and Regions of Attraction
10	Nonlinear Model Predictive Controllers
11	Safety Constraints and Control Barrier Functions
12	Kino-Dynamic Motion Planners and Optimal Planning
13	Uncertainties and Probabilistic Models
14	System Identifications and Reinforcement Learning
15	Addressing Safety and Compliance with Standards
16	Project presentations

Tentative Course Outline: The weekly coverage might change as it depends on the progress of the class. However, you must keep up with the reading assignments.

Week	**Content**
Week 1	• Introduction to Mobility and Locomotion • Review of Basic Physical Laws and Equilibrium • Kinematics of a Particle and Rigid Body • Holonomic vs Nonholonomic Constraints
Week 2	• Dynamics and Equations of Motion • Newton's Laws, Tangential and Normal Components • Underactuated and Overactuated Mobility Systems
Week 3	• Control Architectures for Mobile Robots • Kinetics: Work, Energy, and Conservation Laws • Modeling of Actuators and Motion Constraints
Week 4	• Perception and Localization in Control Loops • Linearization Techniques • Introduction to LQR and State-Feedback Control
Week 5	• Nonlinear Control and Feedback Linearization • Lyapunov Stability and Regions of Attraction • Simulation Examples in MATLAB or Python
Week 6	• Nonlinear Model Predictive Control (NMPC) • Control Barrier Functions and Safety Constraints • Discussion of Real-World Implementation Challenges
Week 7	• Kino-Dynamic Motion Planning and Optimal Control • Probabilistic Models and Dealing with Uncertainty • ROS/Gazebo or Python-based Planning Tools
Week 8	• System Identification and Learning-Based Control • Reinforcement Learning for Mobile Robots • Project Presentations and Case Studies

Table 1: Tentative 8-Week Course Outline: Dynamics, Control, and Planning of Autonomous Robotic Vehicles