Economics 4210: Numerical Methods for Macroeconomists

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- **Time and Location**: Mondays and Wednesdays, 1:45-3:15pm, Rm PCPE 101

- **Grading**: Three take-home exams.

- **Textbook:** Greenwood, Jeremy and Ricardo Marto. *Numerical Methods for Macroeconomists.*

    - https://ideas.repec.org/p/eag/rereps/36.html

- **Programming Language**: MATLAB (from Mathworks)–must be used for assignments.

1 Description

This course will study some of the numerical methods that are used in modern macroeconomics. The class will learn how to solve nonlinear equations, maximization problems, difference equations, dynamic programming problems, differentiate functions numerically, integrate functions numerically, conduct Monte Carlo simulations, construct Markov chains, interpolate functions, and smooth data. This will be done while studying economic problems, such as the determination of labor supply, economic growth, and business cycle analysis. Calculus is an *integral* part of the course and some elementary probability theory will be drawn upon. The MATLAB programming language will be used.

TA: Stefano Cravero. **Email**: scravero@sas.upenn.edu. **Office Hours**: 8:30-10:30, PCPE 208.

Departmental policies regarding courses are available here:

https://economics.sas.upenn.edu/undergraduate/course-information/course-policies

2   Grading

The course will be evaluated on the basis of three take-home assignments. The take-home assignment schedule is as follows:

Handed out	Due
Wed, Feb 19th (tentative)	Wed, Feb 26th
Mon, March 24th (tentative)	Mon, March 31st
Wed, April 23rd	Wed, April 30th

No collaboration with *any* person (either in or out of the class) is allowed for the assignments. You are also *not* allowed to use programs from the web, including AI programs, such as ChatGPT. The assignments will be graded on a mixture of the skills you show in economics, mathematics and programming. More than enough time is given for each assignment. A 10% penalty is assessed for each day an assignment is late.

Regrading. If you believe that an assignment has been graded in error, you *must* contact the TA first. This must be done within one week after receiving the grade. If a resolution cannot be found, I will regrade the entire exam and an average of the two grades will be taken. *Your grade may go up or down.*

Bonus Points. You can earn bonus points by listing all errors in economic logic, mathematics, and computer code that you find in the class notes–keep such errors to yourself.

3   Nonlinear Equations

3.1   Methods

- Bisection Method

- Newton's Method

3.2   Application, Labor-leisure choice

- Edward C Prescott (2004). "Why Do Americans Work So Much More Than Europeans?" *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol. 28, No. 1: 2–13.

4   Maximization (and Minimization)

- Golden Section Search

- Discrete Maximization

- Particle Swarm Optimization

- Calibration

- Prescott, Edward C. and Graham V. Candler (2008). "Calibration." *The New Palgrave Dictionary of Economics.*

5 Graphing

- Jonathan A. Schwabish, "An Economist's Guide to Visualizing Data," *Journal of Economic Perspectives*, 28 (Winter 2014): 209-34.

6 Deterministic Dynamics

6.1 Methods

- Extended Path Method

- Multiple Shooting

6.2 Application, the neoclassical growth model

- Gary D. Hansen and Edward C. Prescott, "Malthus to Solow," *American Economic Review*, 92 (September 2002): 1205-17.

7 Numerical Approximations

- Numerical Differentiation

- Numerical Integration

- Random Number Generators and Monte Carlo Simulation

- Markov Chains

- Interpolation

7.1 Applications

- Welfare Gain from Personal Computers

- Welfare Cost of Business Cycles

- Unemployment

- The Equity Premium Puzzle

- Spline Art

8 Stochastic Dynamics

8.1 Methods

- Linearization Techniques

- Dynamic Programming

  - Discrete State Space Dynamic Programming
  - Quadratic Approximation

8.2 Application, business cycles

- Edward C. Prescott (1986). "Theory ahead of business cycle measurement." *Federal Reserve Bank of Minneapolis Quarterly Review*, 9-22.

- Jeremy Greenwood, Zvi Hercowitz and Gregory W. Huffman (1988). "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review v.* 78: 402-417.