

ECE 1675 (4 Credits) / ECE 2570 (3 Credits): Robotic Control (Spring 2022)

Description: This course focuses on the application of control theory in robotics. Topics to be covered include: review of classical and modern control design methods such as PID control, state feedback, optimal control, adaptive control, and hybrid system control; control of mobile robots; control of robot manipulators; reinforcement learning; cognitive robotics.

Prerequisite: Knowledge of signals and systems.

Times and Places:

Lectures: Wednesday 6 pm–8:30 pm. Classes will begin remotely via Zoom (<https://pitt.zoom.us/j/6288281300>) on Wednesday January 12, 2022. Classes will take place in 1211A&B Benedum Hall fully in person beginning on Wednesday February 2, 2022.

Labs (ECE 1675 students only): Friday 3 pm–5:30 pm, remotely via Zoom (<https://pitt.zoom.us/j/7817111574>, passcode: 210324) throughout the whole semester.

Instructors:

Zhi-Hong Mao
Professor
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(Zoom link) <https://pitt.zoom.us/j/6288281300>

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Teaching Fellow
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(Zoom link) <https://pitt.zoom.us/j/7817111574>, passcode: 210324

Textbooks (Recommended):

[M07] M. Mataric, The Robotics Primer, The MIT Press, 2007.

[AM10] K. J. Astrom and R. M. Murray, Feedback Systems: An Introduction for Scientists and Engineers, Princeton University Press, 2010.

Course Evaluation:

Undergraduate ECE 1675 (4 Credits): Homework 15%, class participation 10%, midterm exam 25%, final exam 35%, and lab 15%.

Graduate ECE 2570 (3 Credits): Homework 25%, class participation 10%, midterm exam 25%, and final exam 40%.

Tentative Schedule for Lectures:

Dates	Topics	Suggested Readings
Module I: Robotics and controls primer		
Jan 12	Lecture 1: Course organization; introduction to robotic control	Chapters 1 and 2 of book [M07]; Chapter 1 of book [AM10]
Jan 19	Lecture 2: Robot components; mathematical representations of dynamical systems	Chapters 3-4, 7-9 of [M07]; Chapters 2 and 8 of [AM10]; Lecture 2 of ECE 1673; Lecture 3 of ECE 2646
Jan 26 and Feb 2	Lectures 3 and 4: Robot control architectures; time responses of dynamical systems; PID control	Chapters 10-18 of [M07]; Chapters 3 and 10 of [AM10]; supplemental material on PID tuning
Module II: Control of mobile robots		
Feb 9	Lecture 5: Locomotion; mobile robot control architecture	Chapter 5 of [M07]
Feb 16	Lecture 6: LTI systems; stability; output feedback and state feedback; pole placement	Chapters 4-6 of [AM10]; Lecture 4 of ECE 2646
Feb 23	Lecture 7: Controllability; observability; separation principle; optimal control	Chapter 7 of [AM 10]
Mar 2	<u>Midterm exam</u>	
Mar 9	No class (spring break)	
Mar 16 and 23	Lectures 8 and 9: Hybrid systems; sliding mode control	Supplemental material on hybrid systems
Mar 30	Lecture 10: Navigation	Chapter 19 of [M07]; supplemental material on sliding mode control
Module III: Control of robot manipulators		
Apr 6 and 13	Lectures 11 and 12: Manipulator kinematics and dynamics; PD control	Chapter 6 of [M07]; Supplemental material on linear control of manipulators
Apr 20	Lecture 13: Nonlinear control of manipulators	Supplemental material on nonlinear control of manipulators
Module IV: Advanced topics		

Lecture 14: Adaptive control; reinforcement learning; cognitive robotics

Apr 27 Final exam

Course Policies:

Academic Integrity

Students in this course will be expected to comply with the University of Pittsburgh's Policy on Academic Integrity and the Swanson School of Engineering Policy. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity and the Swanson School procedures. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy.

All students are expected to adhere to the standards of professional conduct and academic honesty. Any student engaged in cheating, plagiarism, or other acts of academic dishonesty would be subject to disciplinary action. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the SSOE Academic Integrity Policy found at: <https://www.engineering.pitt.edu/Academic-Integrity-Guidelines/>.

To learn more about Academic Integrity, visit the Academic Integrity Guide for an overview of the topic. For hands-on practice, complete the Understanding and Avoiding Plagiarism tutorial.

Disability Services

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Statement on Classroom Recording

To ensure the free and open discussion of ideas, students may not record classroom lectures, discussion and/or activities without the advance written permission of the instructor, and any such recording properly approved in advance can be used solely for the student's own private use.

Student Opinion of Teaching Surveys

Students in this class will be asked to complete a *Student Opinion of Teaching Survey*. Surveys will be sent via Pitt email and appear on your Canvas landing page during the last three weeks of class meeting days. Your responses are anonymous. Please take time to thoughtfully respond, your feedback is important to me. Read more about *Student Opinion of Teaching Surveys*.

Religious Observance

The observance of religious holidays (activities observed by a religious group of which a student is a member) and cultural practices are an important reflection of diversity. As your instructor, I am committed to providing equivalent educational opportunities to students of all belief systems. At the beginning of the semester, you should review the course requirements to identify foreseeable conflicts with assignments, exams, or other required attendance. If at all possible, please contact me within the first two weeks of the semester to allow time for us to discuss and make fair and reasonable adjustments to the schedule and/or tasks.

Diversity and Inclusion

The University of Pittsburgh does not tolerate any form of discrimination, harassment, or retaliation based on disability, race, color, religion, national origin, ancestry, genetic information, marital status, familial status, sex, age, sexual orientation, veteran status or gender identity or other factors as stated in the University's Title IX policy. The University is committed to taking prompt action to end a hostile environment that interferes with the University's mission. For more information about policies, procedures, and practices: <https://www.diversity.pitt.edu/civil-rights-title-ix/policies-procedures-and-practices>. I ask that everyone in the class strive to help ensure that other members of this class can learn in a supportive and respectful environment. If there are instances of the aforementioned issues, please contact the Title IX Coordinator, by calling 412-648-7860, or emailing titleixcoordinator@pitt.edu.

Reports can also be filed online: <https://www.diversity.pitt.edu/civil-rights-title-ix/make-report>

You may also choose to report this to a faculty/staff member; they are required to communicate this to the University's Office of Diversity and Inclusion. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

COVID-19 Statement

In the midst of this pandemic, it is extremely important that you abide by public health regulations and University of Pittsburgh health standards and guidelines. While in class, at a minimum this means that you must wear a face covering and comply with physical distancing requirements; other requirements may be added by the University during the semester. These rules have been developed to protect the health and safety of all community members. Failure to comply with these requirements will result in you not being permitted to attend class in person and could result in a Student Conduct violation. For the most up-to-date information and guidance, please visit coronavirus.pitt.edu and check your Pitt email for updates before each class.

Communication to Instructor Pertaining to Illness

As in any situation regarding class absence (remote or in person), a student who becomes ill (albeit COVID-19 related or not) is responsible for communicating with me regarding course absences. Please contact me and provide documentation when absences affect quizzes/exams. This should be done via email as soon as possible.