

Economics 242: Numerical Methods for Macroeconomists

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- **Time and Location:** Asynchronous on Canvas. They will be posted on Canvas in a timely fashion using Panopto.
- **Office Hours via Zoom:** There will be the occasional meeting during the school's scheduled class time on to answer questions. You may also post questions on the discussion board in Canvas.
- **Grading:** Three take-home exams.
- **Textbook:** Greenwood, Jeremy. *Numerical Methods for Macroeconomists*.
– <http://www.jeremygreenwood.net/papers/numericalmethods.pdf>
- **Programming Language:** MATLAB (from Mathworks)—must be used for assignments.

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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.

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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. The take-home exam schedule is as follows.

HANDED OUT	DUE
Mon, March 1st (tentative)	Mon, March 8th
Wed, March 24th (tentative)	Wed, March 31st
Wed, April 21st	Wed, April 28th

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 and Monte Carlo Simulation

- Markov Chains
- Interpolation

7.1 Applications

- Welfare Cost of Business Cycles
- Welfare Gain from Personal Computers
- The Equity Premium Puzzle

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.
- 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.