Economics 242: Numerical Methods for Macroeconomists

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Time and Location: Mondays and Wednesdays, 2:00-3:30pm, MCNB 285
Grading: Three take-home exams.
Textbook: Greenwood, Jeremy. *Numerical Methods for Macroeconomists*. Available as a Study.Net TEXTPAK.
Programming Language: MATLAB (from Mathworks)–must be used for assignments.

> There cannot be a language more universal and more simple, more free from errors and obscurities,....more worthy to express the invariable relations of natural things than mathematics. It interprets all phenomena by the same language, as if to attest the unity and simplicity of the plan of the universe, and to make still more evident that unchangeable order which presides over all natural causes. Joseph Fourier, *Analytical Theory of Heat*, 1822

> Many people have a passionate hatred of abstraction, chiefly, I think because of its intellectual difficulty; but as they do not wish to give this reason they invent all sorts of others that sound grand. They say that all reality is concrete, and that in making abstractions we are leaving out the essential. They say that all abstraction is falsification, and that as soon as you have left out any aspect of something actual you have exposed yourself to the risk of fallacy in arguing from its remaining aspects alone. Those who argue in this way are in fact concerned with matters quite other than those that concern science. Bertrand Russell, *The Scientific Outlook*, 1931.

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, interpolate functions, smooth data, and conduct Monte Carlo simulations on the computer.

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.

Posting any material from this course online is prohibited.

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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 exams. There will be an extra class on Friday, April 17th, 2:00-3:30 (PCPSE. 101). The take-home exam schedule is as follows.

HANDED OUT	DUE
Wed, February 19th	Tuesday, February 25th
Wed, March 25th	Tuesday, March 31st
Wed, April 22nd	Wed, April 29th

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

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

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

- Interpolation

7.1 Applications

- Welfare Cost of Business Cycles

- Welfare Gain from Personal Computers

8 Stochastic Dynamics

8.1 Methods

- Linearization Techniques

- Monte Carlo Simulation

- Dynamic Programming

  - Discrete State Space Dynamic Programming
  - Markov Chains

8.2 Application, business cycles

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

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

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