

# MECH 6326

## Optimal Control and Dynamic Programming

### 3 Semester Credit Hour

### Spring 2023 Course Syllabus

**Professor:** Dr. Justin Koeln  
Office: ECSW 3.355D  
Office Hours: Tuesdays and Thursdays, 12-1pm  
Email: Justin.Koeln@UTDallas.edu

**Lecture:** Monday, Wednesday 10:00 – 11:15am, ECSW 2.325

**Course Modality and Expectations:**

**Instructional Mode:** Traditional (in-person)

**Course Platform:** eLearning and Microsoft Teams

**Synchronous:** In-person interactive lectures, attendance is required.

**Expectations:** All students are expected to:

- attend in-person lectures and actively engage/participate;
- have regular/frequent access to a computer with Matlab;
- complete assignments on-time and submit assignments via eLearning;
- watch for emails sent via eLearning announcement with important information; and
- email the instructor with any questions regarding course policies/expectations.

**Course Content:** Introduction to stochastic optimal control and dynamic programming, with applications taken from a variety of areas, including automatic control, engineering, supply-chain management, resource allocations, finance, etc. Markov chains and Markov decision processes, optimal policies and value functions with full state information for finite-horizon, infinite-horizon, discounted, and average stage cost problems. Dynamic programming and Bellman equation, value iteration, policy iteration. Linear quadratic stochastic control. Approximate dynamic programming and model predictive control.

**Outcomes:**

- 1) Be able to formulate the problem of stochastic optimal control and distinguish between open-loop and closed-loop control policies
- 2) Understand and explain the principle of optimality and the dynamic programming algorithm
- 3) Convert non-standard problems to basic problems by state augmentation
- 4) Understand and implement algorithms for infinite-horizon problem, including value iteration, policy iteration, and linear programming
- 5) Be able to use dynamic programming to derive the linear quadratic regulator for problems with continuous state and input space with linear dynamics, quadratic cost, and Gaussian uncertainty

6) Understand limitations of dynamic programming and be able to formulate and implement suboptimal approximate dynamic programming heuristics, including certainty equivalent model predictive control

**Prerequisite:** MECH 6300 or permission from the instructor is a pre-requisite. Students should have good knowledge of advanced calculus, probability theory, linear algebra, and programming (in Matlab). Other courses in control, optimization, and dynamical systems may provide additional context.

**Textbook:** *Dynamic Programming and Optimal Control*,  
4<sup>rd</sup> Edition, by Dimitri Bertsekas, ISBN-13: 978-1-886529-43-4  
Available through the UTD Bookstore.  
Ask instructor about using alternative editions.

**Software:** The examples and homework assignments for this course will be completed using Matlab. Some assignments might require the use of addition toolboxes/extensions for Matlab which will be free/open-source and discussed throughout the course. While there are many other software packages that perform similar functions, these tools will be the ones used by the instructor throughout the class and it is expected that you use these same tools.

**Website:** UT Dallas eLearning: <https://elearning.utdallas.edu/>

This site includes all course and schedule information and will be used to facilitate the course. **Check it frequently.**

***Tentative Outline:***

<b>Week of:</b>	<b>Topic</b>	<b>Due on Friday</b>
1/16	Introductions and Motivation (No class Monday)	
1/23	Mathematical Background	
1/30	Dynamic Programming	
2/6	Dynamic Programming	HW #1
2/13	Markov Chains	
2/20	Markov Chains	Project Proposal
2/27	Dynamic Programming for Markov Decision Processes	HW #2
3/6	Project Discussions	
3/13	No Lectures (Spring Break)	
3/20	Policy Iteration	HW #3
3/27	Dynamic Programming for Linear Quadratic Problems	
4/3	Approximate Dynamic Programming	

4/10	MPC and Reinforcement Learning	HW #4
4/17	Project Presentations	
4/24	Project Presentations	
5/1	No Lectures (Last week of classes)	Project Report

**Lecture:** In-person lectures are held Mondays and Wednesdays, 10:00 – 11:15am, in ECSW 2.325. These lectures are a key element of the course, where new material will be presented followed by interactive exercises and discussions. While regular attendance is expected, students who are unable to attend a particular lecture should email the instructor (in advance, if possible).

**Grades:** Final grades will be evaluated as follows (there is no final exam):

Participation:	10%
Homework:	20%
Project Presentation:	20%
Project Report:	50%

**Homework:** Four homework assignments will be assigned and graded. You are encouraged to discuss approaches to solving homework problems with your classmates, however **you must always write/type up the solutions on your own**. Copying solutions, in whole or in part, from other students or any other source will be considered a case of academic dishonesty. **Homework must be submitted electronically via eLearning by 5pm on Friday the week it is due, otherwise it is considered late.**

**Project:** The final project in this course provides the opportunity to apply various techniques learned in this course to an application of your choosing. The final project can be done individually or in teams of 2. You will design your own project based on guidelines provided in separate documents and discussed in class. The outcome of this project will be a conference-type paper/report and presentation. More details will be provided throughout the semester.

*The previous descriptions and timelines are subject to change at the discretion of the Professor.*

### **Classroom Conduct Requirements Related to Public Health Measures**

UT Dallas will follow the public health and safety guidelines put forth by the Centers for Disease Control and Prevention (CDC), the Texas Department of State Health Services (DSHS), and local public health agencies that are in effect at that time during the Fall 2021 semester to the extent allowed by state governance. Texas Governor Greg Abbott's Executive Order [GA-38](#) prohibits us from mandating vaccines and face coverings for UT Dallas employees, students, and members of the public on campus. However, we strongly encourage all Comets to get vaccinated and wear face coverings as recommended by the CDC. Check the [Comets United: Latest Updates webpage](#) for

the latest guidance on the University's public health measures. Comets are expected to carry out [Student Safety](#) protocols in adherence to the Comet Commitment. Unvaccinated Comets will be expected to complete the [Required Daily Health Screening](#). Those students who do not comply will be referred to the Office of Community Standards and Conduct for disciplinary action under the [Student Code of Conduct – UTSP5003](#).

### **Class Recording**

The instructor may record meetings of this course. Any recordings will be available to all students registered for this class as they are intended to supplement the classroom experience. Students are expected to follow appropriate University policies and maintain the security of passwords used to access recorded lectures. Unless the Office of Student AccessAbility has approved the student to record the instruction, **students are expressly prohibited from recording any part of this course. Recordings may not be published, reproduced, or shared with those not in the class, or uploaded to other online environments** except to implement an approved Office of Student AccessAbility accommodation. If the instructor or a UTD school/department/office plans any other uses for the recordings, consent of the students identifiable in the recordings is required prior to such use unless an exception is allowed by law. Failure to comply with these University requirements is a violation of the [Student Code of Conduct](#).

### **Class Materials**

The Instructor may provide class materials that will be made available to all students registered for this class as they are intended to supplement the classroom experience. These materials may be downloaded during the course, however, these materials are for registered students' use only. Classroom materials may not be reproduced or shared with those not in class, or uploaded to other online environments except to implement an approved Office of Student AccessAbility accommodation. Failure to comply with these University requirements is a violation of the [Student Code of Conduct](#).

### **Distance Learning Student Resources**

Online students have access to resources including the McDermott Library, Academic Advising, The Office of Student AccessAbility, and many others. Please see the [eLearning Current Students](#) webpage for more information.

### **Server Unavailability or Other Technical Difficulties**

The University is committed to providing a reliable learning management system to all users. However, in the event of any unexpected server outage or any unusual technical difficulty which prevents students from completing a time sensitive assessment activity, the instructor will provide an appropriate accommodation based on the situation. Students should immediately report any problems to the instructor and also contact the online [eLearning Help Desk](#). The instructor and the eLearning Help Desk will work with the student to resolve any issues at the earliest possible time.

### **Comet Creed**

This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

*“As a Comet, I pledge honesty, integrity, and service in all that I do.”*

**Additional Course Policies**

The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus.

Please go to [UT Dallas Syllabus Policies](#) webpage for these policies.