Econ 5000: Mathematics for Economists
Fall Term 2023

Course Description

This course is designed to prepare incoming Master students in economics for the first-year classes in microeconomics and macroeconomics. We focus on the mathematics that is used in those courses, and on the mathematical foundations that are needed to understand this material. Most of the time, we will only explain the intuition behind the theorems and focus on their applications in economics. We may go over proofs of theorems when necessary. Incoming Econ Ph.D. students in economics who wish to refresh their math knowledge about these topics are also welcome.

Instructor: Yishu Zeng

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- Office Hour: by appointment

Graduate student instructor: TBA

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Note: Please kindly indicate "Econ 5000" in the subject of your email when contacting me or our GSI; it will help us to manage all your emails more efficiently.

Schedule

- Lecture: Monday to Friday 8:30-11:30 am
  - The first day of the class: August 8, 2023
  - The last day of the class: August 23, 2023
  - Final exam on August 25, 2023
- Discussion section: Monday to Friday 12:30- 2:30 pm

  - The waiver exam: 12:30-2:30 pm, August 8; details will be posted soon
  - The first discussion section is on August 9, 2023
  - The last discussion sections is on August 23, 2023
- Zoom links will be posted on eClass.

Lectures

In the Zoom lectures, I will write on an iPad for most of the time. After each class, I will share with you everything I write in a PDF file on eClass, as well as a link of the lecture video. I encourage you to take some notes about things I say or we discuss that you find useful. At least, this will help you stay focused. In addition, studying in groups will be particularly useful, especially for those of you who must study through Zoom videos.

Problem Sets

There will be 2 problem sets (30 points each). You may work in groups, but each of you should turn in his or her own problem sets. Due dates will be specified on the problem sets. Late submissions will be granted at most half of their total points. The problem sets will be graded by effort. Our GSI will discuss the homework and additional problems in the discussion sections. Solutions will be posted on eClass.

Surveys

Occasionally, I will send out some surveys that will help me to learn about all of you, such as your opinions/concerns/questions. These surveys are part of the class participation, and I will assign a few points to each of such surveys. Filling out surveys is voluntary, and by completing them, you can earn extra points that will increase your total score (also see the Exam and Grades section).

Exams and Grades

The final exam (100 points) will take place on Friday, August 25. Letter grades will be Pass or Fail. I will discuss the details with you in class.

Given that this is a review course and your math background may vary, attendance of either the lecture or the discussion section is not mandatory; but they will definitely help you to pass the course and become more prepared for your first-year classes. Eventually, whether

you pass or not depends on whether your total score (problem sets+final exam+surveys) satisfies the passing criterion that I will announce later.

Course Topics

- **Part 1: Basics**
  - Sets, Functions, Correspondences, Numbers, Cardinality, Polynomials
  - Vectors, Algebra of vectors, Vector spaces, Dimension, Linear independence.
  - Linear functions, Matrices, Matrix algebra, Rank of matrices, Inverse matrices.
  - Determinant of matrices, Eigenvectors, Eigenvalues, Inner product of vectors, Length of vectors, Distance between vectors
  - Neighborhoods, Open sets, Closed sets, Compact sets, Sequences, Cauchy sequences.
  - Continuous functions, Upper- and Lower-hemicontinuous Correspondences.
  - Maxima, Minima, The Weierstrass Theorem, the Maximum Theorem
  - Convex sets, Convex hulls, Concave functions, Quasi-concave functions.
  - Contraction mapping theorem, Brouwers' fixed point theorem, Kakutani's fixed point theorem.
- **Part 2: Analysis and Optimization**
  - Derivatives (one-variable function), Mean value theorem, L'Hospital's rule, Higher order derivatives, Taylor's theorem
  - Total derivatives, Partial derivatives, Directional derivatives, The chain rule, Higher order derivatives
  - Inverse function theorem, Implicit function theorem.
  - Riemann integrals, the fundamental theorem of calculus, integration by parts, Fubini's theorem.
  - Unconstrained optimization. First order conditions, Second order conditions
  - Constrained optimization problems with equality constraints, Theorem of Lagrange
  - Constrained optimization problems with inequality constraints, Theorem of Kuhn and Tucker

  - The value function; The envelope theorem for constrained and unconstrained maximization problems.
  - Concave programming

- **Part 3: More advanced topics**
  - Difference Equations, Explicit solutions for linear difference equations.
  - Scalar Ordinary Differential Equations
  - Systems of Ordinary Differential Equations, Stability
  - (*time permitting*) Dynamic Programming, Bellman equation, Euler equation, transversality conditions, Optimal Control.

Books

To prepare for Econ 500, I have used the following books. They might be helpful but you are not required to buy any of them. If you would like to buy only one of these, then I highly recommend **Simon and Blume**, which covers many topics in a very readable style.

- Simon and Blume, Mathematics for Economists
- Aliprantis and Border, Infinite Dimensional Analysis: A Hitchhiker's Guide
- Hefferson, Linear Algebra, (http://joshua.smcvt.edu/linearalgebra/book.pdf)
- Leonard and van Long, Optimal Control Theory and Static Optimization in Economics
- Kreps, Microeconomic Foundations I, Choice and Competitive Markets
- Royden, Real Analysis
- Rudin, Principles of Mathematical Analysis
- Stokey, Lucas, and Prescott, Recursive Methods in Economic Dynamics
- Strang, Linear Algebra and Its Applications
- Sundaram, A First Course in Optimization Theory