ECE 760 Advanced Topics in Control Systems

Winter 2026 - January 05 to April 15

Class time: Monday 14:00-16:50 Location: ECERF W6-087

Instructor:

Mahdi Tavakoli, PhD, P.Eng
(780)492-8935
mtavakol@ualberta.ca
Donadeo Innovation Centre For Engineering 13-356
Office Hours: Please email me for appointments.

Course Description:

*3 (fi) (either term, 3-0-0",)

Prerequisites: Linear algebra (a good understanding),
Linear control (a good understanding),
Nonlinear control (a preliminary understanding),
Introductory robotics (a preliminary understanding).

Course synchronous and asynchronous content delivery schedule:

The course will be delivered in person.

TA Information:

Yeganeh Aliyari Shooredeli (aliyaris@ualberta.ca)

Course Objectives & General Content:

Course title: Robotics: Modelling, Planning and Control.

The course discusses advanced modelling, planning and control methods for robots. Robot control cannot be considered as a straightforward extension/application of general control methods due to the particular dynamics of robotic systems and specialized training is required for students.

Topics covered include motion, force, and impedance control of manipulators. New robotic problems such as mobile robots and continuum robots have precipitated new control theories. The course will start with kinematic and dynamic modelling of robots and then continue to cover some of the advanced control techniques developed for robots in a systematic manner. Topics to be covered include joint-space control including passivity-based, robust and adaptive control methods, task-space control including kinematic control, motion and force control including impedance control, and control of non-holonomic systems.

Learning Outcomes:

By the end of this course, students should be able to:

1. Robot kinematics
2. Redundant robots kinematics
3. Robot dynamics
4. Properties, extensions, and uses of dynamic models
5. Introduction to robot control
6. Position regulation in joint space (free motion)
7. Trajectory tracking in joint space (free motion)
8. Cartesian control (free motion)
9. Interaction modeling and control
10. Trajectory learning
11. Visual servoing (kinematic approach)

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Presentation of learning materials	Synchronous	Varies	15%
Written problem-solving (5 assignments)	Synchronous	Varies	25%
Project outcomes and presentation	Synchronous	Feb 9, 2026; Mar 23, 2026; final report/video due Apr 10, 2026	30%
Midterm 1	Synchronous	Feb 23, 2026	15%
Midterm 2	Synchronous	Mar 30, 2026	15%

Instructors have the leeway to deviate from this average and can assign grades based on their own scheme. All grades are approved by the department chair (or delegate). The office of the Dean has final oversight on all grades.

Term Work

All term work solutions will be posted no later than the last day of classes. All term work will be returned to students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work, shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

Additional Notes

1) Each student will be assigned some material to read and present to the rest of the class. All class activities will be moderated by the instructor.

2) Problem sets will be given to students to solve.

3) Students will have a term project to do. As part of the term project, the modelling, planning and control methods under investigation need to be applied to case studies.

Calculator Policy

Approved programmable or approved non-programmable calculators are permitted in examinations. Any calculator taken into an examination must have a sticker identifying it as an acceptable programmable calculator (green sticker) or non-programmable calculator (gold sticker). Students can purchase calculators at the University Bookstore with the stickers already affixed. Calculators purchased elsewhere can be brought to the Student Services where the appropriate sticker will be affixed to the calculator.

Expectations for AI use

In this course, we commit to AI use guided by ethical and transparent principles. While students are allowed to use advanced automated tools (such as ChatGPT or Dall-E 2) for certain written assignments, it is crucial to adhere to the following guidelines:
Seek prior approval from the instructor for AI use in specific assignments.
When allowed, clearly attribute and cite any AI-generated content in your work, including prompts and AI outputs as part of your academic record. Include an additional reflection component in your assessments, discussing how AI tools contributed to your learning process.
IMPORTANT: Please note that AI use is strictly prohibited in assessments and assignments not approved by the instructor. Failure to abide by this guideline may be considered an act of cheating and a violation as outlined in the relevant sections of University of Alberta (November 2022) Code of Student Behaviour .

Text and References (Mandatory):

Textbook #1: H. J. Marquez, Nonlinear Control Systems: Analysis and Design, Wiley, 2003.

Textbook #2: J. J. Craig, Introduction to Robotics: Mechanics and Control, Pearson, 4th edition, 2018.

Textbook #3: B. Siciliano, L. Sciavicco, G. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer, 3rd Edition, 2009.

Text and References (Recommended):

As supplementary reading material, students may choose to self-study Chapters 2-6 of Theory of Robot Control by Canudas de Wit, Carlos, Siciliano, Bruno, Bastin, Georges (Eds.), Chapter 7 (Nonholonomic Behavior in Robotic Systems) and Chapter 8 (Nonholonomic Motion Planning) of A Mathematical Introduction to Robotic Manipulation by Richard M. Murray, Zexiang Li and S. Shankar Sastry.

Website:

Canvas

Did you know that the University of Alberta has various low-to-no-cost services to help students succeed? Visit http://www.deanofstudents.ualberta.ca/ for information about the academic, wellness, and various other support services available to U of A students. It's never too early or too late to seek help!

	Textbook (Ch.Sect.Par)	Lecture
	Textbook #1	
Nonlinear control fundamentals	3	Lyapunov Stability: Autonomous Systems
	4	Lyapunov Stability: Nonautonomous Systems
	Textbook #2	
Robot kinematics fundamentals	1	Robotics overview
	2	Spatial descriptions & transformations
	3	Forward kinematics
	4	Inverse kinematics
	5	Jacobians
	Textbook #3	
Redundant robots	2.10.2, 3.4, 3.5, App. A.7, App. A.8	Kinematic redundancy
Euler-Lagrange dynamic model	7.1, 7.3, App. B	Lagrangian dynamics
Properties, extensions, and uses of dynamic models	7.2, 7.4, 7.6, 7.7, 7.8	Linear parametrization
Introduction to robot control	8.1, App. C.2, App. C.3	Introduction to robot control
Position regulation in joint space (free motion)	8.2, 8.3 (parts), 8.5 (intro), 8.5.1	Regulation
		Iterative learning
Trajectory tracking in joint space (free motion)	8.5.2, 8.5.3, 8.5.4, 8.7	Trajectory tracking control
		Adaptive trajectory control
Cartesian control (free motion)	8.6	Cartesian control
Interaction modeling and control	All Chap. 9 except: 9.4.3, 9.5.2, 9.7.1	Environment interaction control
		Impedance control
		Hybrid control
Machine learning for robotics	Research papers will be provided	Trajectory learning using DMP
		Introduction to ProMP, state-based learning and reinforcement learning
Visual servoing (kinematic approach)	10.1, 10.2 (parts), 10.3.2, 10.3.3, 10.5 (parts), 10.6, 10.7.2, 10.8.2, 10.9	Visual servoing
Textbook #1: H. J. Marquez, Nonlinear Control Systems: Analysis and Design, Wiley, 2003.		
Textbook #2: J. J. Craig, Introduction to Robotics: Mechanics and Control, Pearson, 4th edition, 2018.		
Textbook #3: B. Siciliano, L. Sciavicco, G. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer, 3rd Edition, 2009.		

University and faculty policies

Respect and professionalism

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards.

The faculty prepares students to uphold industry standards to become a Professional Engineer (P.Eng). Therefore, respect, professionalism, and accountability must be upheld within the Faculty of Engineering and the University of Alberta.

Academic integrity and student conduct

The University of Alberta is committed to the highest standards of academic integrity and honesty, as well as maintaining a learning environment that fosters the safety, security, and the inherent dignity of each member of the community, ensuring students conduct themselves accordingly. Students are expected to be familiar with the standards of academic honesty and appropriate student conduct, and to uphold the policies of the University in this respect.

Students are particularly urged to familiarize themselves with the provisions of the Student Academic Integrity Policy and the Student Conduct Policy, and avoid any behaviour that could

potentially result in suspicions of academic misconduct (e.g., cheating, plagiarism, misrepresentation of facts, participation in an offence) and non-academic misconduct (e.g., discrimination, harassment, physical assault). Academic and non-academic misconduct are taken very seriously and can result in suspension or expulsion from the University.

All students are expected to consult the Academic Integrity website for clarification on the various academic offences. All forms of academic dishonesty are unacceptable at the University. Unfamiliarity of the rules, procrastination or personal pressures are not acceptable excuses for committing an offence. Listen to your instructor, be a good person, ask for help when you need it, and do your own work -- this will lead you toward a path to success. Any academic integrity concern in this course will be reported to the College of Natural and Applied Sciences. Suspected cases of non-academic misconduct will be reported to the Dean of Students. The College, the Faculty, and the Dean of Students are committed to student rights and responsibilities, and adhere to due process and administrative fairness, as outlined in the Student Academic Integrity Policy and the Student Conduct Policy. Please refer to the policy websites for details on inappropriate behaviours and possible sanctions.

The College of Natural and Applied Sciences (CNAS) has created an Academic Integrity for CNAS Students eClass site. Students can self-enroll and review the various resources provided, including the importance of academic integrity, examples of academic misconduct & possible sanctions, and the academic misconduct & appeal process. Students can also complete assessments to test their knowledge and earn a completion certificate.

"Integrity is doing the right thing, even when no one is watching." -- C.S. Lewis

The Faculty of Engineering expects an environment free of harassment, discrimination, and bullying. We encourage you to talk to the Office of Safe Disclosure and Human Rights about experiences, questions, or concerns. Additional resources and support for students are attached below.

Engineering students studying in the province of Alberta must also follow the Code of Ethics set by the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Course outline policies, course requirements, evaluation and grading information can be found in the University Calendar.

Safety during learning activities

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control.

Anyone found to be unable to function safely in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Academic Integrity Policy and Student Conduct Policy. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of unsafe work.

Audio and video recording

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan.

Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. Students must not bring any unauthorized electronic device into an examination room, including cell phones or other devices.

Student services and support

Health & Wellness Support

Counselling and Clinical Services

Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation. Visit uab.ca/CCS to learn more.

Wellness Supports Social Workers

Free one-on-one support for students in the areas of housing, finances, academics, personal wellness, life skill development, family dynamics, system navigation, and any area of life where there is a desire to invite change. Visit uab.ca/wellness to learn more.

Sexual Assault Centre

Free, anonymous, and confidential drop-in counselling. Visit uab.ca/UASAC to learn more.

The Office of Safe Disclosure & Human Rights (OSDHR)

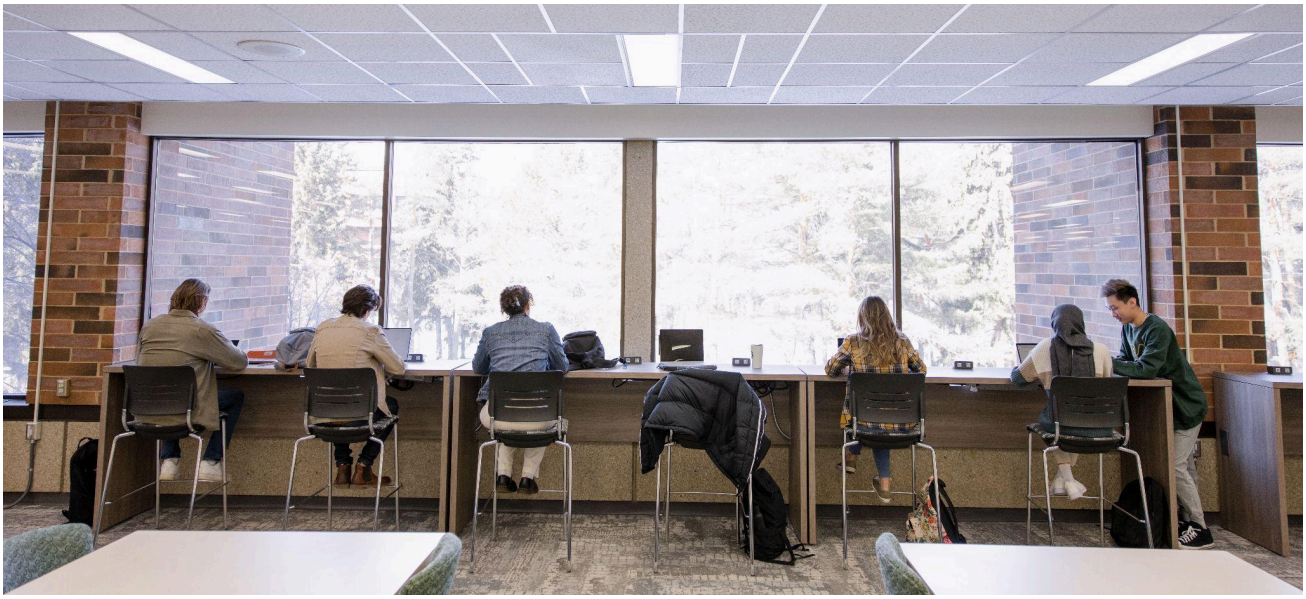
The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy. Visit uab.ca/OSDHR to learn more.

HIAR (Helping Individuals at Risk)

If you're worried about someone, contact HIAR, who can help assess risk and connect individuals to support. Learn more at uab.ca/HIAR.

Immediate External Supports

Health Link Alberta: 811
Suicide Crisis Helpline: 988



Academic support

Academic Success Centre
Access to a variety of services to maximize your academic success. Learn more at uab.ca/ASC.

Accessibility Resources
Connects students with disabilities to accommodations. Learn more at uab.ca/Access under accommodations + accessibility.

Decima Robinson Support Centre
Academic support for 100- or 200-level introductory calculus, linear algebra and statistics courses. Visit uab.ca/DSC to learn more.

Engineering Student Success Centre
The Faculty of Engineering provides drop-in tutoring for first-year courses. Visit uab.ca/ESSC to learn more.

Office of the Student Ombuds
Call for complex problems and conflict mediation. Learn more at uab.ca/ombuds.

Financial support

Student Service Centre

For awards and other funding support. Learn more at uab.ca/ask.

Campus Food Bank

The Campus Food Bank Society is an independent charity supporting University of Alberta students, faculty, staff, and alumni for up to five years. For additional information visit their website at campusfoodbank.com.