ECON 6170: Intermediate Mathematical Economics I

Lectures:	Tuesdays and Thursdays, 2.55pm to 4.10pm, Rockefeller Hall 132
TA discussions:	Fridays 2.55pm to 4.10pm, Uris Hall 202
Instructor:	Takuma Habu (takumahabu@cornell.edu)
Instructor office hour:	Thursdays, 4:30pm to 5:30pm, Uris Hall 446
TA:	Patrick Ferguson (pcf44@cornell.edu)
TA office hour:	Mondays and Thursdays, 4.15pm to 5.15pm, Uris Hall 445.

Overview

The class will develop mathematic skills and knowledge needed to read academic economics papers and produce research as a professional economist. In doing so, you will develop the skill to read and evaluate proofs (is it correct?), as well as develop the skills to compose your own proofs. These skills are essential to understanding any branch of economics (theoretical, empirical, experimental etc.).

We will begin with some real analysis that forms the foundation for static optimisation theory. We we will then study topics that appear frequently in economics such as convex analysis, monotone comparative statics, and fixed point theorems. In learning the material, you will have plenty of practice on how to think in rigorous terms: assumptions, statement, proof. The emphasis is on understanding definitions, building a mental map of prototypical examples, and becoming comfortable with proving results formally. You are expected to have seen (but possibly not mastered) most of this material before. The emphasis here will be on getting you acquainted with terminology, definitions, and proofs. We will also explore how the results are used across a wide range of context.

Tips for success Just reading books and notes, and listening to lectures (i.e. passive learning) *will not* work—you have to learn actively by working through the proofs and examples we go over in class (active reading), taking notes during class (active listening), and solving practice questions and problem sets. Working in groups is strongly encouraged BUT always try to work through all problems on your own before meeting with others. And check your understanding by explaining it to others! Like most other PhD classes, the workload is set assuming group thinking/work and so will likely overload you if you were on your own!

Prerequisites

I assume that you understand the materials that we covered in the *Math Review for the Field of Economics* during the summer. In any case, I expect there to be a lot of heterogeneity in mathematical preparation, and that is okay! Those with less experience with Real Analysis will naturally find some topics tougher but hopefully rewarding to learn. Those with more experience will still likely encounter a lot that is new.

Grading

Grading is based on problem sets (40%) and tests (60%). Problem sets will be given out after the relevant classes. Answers to problem sets are encouraged to be typeset using Latex but can also be (neatly) handwritten. You may work in groups but you must submit your own solutions and list students with whom you collaborated with. Late assignments are typically not accepted; however, please contact me if you are facing special circumstances.

Textboooks

The material is self contained and most of the class can be followed through class notes alone. There may be required reading posted on Canvas for some classes. If you would like more solid references, you may consider the following textbooks: *Real Analysis with Economic Applications* by Efe Oke; *A First Course in Optimization Theory* by Raghu Sundaram; *Mathematics for Economists* by Carl P. Simon and Lawrence Blume; *Further Mathematics for Economic Analysis* by Knut Sydsaeter, Peter Hammond, Atle Seierstad, and Arne Strom; *Microeconomic Foundations I* by David Kreps; *Principles of Mathematical Analysis* by Walter Rudin; *Convex Optimization* by Lieven Vandenberghe and Stephen P. Boyd; *Real Analysis* by Halsey Royden and Patrick Fitzpatrick.

Expectations, Course Policies and Resources

This course aims to collectively create a welcoming, supportive and tolerant environment for all students and respects the various forms of diversity that they bring, including differences related to race, gender, sexuality, class, nationality, geography, age, size, ability, etc. To this end, I ask that we be respectful of each other, actively listen, participate, ask relevant questions, and give balanced, specific, and constructive feedback to each other. Our focus is on achieving the student learning outcomes. In order to do this, it is important you be prepared and do your best.

Academic Integrity

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work.

Resources and Accommodations

You will find all the relevant materials on the Canvas course site. I have enabled Ed Discussion for the course (https://edstem.org/us/courses/44155/discussion/) to facilitate communication—please use it to ask questions about the course material or administrative issues. I emphasise that if *you* have a question, it's very likely that others have the same question too! Moreover, if you know the answer, please help your classmates and post responses.

Services and reasonable accommodations are available to persons with temporary and permanent disabilities, students with DACA or undocumented status, students facing mental health or other personal challenges, and students with other kinds of learning challenges. Please feel free to let me know if there are circumstances affecting your ability to participate in class. Some resources that might be of use include the following.

- ▷ Office of Student Disability Services: https://sds.cornell.edu.
- ▷ Cornell Health CAPS (Counseling & Psychological Services): https://health.cornell.edu/services/counseling-psychiatry.
- ▷ Undocumented/DACA Student support: See the list of campus resources at https://dos.cornell.edu/undocumented-daca-support/undergraduate-admissions-financial-aid.

Course Outline

A tentative course outline is the following (with roughly 2-4 lectures per module). We will keep the schedule flexible, so topics may be added and removed from this list.

(i) **Real sequences.** Real numbers; Supremum and infimum; Convergence of sequences; Bounded sequences, monotone sequences; Sub-sequences and Bolzano-Weierstrass theorem.

(ii) **Euclidean topology.** Cauchy sequences; Open and closed sets, compactness; Continuity and semi-continuity of real functions; Extreme value theorem, intermediate value theorem; Beyond Euclidean spaces.

(iii) **Convexity.** Convex set, convex hull of a set; Concave and convex functions; Quasi-concavity and quasi-convexity; Separating hyperplane theorem; Supporting hyperplane theorem.

(iv) **Correspondences.** Hemicontinuity; Berge's theorem of the maximum.

(v) **Differentiation.** Differentiability, partial and total derivatives; Mean value theorem, Taylor's theorem; Implicit and inverse function theorem.

(vi) **Static optimisation.** Unconstrained optimisation; Lagrangian method and Karush-Kuhn-Tucker (KKT) conditions; Weak/Strong duality*.

(vii) **Comparative statics.** Implicit function theorem; Envelope theorem; Lattices and monotone comparative statics.

(viii) **Fixed-point theorems.** Brouwer and Kakutani; Tarski; Banach.

Tentative exam schedule

Exams	**Date**
Mid-term 1	23 September 2024
Mid-term 2	28 October 2024
Mid-term 3*	26 November 2023
Final	Finals week (TBC)