Syllabus: PhD Math Review

Department of Applied Economics, University of Minnesota

Aug 9-27, 2021

Meeting Times: 9-12 Mon-Fri by Zoom (link)

Instructor: Matt Bombyk (bomby001@umn.edu)

Office Hours: By Zoom, 1-2 PM M-F or by appointment (link)

Course Description

This course is intended as a review of the key mathematical techniques used in microeconomic and econometric analysis. In particular, it is intended to give students the mathematical knowledge needed to succeed in the first-year Ph.D Micro theory and Econometrics sequences in the Applied Economics department. Much of the material will be review for most students, but the emphasis will be on different topics than in traditional math classes.

Some of the material is likely to be new, but is so foundational for all economic analysis that it is worth learning beforehand. This includes the sections on optimization, comparative statics, and asymptotic statistics. Highly specialized mathematical topics used in particular economic applications will generally be taught in the economics courses themselves, so this course is intended to lay and reinforce the foundations for understanding those specialized topics.

The course will be held on Zoom. Recordings of the Zoom meeting, and copies of the whiteboard notes, will be available for students after class.

References

These books are not required, but will be very useful as references. Any version should work. I recommend buying Simon and Blume at the least.

- **Stewart: Calculus.** I will be using 5e since that's what I have. You can get the 5th edition on Amazon for about $10 used. The current version is 9e. I think it's a really nice intro calculus book, and probably many of you have used it before. Get the full one, not the version which contains only the first half.
- **Simon and Blume: Mathematics for Economists.** This covers almost all the topics in this class, explains them clearly, and proves most important theorems. It is a great reference for any economics student.
- **Chiang: Fundamental Methods of Mathematical Economics.** This covers most of the topics in this class, and has a heavy economics emphasis with lots of worked examples. It is especially good for learning about differentials, comparative statics, and optimization.

- **DeGroot and Schervish: Probability and Statistics.** This is the standard probability and statistics textbook for the UMN Statistics department's first-year master's sequence. Excellent reference.
- **Greene: Econometric Analysis.** Textbook for APEC 8211. The appendices cover much of the probability, statistics, and linear algebra concepts in this course.
- **Mas-Colell, Whinston, and Green: Microeconomic Theory.** Textbook for APEC 8001-4. Appendices cover many important math topics for economists, including optimization.
- **Strang: Linear Algebra and It's Applications.** Probably the best and most intuitive intro text for linear algebra. The author also has very popular lectures available for free on MIT OpenCourseWare.
- **Velleman: How to Prove It.** Great resource for learning about mathematical logic and practicing proofs.

Course Schedule

Day 1: Logic, proofs

Day 2: sets, topology of Euclidean space, convex sets

Days 3-4: Single variable calculus—functions, limits, continuity, derivatives, integrals, sequences, series, key theorems

Day 5: Multivariate calculus—partial derivatives, total derivatives, matrix derivatives, differentials, chain rule, implicit function theorem

Day 6: Function properties—homogeneity, homotheticity, concavity, quasiconcavity, monotonicity, correspondences, continuity, fixed point theorems

Days 7-9: Linear algebra—matrix algebra, linear systems, linear independence, determinants, inverse, eigenvalues and eigenvectors, symmetric matrices, definiteness, vector spaces

Days 10-12: Optimization—unconstrained, constrained, nonlinear programming, concave programming, maximum theorem, envelope theorem, comparative statics

Day 13: Probability theory—random variables, expectations and variance, common distributions

Days 14-15: Statistics—least squares, inference, law of large numbers, central limit theorem, asymptotic theory