This document covers the first half of the Fall Term. The remainder of the semester will be taught by Robert Barro.

Note: Enrollment is strictly limited to PhD students in the Economics Department, Business Economics program, and PEG program. Qualified Harvard undergraduates may also enroll. No other students may take the course for credit or as auditors. This is the policy of the department of economics and I am obligated to enforce it.

Course Concept: The first half of this course will cover dynamic optimization methods (i.e., Dynamic Programming) in discrete time and continuous time. To illustrate these concepts, we will study applications in asset pricing, consumption, investment, and search. This course is intended for graduate students although advanced undergraduates with appropriate mathematical training (multivariable calculus and real analysis) are encouraged to attend.

Problem Sets: I will assign six short weekly problem sets. The problem sets will be posted on the course web site. The posting dates will be Tuesdays. The first problem set will be posted September 2 (the first day of class). Problem sets are due in class one week after they are posted. Solution sets will be posted on the course web site the same day that problem sets are due. Problem sets will be graded within one week after they are turned in. Graded problem sets will be handed out in class. If a student is not present to pick them up in class, they will be left with my assistant, Emily De Puy (Littauer M-13).

Office hours: Email Emily De Puy edepuy@fas.harvard.edu for office hours appointments. If you prefer, you can also come to walk-in office hours (no appointment needed). To find the time of my next office hours, please email Emily.

Sections: We will have two kinds of sections. Teaching fellows (TF’s) will hold sections every week. Over the course of the semester, I will hold an additional five sections (at a time to be arranged with the class) designed to discuss how to develop your research program.

Special dates:
- September 2: First day of class
- September 25: Rosh Hashanah (class will be held and videotaped).
- October 2: section will be held in class this week.
- October 16: Beginning of second half of the semester. Robert Barro takes over.
- November 27: Thanksgiving (no class).
- December 3: Reading period begins (Wednesday).
Texts (at COOP):

Avinash Dixit and Robert Pindyck, Investment Under Uncertainty, (1994)


Unless otherwise noted, readings listed below are required.

Lecture 1: Introduction to Dynamic Programming

- Stokey and Lucas chapter 1-2.

1. Introduction to dynamic programming
2. The Bellman Equation
3. Three ways to solve the Bellman Equation
4. Application: Search and stopping problem

Lecture 2: Iterative Methods

- Stokey and Lucas chapter 3.
- (Optional) Stokey and Lucas chapter 4.
- (Optional) Ljungqvist and Sargent chapters 2-3.

1. Functional operators
2. Iterative solutions for the Bellman Equation
3. Contraction Mapping Theorem
4. Blackwell's Theorem
5. Application: Search and stopping problem
Lecture 3: Classical consumption models

- Romer, Chapter 7

1. Consumption: Basic model and the early theories
2. Linearization of the Euler Equation
3. Empirical tests without "precautionary savings effects"
4. The Marginal Propensity to Consume
Lecture 4: Consumption with liquidity constraints


1. Precautionary savings motives
2. Liquidity constraints
3. Application: Numerical solution of a problem with liquidity constraints
4. Comparison to "eat-the-pie" problem
5. Discrete numerical analysis

Lecture 5: Non-stationary dynamic programming and the lifecycle


1. Non-stationary dynamic programming
2. Lifecycle problem with liquidity constraints
3. Simulated Euler equation tests with liquidity constrained households
Lecture 6: Empirical implementation of consumption models.

- (Optional) David Laibson, Andrea Repetto, Jeremy Tobacman “Estimating Discount Functions from Lifecycle Consumption Choices.”

1. Quasi-hyperbolic Discounting
2. Hyperbolic Euler Equation
3. Lifecycle simulations
4. Method of Simulated Moments (MSM)
Lecture 7: Asset pricing and consumption.


1. Equity premium puzzle
2. Calibration of risk aversion
3. Resolutions of the equity premium puzzle
Lectures 8: Intro to Continuous Time Dynamic Programming.
- Dixit and Pindyck chapter 3.

1. Continuous time random walks: Wiener Process
2. Ito's Lemma
3. Continuous time Bellman Equation

Lectures 9-10: Applications of Continuous Time Dynamic Programming
- Dixit and Pindyck chapters 4 and 5

1. General Solutions
   a. Boundary Conditions
2. Application: Merton's consumption problem
3. Application: Stopping Problems
   a. Boundary condition: Value Matching
   b. Boundary condition: Smooth Pasting
   c. Solving second order ODE's
Lecture 11: Classical Investment Models.

- Dixit and Pindyck chapter 1
- Romer, chapter 8

1. Introduction to investment
2. Static model
3. Dynamic model: q-theory of investment
4. Phase diagrams

Lecture 12: Investment under uncertainty with non-convexities.

- Dixit and Pindyck chapter 2

1. Empirical evidence on investment
2. Lumpy investment introduction
3. Lumpy investment models: Bertola and Caballero (1990)
4. Lumpy investment and delayed responses
5. Lumpy decisions across economics
6. Optional: Analytic example of q-model
7. Optional: Ergodic distributions and the Kolmogorov Equation
Additional Five Lectures Given in Section: How to Optimize Your Time as a Doctoral Student

1. Can Brenda tell me if I was admitted by mistake?
2. Why does David assign more than 168 hours of readings and problem sets per week?
3. Where can you purchase alarm clocks without snooze buttons?
4. Where can I get a pirated copy of Civilization V?
5. Is marijuana legalized in Massachusetts?
6. Is it possible to graduate if you only do 50% of the reading assignments?
7. What if you do 20%? 10%?
8. Do the faculty believe that we understand their lectures?
9. When should I start research?
   What makes a research project successful?
10. How should I manage a portfolio of research projects?
11. What does the theory of option value say about optimal stopping times for partially finished research projects?