# MECE 6397: Learning Based Control
# Spring 2025

| Class Sections | Days and Times | Classroom | Instructional Mode |
|----------------|----------------|-----------|--------------------|
| MECE 6397-08 (22044) | MoWe 2:30pm-4:00pm | TU2 215 | Face-to-face |
| MECE 6397-09 (22045) | MoWe 2:30pm-4:00pm | N/A | Synchronous online |
| MECE 6397-10 (22046) | MoWe 2:30pm-4:00pm | N/A | Synchronous online |

**Instructor:** Marzia Cescon
**Office Room:** Room W206, Engineering Building 2
**Office Hours:** Wednesday 1:00-2:00 pm or by appointment (please send email).
**Phone:** 713-743-2037
**Email:** mcescon2@uh.edu

## Important Note
This whole syllabus document is important and should be read in its entirety.

## Syllabus Changes
Please note that the instructor may need to make modifications to the course syllabus and may do so at any time. Notice of such changes will be announced as quickly as possible through Canvas.

## Course format
For the regular section MECE 6397-08, this course is being offered as a series of face-to-face classrooms meetings. For students enrolled in MECE 6397-09 and MECE 6397-10, this course is being offered as synchronous online.

## Academic Honesty Policy
High ethical standards are critical to the integrity of any institution, and bear directly on the ultimate value of conferred degrees. All UH community members are expected to contribute to an atmosphere of the highest possible ethical standards. Maintaining such an atmosphere requires that any instances of academic dishonesty be recognized and addressed. The UH Academic Honesty Policy is designed to handle those instances with fairness to all parties involved: the students, the instructors, and the University itself. All students and faculty of the University of Houston are responsible for being familiar with this policy.

Students may be asked to sign an honor code statement as part of their submission of any graded work including but not limited to projects, quizzes, and exams: "*I understand and agree to abide by the provisions in the University of Houston Graduate Academic Honesty Policy. I understand that academic honesty is taken very seriously, and in the cases of violations, penalties may include suspension or expulsion from the University of Houston.*"

## Title IX/Sexual Misconduct
Per the UHS Sexual Misconduct Policy, your instructor is a "responsible employee" for reporting purposes under Title IX regulations and state law and must report incidents of sexual misconduct (sexual harassment, non-consensual sexual contact, sexual assault, sexual exploitation, sexual intimidation, intimate partner violence, or stalking) about which they become aware to the Title IX office. Please know there are places on campus where you can make a report in

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confidence. You can find more information about resources on the Title IX website at https://uh.edu/equal-opportunity/title-ix-sexual-misconduct/resources/.

**Reasonable Academic Adjustments/Auxiliary Aids**

The University of Houston is committed to providing an academic environment and educational programs that are accessible for its students. Any student with a disability who is experiencing barriers to learning, assessment or participation is encouraged to contact the Justin Dart, Jr. Student Accessibility Center (Dart Center) to learn more about academic accommodations and support that may be available to them. Students seeking academic accommodations will need to register with the Dart Center as soon as possible to ensure timely implementation of approved accommodations. Please contact the Dart Center by visiting the website: https://uh.edu/accessibility/ calling (713) 743-5400, or emailing jdcenter@Central.UH.EDU.

**Excused Absence Policy**

Regular class attendance, participation, and engagement in coursework are important contributors to student success. Absences may be excused as provided in the University of Houston Undergraduate Excused Absence Policy and Graduate Excused Absence Policy for reasons including: medical illness of student or close relative, death of a close family member, legal or government proceeding that a student is obligated to attend, recognized professional and educational activities where the student is presenting, and University-sponsored activity or athletic competition. Under these policies, students with excused absences will be provided with an opportunity to make up any quiz, exam or other work that contributes to the course grade or a satisfactory alternative. Please read the full policy for details regarding reasons for excused absences, the approval process, and extended absences. Additional policies address absences related to military service, religious holy days, pregnancy and related conditions, and disability.

**Recording of Class**

Students may not record all or part of class, livestream all or part of class, or make/distribute screen captures, without advanced written consent of the instructor. If you have or think you may have a disability such that you need to record class-related activities, please contact the Justin Dart, Jr. Student Accessibility Center. If you have an accommodation to record class-related activities, those recordings may not be shared with any other student, whether in this course or not, or with any other person or on any other platform. Classes may be recorded by the instructor. Students may use instructor's recordings for their own studying and notetaking. Instructor's recordings are not authorized to be shared with anyone without the prior written approval of the instructor. Failure to comply with requirements regarding recordings will result in a disciplinary referral to the Dean of Students Office and may result in disciplinary action.

**Copyright**

Materials in this course may be protected by copyright and should not be redistributed. Visit the UH Library Copyright Resources (guides.lib.uh.edu/copyright) for support resources regarding the basics of copyright, tools, fair use, and copyright law.

**Resources for Online Learning**

The University of Houston is committed to student success and provides information to optimize the online learning experience through our Power-On website. Please visit this website for a comprehensive set of resources, tools, and tips including obtaining access to the internet, AccessUH, Blackboard, and Canvas; using your smartphone as a webcam; and downloading Microsoft Office 365 at no cost. For questions or assistance contact UHOnline@uh.edu.

**UH Email**

Please check and use your Cougarnet email for communications related to this course. Faculty use the Cougarnet email to respond to course-related inquiries such as grade queries or progress reports for reasons of FERPA. To access your Cougarnet email, login to your Microsoft 365 account with your Cougarnet credentials. Visit University Information Technology (UIT) for instructions on how to connect your Cougarnet e-mail on a mobile device.

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**Security Escorts and Cougar Ride**
UHPD continually works with the University community to make the campus a safe place to learn, work, and live. The security escort service is designed for the community members who have safety concerns and would like to have a Security Officer walk with them, for their safety, as they make their way across campus. Based on availability either a UHPD Security Officer or Police Officer will escort students, faculty, and staff to locations beginning and ending on campus. If you feel that you need a Security Officer to walk with you for your safety, please call 713-743-3333. Arrangements may be made for special needs.

Parking and Transportation Services also offers a late-night, on-demand shuttle service called "Cougar Ride" that provides rides to and from all on-campus shuttle stops, as well as the MD Anderson Library, Cougar Village/Moody Towers and the UH Technology Bridge.  Rides can be requested through the UH Go app.  Days and hours of operation can be found at https://uh.edu/af-university-services/parking/cougar-ride/.

**Mental Health and Wellness Resources**
The University of Houston has a number of resources to support students' mental health and overall wellness, including CoogsCARE and the UH Go App. UH Counseling and Psychological Services (CAPS) offers 24/7 mental health support for all students, addressing various concerns like stress, college adjustment and sadness. CAPS provides individual and couples counseling, group therapy, workshops and connections to other support services on and off-campus. For assistance visit uh.edu/caps, call 713-743-5454, or visit a Let's Talk location in-person or virtually. Let's Talk are daily, informal confidential consultations with CAPS therapists where no appointment or paperwork is needed.
The Student Health Center offers a Psychiatry Clinic for enrolled UH students. Call 713-743-5149 during clinic hours, Monday through Friday 8 a.m. - 4:30 p.m. to schedule an appointment.
The A.D. Bruce Religion Center offers spiritual support and a variety of programs centered on well-being.
**Need Support Now?**

**If you or someone you know is struggling or in crisis, help is available. Call CAPS crisis support 24/7 at 713-743-5454,**

# Course Description

Over the next decade, the biggest generator of data is expected to be devices which sense and control the physical world. This will require a rigorous rethinking of the discipline of automatic control to incorporate aspects of machine learning and optimization, in order to meet the new challenges arising. While control theory has been firmly rooted in tradition of model-based design, the availability and scale of data (both temporal and spatial) will require rethinking of the foundations of this discipline. From a machine learning perspective, on the other hand, one of the main challenges going forward is to go beyond pattern recognition and address problems in data driven control and optimization of dynamical processes. This course will provide the students with an introduction to topics at the intersection of learning and control theory, placing them in the appropriate historical context of system identification and adaptive control.

## Contents

The development of suitable models for describing dynamical systems is a central problem within automatic control, and it is critical for the development of robust and high-performance control laws. When relationships between physical quantities are not fully known, then models and the control laws may instead be generated from collected data, through system identification, machine learning, or adaptive control. The purpose of the course is to teach the basic principles of how this is done.

The first part of the course is devoted to adaptive control and system identification for systems with several input and output signals. The focus is on state-space models and methods for generating these, and iterative methods for learning.

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The second part of the course is devoted to reinforcement learning. This includes the theory of dynamic programming and various approximate methods thereof.

### Aim

The course provides fundamental theory and methodology for developing control laws based on measured input and output signal data. The aim of the course is that the students should learn the important principles within the area of learning-based control, and to understand their limitations.

## Required Readings and Materials

There is no traditional textbook for this course. Our discussions will be guided by lecture notes, books, papers, monographs, and videos that are available online that the instructor will provide to the students. Reading material will be available to students via Canvas. Exercise material and homework assignments will be available on MATLAB file Exchange at the following link: https://www.mathworks.com/matlabcentral/fileexchange/176959-learning-based-control-with-matlab-and-simulink

### Artificial Intelligence

Use of an AI Generator such as ChatGPT, iA Writer, MidJourney, DALL-E, etc. to complete any assignments to be handed in is explicitly prohibited. It's imperative that all work submitted should be your own. Any assignment that is found to have been plagiarized or to have used unauthorized AI tools may receive a zero and / or be reported for academic misconduct.

## Course Prerequisites

Students are expected to be mathematically mature with a solid background in linear algebra, calculus and probability, and be familiar with basic concepts in optimization and control.
Required prerequisites: MECE 3338 (Dynamics and control of mechanical systems) or equivalent, MECE 5367 (Control System Design and Analysis) or equivalent, MECE 6388 (Optimal control theory) or equivalent.

## Participation and Attendance

Students are responsible for knowing and adhering to all university and college dates and deadlines. Such dates and deadlines include those for enrollment (registration), adding and dropping of courses, academic holidays, payment and refunds, and applying for graduation. Visit the UH Academic Calendar (uh.edu/academics/catalog/academic-calendar) and the current final exam schedule (https://uh.edu/academics/courses-enrollment/final-exam-schedules/) for specific dates.

In a case of emergency, it is the student's responsibility to keep posted on all official University alerts or closures.

## Instructional Continuity Plan

This course will adhere to the University of Houston Instructional Continuity plan to provide reasonable extensions or modifications to course requirements in the event of campus-wide disruption that prevents regular course interactions. It is the student's responsibility to keep posted on all official University alerts or closures (alerts.uh.edu). The university notifies the campus community through TV announcement monitors, sound alerts, email, text, web, and the 'UH Go' app (uh.edu/go). Students should take time to review their personal information and ensure the most current emergency contact information is provided within myUH (alerts.uh.edu/update-contact-information).

Possible hazards that may result in a closure are: Active Shooter, Bomb Threats, Extreme Heat, Fire, Flood, Hazardous Material Release, Hurricanes, Severe Weather, and Winter Weather (uh.edu/emergency-management/be-prepared).

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# Course structure and evaluation

We will try to adhere to the following structure. The course is roughly divided into 2 parts: lectures and course project, respectively. The lecture part spans from week 1 to 9, it includes lectures, a number of related homework and their solution in interactive learning sessions. The course project runs from week 10 to 15 with some intermediate updates along the road. Suitable choices for projects include implementing, evaluating and comparing tools introduced in class, extending existing theoretical results, and applying tools to a domain specific problem of their choosing. Students will be evaluated based on the assignments, and the project of their choice (see below for details).

# Semester project

Projects may be done individually or in groups of two. In case of graduate research assistants, students are encouraged (but not required) to propose a topic that connects class material to aspects of their research. The first component of the project will consist of a written proposal (2 pages limit, excluding references) and a 3-minute elevator pitch. This proposal should include motivation, prior work, problem statement, and ideas/methods/approach to solving the problem. The second component will be a mid-project update (2 pages limit, excluding references) and a 1-slider presentation. This update should include a description of current progress, which may include preliminary results (either computational or theoretical), a description of attempted methods/approaches, current roadblocks, and an outline of your plans for the rest of the semester. The final component of the project will be an end-of-semester report (6 pages limit, excluding references) and accompanying oral presentation. The final report is meant to mimic a conference setting, and therefore the report should be a self-contained document with an introduction, literature review, problem formulation, main results (and experiments if applicable), and discussion/conclusion sections. Similarly, each group will be expected to give a 10-15 min presentation, where they describe the problem their project addresses, their progress and potential innovations and concluding remarks.

Deciding of a topic: Each team is strongly encouraged to discuss with the instructor before the proposal submission. Students may start pitching their idea to the instructor anytime during week 1 to 9. This will give them the opportunity to explore potential projects, as well as receive feedback and suggestions. It is not possible to switch to another problem post proposal presentation.

Project grading: The goal of the project is to stimulate research and discussions between you, your peers and the instructor and to practice scientific writing and technical oral presentation. The project grade will not be based on the amount of progress towards solving an open problem. Rather, it will be a reflection of the amount of effort put into the project and on the clarity and quality of the submitted proposal/update/report and final presentation.

A selection of past years course projects is available at this link.

# Tentative schedule

| DATE | MECE 6397 LECTURES | ASSIGNMENTS |
|---|---|---|
|  |  |  |
| 13 – Jan | L0 - Practical aspects of the course. Introduction to the subject. Applications. | HW0 |
| 15 – Jan | L1 – Feedback fundamentals: dynamical systems model and representations | HW1 |
| 20 – Jan | MLK day |  |
| 22 – Jan | L2 – Feedback fundamentals: a closer look at feedback |  |
| 17 – Jan | L3 – Gain Scheduling | HW2 |
| 19 – Jan | L4 – Intro to adaptive control. Self-Oscillating Adaptive Systems (SOAS) HW1 Review |  |

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| Date | Topic | Due |
|---|---|---|
| 3 – Feb | L5 – Model reference adaptive systems | HW3 |
| 5 – Feb | L6 – Model reference adaptive systems – part 2<br>HW2 review | |
| 10 – Feb | L7 – Learning Dynamical Systems in Real Time | |
| 12 – Feb | L8 – HW3 Review | |
| 17 – Feb | L9 – Self Tuning Adaptive Control | HW4 |
| 19 – Feb | L10 – Self Tuning Adaptive Control | |
| 24 – Feb | L11 – Iterative Learning Control and Run-to-Run Control | HW5 |
| 26 – Feb | L12 – HW4 Review and leftovers from previous HWs | |
| 3 – Mar | L13 - Machine learning Based components | HW6 |
| 6 – Mar | L14 – Intro to Reinforcement Learning. Multi-armed bandit | |
| 10 – Mar | Spring break | |
| 12 – Mar | Spring break | |
| 17 – Mar | L15 – Markov Decision Processes (MDP) and Dynamic Programming<br>Review HW5 | HW7 |
| 19 – Mar | L16 – Deep Reinforcement Learning<br>HW6 Review | |
| 24 – Mar | No class – work on project | |
| 26 – Mar | No class – work on project | |
| 31 – Mar | Project proposal deadline and 3-min elevator pitch | Proposal |
| 2 – Apr | L17 – HW7 review | |
| 7 – Apr | No class – work on project | |
| 9 – Apr | No class – work on project | |
| 14 – Apr | Project update deadline and 1-slider presentation | Update |
| 16 – Apr | No class – work on project | |
| 21 – Apr | No class – work on project | |
| 23 – Apr | No class – work on project | |
| 28 – Apr | No class – work on project | |
| 30 – Apr | Final presentations | |
| 5 – May | Project paper deadline | Paper |

# Communication Guidelines and Feedback

## Official UH Email Mailbox

All students are provided an *official* UH email mailbox to use during their enrollment at the University of Houston. The email account will be the primary way instructors, UH entities, and support staff communicate with students. The purpose of this action is to: (1) help retain the integrity and privacy of your personal email account by keeping UH related correspondence within its own email mailbox and (2) provide additional course curriculum Office 365 tools and functionality (uh.edu/office365).

### Access and Use Your UH Email Mailbox

There are two ways to access and use your official UH email mailbox.
1. Visit AccessUH and click on the "Office 366" icon to gain access to the Outlook web app.

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2. Download the free Microsoft Outlook app and follow the appropriate tutorial to check, send, and receive UH emails on mobile devices.
   a. [Android Mobile Devices (uofh.sharepoint.com/sites/citelab/SitePages/training-library.aspx)](uofh.sharepoint.com/sites/citelab/SitePages/training-library.aspx)
   b. [Apple Mobile Devices (uofh.sharepoint.com/sites/citelab/SitePages/training-library.aspx)](uofh.sharepoint.com/sites/citelab/SitePages/training-library.aspx)

**Update Your Destination Email in AccessUH**

Manually update your 'destination' email address to redirect to your new official UH email mailbox. Visit the UIT website to learn how to [update the destination email](uh.edu/infotech/services/accounts/email/update-student-address) within AccessUH (uh.edu/infotech/services/accounts/email/update-student-address).

# Student Responsibility and Expectations

A [responsible student](catalog.uh.edu/content.php?catoid=6&navoid=1082) (catalog.uh.edu/content.php?catoid=6&navoid=1082) is a successful student. At the University of Houston, students are expected to conduct themselves in a mature and responsible manner, respect the opinions, rights, and personal property of others, and meet their financial obligations. Students are responsible for seeking help and guidance from all of the resources that the university makes available to them. They are expected to be proactive and remain informed about university dates and deadlines, and understand academic and disciplinary policies. They are responsible for communication with their professors, advisors, and university staff, and the commitment to being organized and prepared to learn. Above all, our students are expected to strive for honesty and academic integrity throughout their period of study at the University of Houston.

- [UH Student Behavior and Conduct](uh.edu/dos/behavior-conduct) (uh.edu/dos/behavior-conduct)
- [UH Conduct Assessment and Response (CART) Team](uh.edu/cart) (uh.edu/cart)

[The College of Education the General Ethics Principles Guide (uh.edu/education/student-services/pdf/coe-ethics-code.pdf) describes the standards of practice expected of all college members (employees and students). Members of the college are expected to adhere to the following six principles: College of Education members will… (1) Treat all people with dignity and respect. (2) Foster healthy and caring relationships. (3) Leverage change to strive for excellence. (4) Serve the profession with integrity. (5) Communicate clearly and openly. (6) Promote trust and confidence.](uh.edu/education/student-services/pdf/coe-ethics-code.pdf)

During the period of this course, students may be expected to participate in synchronous online discussions. The following online etiquette will help respect each other's privacy while also creating a friendly atmosphere.
- Keep chats on topic - Avoid inappropriate conversions that may distract others from the course topic or objective.
- Avoid strong/loud language - Be polite. Language can easily be misinterpreted in written communication. Before sending an email or chat message make sure it clearly conveys the intended feeling.
- Use emoticons to express feelings - Nonverbal cues can reinforce the feeling of a message. Use sparingly.  :-)
- Respect privacy of peers - Do not post someone's personal information online without their expressed permission.
- Use appropriate dress code on camera - During a video conference dress as if attending a face-to-face class. Avoid offensive clothing.
- Be mindful of background noise and scene/location - Take advantage of quiet areas to avoid distractions to fellow classmates. Avoid offensive décor or noise.
- Be helpful - Assist fellow classmates in understanding course materials.

# Emergency Preparedness Information

## Emergency Phone Numbers

**713-743-3333** UH Police
**911** Emergency Dispatch

## Security Escort

The Security escort service is designed for the community members who have safety concerns and would like to have a Security Officer walk with them, for their safety, as they make their way across campus. Call **713-743-3333** to make arrangements.

## FIRE

# Evacuate

> If the fire alarm is not sounding, activate the nearest alarm pull station.
> Call **713-743-3333** or **911** to report the fire.
> Notify and assist people in the immediate area.
> As you leave, close all doors behind you to limit the movement of smoke or flames.
> Do not re-enter the building until authorized to do so by emergency personnel.
> Never assume an alarm is false.
> Do not use elevators.
> If unable to exit the building, go to nearest exit stairwell or safe area of refuge and call **713-743-3333** or **911** to report your location.
> If trained, use a fire extinguisher if the fire is small and contained, and the room is not filled with smoke.

**Two emergency exits are located:**

1. Farish Hall - Northwest Stairwell (A stairs)
2. Farish Hall - Southeast Stairwell (C stairs)

**Primary (Near) Meeting Area:**

Green space between Farish Hall and McElhinney Hall.

**Secondary (Far) Meeting Area:**

Green space at Ezekiel W. Cullen water fountains.

## UH Alert

# UHALERT

**In the event of a campus emergency, the University of Houston will activate the UH ALERT Emergency Notification System to provide critical information. UH ALERT utilizes the following methods to send UH ALERTS:**

> UH ALERT Website (alerts.uh.edu)
> Email
> Text Message
> Facebook Alerts (facebook.com/UHAlert )
> Twitter Alerts (twitter.com/UHAlert)
> UH Mobile App (uh.edu/go)
> Digital Signage
> Outdoor Warning Siren

**For more information visit the UH ALERT website.**

## Weather

# Shelter-in-Place

> Seek shelter indoors.
> Check uh.edu/emergency for shelter-in-place directive for the UH campus.
> If a Tornado Warning is issued, seek shelter indoors in an interior room away from windows, and on the lowest floor possible.

## Active Shooter

# Avoid, Deny, Defend

**If an active shooter or violent person is in your vicinity, please attempt to take the following steps:**

> **AVOID:** If possible, exit the building immediately and call **713-743-3333** to reach UH Police, or dial **911.**
> **DENY:** If you cannot exit, clear the hallway quickly, remain behind closed doors in a locked or barricaded room, if possible, and stay away from interior windows.
> **DEFEND:** Do not attempt to confront or apprehend the shooter, unless it is a last resort.

See **http://uh.edu/police/active_shooter.html** for more information about "Avoid, Deny, Defend."

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