14.451: Dynamic Optimization Methods with Applications

Christian Wolf
E52-554, 609-356-4327
Office hours: Th 4pm-5pm
E-mail: ckwolf@mit.edu

Fall 2022
Lectures: Tu, Th 1pm-2:30pm (E51-151)
Recitations: F 2:30pm-4pm (E51-151)

Course Overview

This course introduces a set of analytical tools that help to analyze optimization problems over time. We will focus on the types of problems that are frequently encountered in economics. We will attack these problems using multiple mathematical techniques, such as the variational approach, dynamic programming, and the maximum principle. These techniques not only help to solve optimization problems, but more importantly, they also deepen our understanding of the economic trade-offs captured by these problems. We will cover various applications that illustrate these techniques, including the neoclassical (benchmark) theories of consumption and investment. However, our main goal will be to gain a strong command of the tools, so that they can be applied in subsequent courses and in research.

The course will meet in E51-151 for lectures on Tuesdays and Thursdays at 1pm-2:30pm, and in the same room for recitations on Fridays at 2:30pm-4pm. The teaching assistant for the course is Alex Carrasco (alexcm@mit.edu). My office hours are on Thursdays 4pm-5pm (in E52-554) and Alex's office hours are on Mondays 3:00pm-4:00pm (location E52-448).

All materials for the course will be posted on the course website, which is located at:
https://canvas.mit.edu/courses/15694

Assignments, Exams, and Grading

There will be four problem sets that will account for 40% of your grade in total. The assignments will be posted on the website, and they will be returned in class on the due date. You are permitted and encouraged to collaborate on the problem sets. You can hand in write-ups for groups of up to three people. We will post the solutions to all of the problems on the website.

There will be an in-class exam that will account for 60% of your grade. The exam will take place on Tuesday, October 25. The last lecture of the course is on Thursday, October 20.

Prerequisites

The course prerequisites are multivariable calculus and familiarity with finite dimensional optimization methods. Real analysis, linear algebra, and familiarity with numerical computing software (such as MATLAB, Python or Julia) are helpful but not required.

Textbook and Readings

I recommend the following references for the course:

- (SLP) Nancy L. Stokey and Robert E. Jr. Lucas with Edward C. Prescott, 1989, Recursive Methods in Economic Dynamics, Harvard University Press.
- (A) Daron Acemoglu, 2009, Introduction to Modern Economic Growth, Princeton University Press.
- (D) Optimization in Economic Theory, 2009, by Avinash Dixit, Oxford University Press.

These books will be on reserve in the library. (D) provides an accessible and intuitive account of the finite dimensional optimization techniques that are commonly used in economics. This material might be useful to review before or while taking this course. (SLP) and (A) are more closely related to the topics that we will cover in the course. (SLP) is a useful reference for dynamic programming techniques in discrete time. (A) provides a useful reference for optimal control and variational techniques in continuous time, as well as some of the other topics.

These books are recommended but not required. We will mainly rely on lecture slides that build upon these books and on notes by previous generations of teachers (Alp Simsek, Iván Werning, Marios Angeletos, Guido Lorenzoni, and Bruno Strulovici).

Recitations

The course will meet once a week in recitations, taught by the teaching assistant, Alex Carrasco. The recitations are very important for the functioning of this course. Alex will review and expand upon the material covered in lectures, review the problem set solutions (after they are due), and help you to prepare for the problem sets and the exam.

Reporting bias-related or other incidents

The Economics Department fully endorses the Institute Discrimination and Harrassment Response Office (IDHR) reporting process for any bias-related incident. You can submit reports at https://idhr.mit.edu/submitincidentreport. We encourage students to use this valuable resource if needed for any reason. This process is useful for addressing any issues that may arise with professors, teaching assistants, or other students in this course. If you've had a negative experience and aren't sure if IDHR is the place to go, they can also help you find the

right office at MIT to receive support. The department values such reports as important to our pursuit of equitable and inclusive treatment for all students, faculty, and staff.

Accessibility and support

The Economics Department values an inclusive environment. If you need a disability accommodation to access this course, please communicate with us early in the semester. If you have your accommodation letter, please meet with the faculty so that we can understand your needs and implement your approved accommodations. If you have not yet been approved for accommodations, please contact Student Disability Services at uaap-sds@mit.edu to learn about their procedures. We encourage you to do so early in the term to allow sufficient time for implementation of services/accommodations that you may need.

Tentative Course Schedule, Fall 2022

Date	Lecture	Note	Topic	Reading
Sep 8, Th	1		Introduction and key concepts	(SLP: 3) (A: 6.1, App.A)
Sep 13, Tu	2	Pset 1 out	Variational approach and optimality conditions	(SLP: 4.5) (A: 6.6)
Sep 15, Th	3		Principle of optimality and dynamic programming	(SLP: 4.1-2; A: 6.2-3)
Sep 20, Tu	4	Pset 1due Pset 2 out	Applications of dynamic programming	(SLP: 5, 4.3-4) (A: 6.8)
Sep 22, Th	5		Deterministic dynamics and local stability	(SLP: 6) (A: App.B)
Sep 27, Tu	6	Pset 2 due Pset 3 out	Optimal control and the maximum principle	(A: 7.1-2) (D:10)
Sep 29, Th	7		Infinite-horizon optimal control with discounting	(A: 7.5, 7.7)
Oct 4, Tu	8		Continuous time dynamics	(A: 7.8, 8.3-5, 8.9)
Oct 6, Th	9	Pset 3 due Pset 4 out	Dynamic programming in continuous time	(A: 7.3)
Oct 13, Th	10		Stochastic dynamic programming	(SLP: 9.1-2, 9.5) (A: 16.1, 16.3)
Oct 18, Tu	11		Applications of stochastic dynamic programming	(SLP: 10, A:16.5) (D:11)
Oct 20, Th	12	Pset 4 due	Stochastic dynamics	(SLP: 9.6, 11-12)
Oct 25, Tu	Exam		Exam	