Econ 401

Mathematical Methods

Fall 2024

Time and Location: The class starts on Mon., August 26 and ends on Thu., September 19. 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. All classes will be in New Global Hub 1410, unless a different location is announced.

Instructor: Wojciech Olszewski, wo@northwestern.edu, office hours: every day 8-9 P.M. on Zoom, or by appointment in New Global Hub 3231; **Teaching Assistants:** Nina Fluegel (ninafluegel2026@u.northwestern.edu) and Yutong Zhang (zhangyutong2017@u.northwestern.edu)

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. Large parts of each class will be devoted to proofs.

Except Wednesdays, there will be daily lectures, followed by problem sessions. Every day, there will be a new problem set. We are unable to grade problem sets daily, but we will discuss them in problem sessions. On Wednesdays, there will be extra long TA sessions for solving questions and reviewing issues with which students reported problems. Lectures have been recorded, and students will be given links to the recordings. This should enable students to participate in lectures remotely. However, this form of studying is much less effective than attending classes and sessions. There will be an exam, which will consist of two parts, and your grades from these exams will be available to all faculty members from your department. 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 in the coming academic year, and potential additional readings.

Textbooks

The primary reference for this course will be a set of lecture notes, which will be posted on Canvas in advance (at least one day before the class). The class will be recorded in advance, and students will be given links to the recordings (again, at least one day before the 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 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.

Course Outline (Tentative)

The following is a tentative course outline.

Date	Lecture
8/26	Linear Algebra: Systems of Equations, Elementary (and other basic) Operations on Matrices
8/27	Linear Algebra: Determinants, Linear Mappings, Geometry Concepts
8/29	Linear Algebra: Eigenvalues, Eigenvectors, Jordan Theorem
8/30	Topology: Metrics, Open Sets, Sequences
9/03	Topology: Compactness, and other properties of topological spaces
9/05	Topology: Mappings, Correspondences, (Hemi-) Continuity, Fixed Points, Min-Max Theorem
9/06	Examination
9/09	Real Analysis: Differentiation, and basics of Integration
9/10	Real Analysis: Differentiation, and basics of Integration, to be continued
9/12	Real Analysis: Optimization: Unconstraint Optimization, Equality-Constrained Optimization
9/13	Real Analysis: Inequality-Constrained Optimization
9/16	Probability Theory: Basic Concepts in Discrete Spaces
9/17	Probability Theory: Lebesgue Measure, and more general objects and concepts
9/19	Examination