Introduction to Robotics

ECE 383/ME 442/ME 555
Fall 2024

Class: T/Th 10:05–11:20 am
Lab: Th 3:05–5:35 pm

Instructor information

Dr. Siobhan Oca (she/her), Email: xxxx

Teaching assistants:

Lab Staff Engineers:
Evan Kusa

What is this course about?

Applied robotics draws from many different fields and allows automation of products as diverse as cars, vacuum cleaners, and factories. This course is a challenging introduction to basic concepts used broadly in robotics; it is valuable for students who wish to work in the area. Topics include simulation, kinematics, control, sensing, and system integration. The mathematical basis of each area is emphasized, and concepts are motivated using common robotics applications and programming exercises. You will participate in two projects over the course of the semester, in which you will implement algorithms that apply each of the topics discussed in class to real robotics problems.

What background knowledge do I need before taking this course?

Prerequisite	Math 216 Linear Algebra & Differential Equations
Corequisite	ME 344L/ECE 382L Control of Dynamic Systems

What will I learn in this course?

By the end of this course, you will be able to:

- Describe kinematics, kinetics, sensing, motion planning, and control of robotic manipulators;
- Model manipulators and analyze their performance by running simulations with Robot Operating System (ROS);
- Understand and utilize ROS to perform basic tasks with a robot arm manipulator;
- Describe key aspects of robot system development for a given application and understand the limits of this system.

What required texts, materials, and technologies will I need?

Textbooks There is **no required textbook** for this class. Still, you may find the following textbooks useful:

- Herath, D., St-Onge, D. (2022). Foundations of Robotics: A Multidisciplinary Approach with Python and ROS. Springer Nature Singapore. Full Textbook link.
- Kevin M. Lynch and Frank C. Park, *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press, 2017. Preprint link.
- Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*, Wiley, 2020, 2nd ed. 1st ed. link.
- John J. Craig, *Introduction to Robotics: Mechanics and Control*, Addison-Wesley Publishing, 1989.
- Alonzo Kelly, *Mobile Robotics: Mathematics, Models, and Methods*, Cambridge University Press, 2013.

Technology You will need access to a **computer**, from which you will remotely access a VM for this course. You will need a **scientific calculator** for quizzes (contact an instructor if this is a financial issue for you.)

How will my grade be determined?

Homework/Lab	20%
Quizzes (4)	35%
Midterm project	15%
Final project	30%

Homework/Lab Weekly homework will be assigned to help you learn the course material by practicing the skills introduced in class. Homework will be a combination of technical (math-based concept application), conceptual (vocabulary, description, and analysis), and computational problems (using ROS to simulate robotic systems) based on labs performed each week.

You are welcome to work with classmates and use LLMs, but 1) credit anyone/any program who/that helped you with a footnote, and 2) be mindful of whether you are developing each skill. You will turn in your homework assignments through Gradescope. Code, graphs, or other files should be included in the same file as the rest of your homework. Export all files to PDF, and append them together to create a single file. Assignments submitted late, within two days of the deadline, will receive a maximum of 80%. Assignments submitted over two days late or through any other means will not earn the privilege of TA feedback and will receive 0%. The lowest assignment grade will be dropped.

Quizzes There will be four quizzes to assess your knowledge of topics and applications presented in class. Three will be in-class (bring your scientific calculator) for 45 minutes. There will be one take-home quiz, so you will be able to use a computer then, but no LLMs or other people resources.

Projects There will be a midterm and final project to show mastery of concepts through application in the (open source) industry standard platform—Robot Operating System (ROS). The midterm project will be using a robot arm file, provided by the

instructor, in simulation to perform moving the end effector to trace your initials.

The final project will be a group project, for which you will propose a robot system and task (to be approved by the instructor) and show the physical robot in simulation. You will present your project in a portfolio, as well as a final presentation.

ME 555 / Graduate Students If you are taking the course as a graduate student (ME 555 version), the course will be different in three ways. Graduate students will complete 2 of the challenge HWs. For the final project, Graduate students will:

1. Implement their robot task on a physical system, and
2. Report testing an aspect of their project in a research paper format (in addition to the portfolio).

Grading scheme The instructors reserve the right to adjust class grades higher as they deem appropriate. Your final letter grade will correspond to your weighted average according to the usual scheme (upper bounds are exclusive).

	$X-$	X	$X+$
A	90–93	93–97	$\geq$97
B	80–83	83–87	87–90
C	70–73	73–77	77–80
D*	60–63	63–67	67–70
F		< 60	

*Note, graduate courses do not have a D grade, so an average below 70 is an F.

What are the course policies?

Academic integrity It is the expectation that students, TAs, and instructors will regard each other with mutual respect.

Students will abide by the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Part of what this means is that you credit others on assignments where collaboration is permitted (homework) and complete individual assignments (quizzes) individually and not share your work with anyone else. The exact policy for projects will be included in the assignment description.

Absences and late work Absence due to illness will need to be reported within the same day of missed lecture or assignment deadline by submitting a Short Term Illness Notification Form (STINF). **Do not come to class if you are ill.** Varsity athletes must comply with all regulations given by Trinity College. In addition to these formalities, students need to communicate with the instructor in-person or by email. Absence to

observe a religious holiday should be communicated at the start of the semester.

Extenuating circumstances (such as family emergencies) that will prevent a student from attending class or reaching assignment deadlines should be discussed with the instructor as soon as possible and will be accommodated on a case-by-case basis.

Communication We will post information and updates on the course Sakai site with email notifications for important communications. Please use Ed Discussion (via Sakai) for course-related questions. Making the post public is best (others are likely to have the same question, and you can remain anonymous to other students if you prefer), but there is also an option to post privately to the instructors and TAs. Please reserve email for more general issues, such as accommodation or recommendation letter requests or illness notification. We will endeavor to respond the same work day (next work day on weekends).

Accommodations The Student Disability Access Office (SDAO) is available to ensure that students are able to engage with their courses and related assignments. Students should contact the SDAO to request or update accommodations under these circumstances. We will work with that office to provide you with equal access to course materials and make accommodations for quizzes and other assessments. Please give us as much notice as possible of the requested accommodation.

Support Please reach out to an instructor if you need help of any kind. We can point you to resources for mental health, academic support, and financial assistance.