

Stochastic Control
EEL 6935, Section 26375

Class Periods: Tuesday, Periods 8-9 (3:00 PM - 4:55 PM) and Thursday, Period 9 (4:05 PM - 4:55 PM)

Location: LAR 0239

Academic Term: Spring 2023

Instructor: Sean Meyn

Email Address: meyn@ece.ufl.edu Please contact through the Canvas website

Office Phone Number: 392-8934

Office Hours: Tues 9-10, Zoom.

Supervised Teaching Student: Fan Lu

Email Address: fan.lu@ufl.edu

Office hours: Wed, 1:30-2:30, 484 NEB

Course Description (3 credits) Stochastic methods for control, in applications ranging from finance to power systems to medicine. Markov and linear models, with full or partial state information. Optimal control techniques and dynamic programming are emphasized, along with approximate dynamic programming techniques, and reinforcement learning algorithms.

Course Pre-Requisites / Co-Requisites

EEE 5544 Stochastic Methods I. An introductory course on control systems such as EEL 4657 is recommended. Familiarity with Matlab or Python is essential.

Course Objectives

Theory and application of dynamic programming and simulation oriented methods for control design and performance evaluation. Topics include:

- Principle of optimality and dynamic programming for both deterministic and stochastic systems
- Lyapunov stability theory for deterministic and stochastic systems
- Optimal control for linear systems
- Optimal control for Markov Decision Processes
- Approximate Dynamic Programming
- Partial information, the belief state, and application to multi-armed bandits.
- Stochastic approximation – general convergence theory and variance analysis
- Reinforcement learning: TD-learning, Q-learning and actor-critic methods

Materials and Supply Fees

None

Required Textbooks and Software

- Control Systems and Reinforcement Learning, 1st edition
- Sean Meyn
- Cambridge University Press
- ISBN number: 1316511960

Pre-publication available freely online: <https://meyn.ece.ufl.edu/control-systems-and-reinforcement-learning/>

Recommended Materials

- Handouts will be distributed

Course Schedule

I. Basics and previews Chapters 3 and 7, and review

Week 1: Controlled Markov models and MDPs.

Week 2: Examples: both deterministic and stochastic

Week 3: Temporal difference origins

II. Performance evaluation Chapter 6

Week 4: Probability review

Week 5: Markov models and more examples

Week 6: Lyapunov techniques for stability and performance

Week 7: Monte-Carlo methods

First Midterm Exam

III. Numerical methods Appendix B and handouts

Week 8: Approximate dynamic programming.

Week 9: Numerical techniques: policy and value iteration; LP formulation.

Week 10: Partial information (belief state), with applications to

Linear quadratic optimal control; Multi-armed bandits (with UCB heuristic).

IV. Adaptation and Learning

Week 11: Stochastic approximation Chapter 8

Week 12: TD Learning Chapters 9 and 10

Week 13: Q Learning

Second Midterm Exam

Actor-critic methods (time permitting)

Attendance Policy, Class Expectations, and Make-Up Policy

Homework problems will be assigned on a weekly to bi-weekly basis, to be handed in at the beginning of class on the date due. They will be graded and returned the following week. Late homework cannot be accepted.

Cell phones and other electronic devices are to be silenced. No text messaging during class or exams.

Exam conflicts must be brought to the professor's attention as soon as possible. Professor Meyn will work with the student to find a solution.

Evaluation of Grades

In addition to homework and two in-class exams is a review paper to be submitted by the last day of classes.

Review Paper: By early March, each student will pick out one research paper on stochastic control, and one paper that is referenced in the chosen paper.

The report will be about 4 pages long, *not including any illustrations or computer plots you might want to include*, and it should be typed, with 11pt font and margins similar to this handout. It will consist of four parts:

1. *Summary* 5%. Approximately ½ page. It should be written in your own words, and *clear enough to allow a fellow student to understand the **main contribution** of the paper.*
2. *Critique* 30%. Comparison of the results of the paper to what has been discussed in class. Indicate the merits/shortcomings of the paper. Explain how the paper is related to the supporting reference.
3. *Extensions* 30%. Treated like a proposal for a thesis. What further directions might be explored? What other methods could the author have considered? Are there related applications that might be examined? *Do not copy the extensions section of the paper!*
4. *Numerical experiments* 15%. Use Matlab or Python to perform simulations to experiment with the issues raised in the paper. *You will not receive credit for this part of the report unless you provide meaningful interpretations of your simulation results.*

Assignment	Total Points	Percentage of Final Grade
Homework Sets (9)	100	20%
Midterm Exam 1	100	30%
Midterm Exam 2	100	30%
Review Paper	100	20%
		100%

Grading Policy

The following is given as an example only.

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

[UF Graduate Catalog](#)
[Grades and Grading Policies](#)

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every

person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

On-Line Students Complaints: <https://distance.ufl.edu/state-authorization-status/#student-complaint>.