Econ 401

Mathematical Methods

Fall 2020

Time and Location: The class starts on Thu., August 20 and ends on Mon., September 14. Lectures: 9 A.M-12 P.M. (on days other than Wed.); Problem Sessions: 1-2 P.M., and on Wed. also 9 A.M.-12 P.M.

Instructor: Wojciech Olszewski, wo@northwestern.edu, office hours: Thu. 6-7 P.M. and by appointment; **Teaching Assistants:** Maren Vairo, mvairo@u.northwestern.edu, and Fransisco Pareschi, francisco-pareschi2023@u.northwestern.edu, office hours: TBA

Econometrics Review: an independent class taught by Deborah Kim, deborahkim2022@u.northwestern.edu. The class starts on Thursday, August 27, and ends on Monday, September 14. Lectures: Mon. - Fri., 2 P.M. - 4 P.M.

All four of us will use the same site on CANVAS.

Course Overview

The purpose of this course is to refresh incoming PhD students with essential mathematical tools for their programs. The course covers topics in topology, real analysis, optimization, linear algebra and probability theory. Aside from providing mathematical tools, this course aims to contribute to developing the level of mathematical sophistication necessary to conduct research in many areas of economics. The course will therefore emphasize logical clarity and mathematical rigor, along with the ability to follow and construct proofs. Some part of each class will be devoted to writing rigorous proofs. Except Wednesdays, there will be daily lectures, followed by problem sessions and daily problem sets. On Wednesdays, there will be extra long TA sessions solving questions and reviewing issues with which the students say they had problems. On one of the last days of class, there will be a mandatory exam. I will be available to discuss final exams during the first weeks of the fall quarter. For those who feel they may benefit from some additional mathematical training, I would also be happy to discuss courses offered by the mathematics department at that time, or potential other readings. I will also be available for a limited number of extra classes during the fall to cover math material that students are having trouble with.

Textbooks

The primary reference for this course will be a set of lecture notes, which will distributed in class. A textbook designed for this kind of class is Simon and Blume (1994): Mathematics for Economists. As an introduction to topology and real analysis, I would recommend Rudin (1976): Principles of Mathematical Analysis, or Ok (2005): Real Analysis with Economic Applications. The former book is a classic math textbook for this material. The latter book contains some more advanced material, and its advantage is that its

author is an active-in-reaserch economist. Oxtoby (1980): Measure and Category is an excellent introduction to probability theory and topology, but its focus is somewhat different from a typical math refresher course. Students should also consider studying popular probability theory textbooks such as Billingsley or Shiryaev. The mathematical appendix of Mas-Colell, Winston and Green (1995): Microeconomic theory contains a condensed overview of mathematical tools which are used in microeconomic theory. Finally, Aliprantis and Border (2006): In finite Dimensional Analysis: A Hitchhiker's Guide is a great reference book containing many results from various areas of mathematics, which turned out useful in economics.

"Prerequisite" readings

Some students ask for readings, for the vacation before entering the graduate school. I would recommend to look first at the appendix of Mas-Colell, Whinston and Green. If you know, and can prove on your own, most theorems from this appendix, you will not need any in advance readings. You may use your time to study more advanced probability textbooks, or review Aliprantis and Border. Otherwise, I would recommend to read Rudin if you have no, or little, experience with writing proofs; and to read Simon and Blume if you see large parts of the material for the first time, or have seen it a long time ago. From Rudin, I would recommend Chapters: 2, the first five sections of 3, 4-5, the first three sections of 6, 7, and 9. Particularly relevant chapters from Simon and Blume are 7-19, 23, and 29-30.

Course Outline (Tentative)

The following is a tentative course outline.

Date	Lecture
8/20	Linear Algebra: Systems of Equations, Elementary (and other basic) Operations on Matrices
8/21	Linear Algebra: Eigenvalues, Eigenvectors, Jordan Theorem
8/24	Linear Algebra: Determinants, Linear Mappings, Geometry Concepts
8/25	Topology: Metrics, Open Sets, Sequences
8/27	Topology: Compactness, and other properties of topological spaces
8/28	Topology: Mappings, Correspondences, (Hemi-) Continuity, Fixed Points, Min-Max Theorem
8/31	Real Analysis: Differentiation, and basics of Integration
9/01	Real Analysis: Differentiation, and basics of Integration, to be continued
9/03	Real Analysis: Optimization: Unconstraint Optimization, Equality-Constrained Optimization
9/04	Real Analysis: Inequality-Constrained Optimization
9/07	No Class
9/08	Examination
9/10	Probability Theory: Basic Concepts in Discrete Spaces

9/11	Probability Theory: Lebesgue Measure, and more general objects and concepts
9/14	TBD