

# MATHEMATICAL METHODS FOR PHD AND MACRM

Summer 2020

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<b>Time:</b>	MTWRF 9:00 am– 10:30 am	<b>Place:</b> <i>Zoom</i>

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**Course Pages:** <https://sites.google.com/site/liqunliu90/group-assignments/math-camp>

**Recitation Session:** 8:00-9:00 pm

**Registration:** Harris PhD and MACRM students.

**Overview:** In modern days, one cannot understand economic theory without a working knowledge of mathematical analysis. This course aims to prepare students to succeed in the Harris PhD core courses, and provide a solid foundation for future technical training. *Prerequisites:* Multivariate calculus and linear algebra.

**Plan:** The course covers topics relevant to the study of applied theory and econometrics. Due to the pandemic, the course will be a mix of recorded and zoom lectures. Before the math camp officially starts, I expect you to go through materials posted on the course page, including a review of analysis in  $\mathbb{R}^n$ , linear algebra, and differential equation. We will then meet via zoom discussing convex analysis, optimization, and monotone comparative statics. Motivating examples are drawn from economic theory.

**Requirement:** There will be daily problem sets to be discussed in the recitation sessions. I encourage you to work in groups. But each student has to write up independent solutions to master the materials.

## Main References:

- Cinlar, Erhan and Robert Vanderbei (CV), *Real and Convex Analysis*, Springer, 2012.
- Hirsch, Morris, Stephen Smale and Robert Devaney (HSD), *Differential Equations, Dynamic Systems, and An Introduction to Chaos*. Elsevier, 3rd ed. 2013
- Jehle, Geoffrey and Philip Reny (JR), *Advanced Microeconomic Theory*, Addison Wesley Longman, 2nd ed. 2001
- Ok, Efe, *Real Analysis with Economic Application*, Princeton, 2007
- Vohra, Rakesh, *Advanced Mathematical Economics*, Routledge 2005

## Optional Texts

- Aliprantis, Charalambos and Kim Border, *Infinite Dimensional Analysis: A Hitchhiker's Guide*, New York, Springer-Verlag, 1999.
- Corbae, Dean, Maxwell Stinchcombe and Juraj Zeman, (DSZ) *An Introduction to Mathematical Analysis for Economic Theory and Econometrics*, Princeton, 2009

## Main Topics

## 1. Metric Space (Recorded Lectures)

- Basics: set theory, binary relation, equivalence class
- Metric space: real line, topology, convergence, completeness, compactness, Heine-Borel, connectedness, intermediate value theorem, continuity
- Normed vector space, derivative, mean value theorem, implicit/inverse function theorem

Main reference: CV

## 2. Linear Algebra, Differential Calculus and ODE (Notes+Siegel's Lectures)

- Linear algebra: vector space, linear dependence, matrix, determinants, eigenvalues and eigenvectors, diagonalization
- First and second order ODE

Main reference: Vohra, HSD

## 3. Convex Analysis and Optimization (Zoom)

- Convex Analysis: convex sets, separating hyperplanes, (quasi) concave functions
- Optimization: unconstrained/constrained optimization, Karush-Kuhn-Tucker condition

Main reference: Vohra, DSZ, JR

## 4. Advanced Topics (Zoom)

- Fixed point theorem: Banach, Brouwer, Kakutani
- Lattice theory and supermodularity, monotone comparative statics
- Envelope Theorem

Main reference: Ok, Vohra, Yildiz's lecture notes,