

**Instructor:** Sergio Ocampo-Díaz \_\_\_\_\_ ocamp020@umn.edu

**Teaching Assistant:** Salim Syed-Chanto \_\_\_\_\_ syedc001@umn.edu

**Lectures:** Monday to Friday - 9:30am to 12:00m

**Room:** CSOM 2-233 (Carlson School of Management, room 2-233)

**Recitations:** Tuesday and Friday - 2:00pm to 3:30pm

**Room:** Hanson 1-111

**Office Hours:** All office hours are by appointment. Contact the instructor or TA by email.

**Content:** This course will serve as a basic review of some fundamental mathematical concepts and techniques that are necessary for the study of modern economics. Due to time constraints, we cannot hope to survey all the mathematics that you may employ during your studies. The goal of this course is to ensure that upon completion all students are prepared to begin graduate economic coursework at Minnesota. Thus the course focuses on certain material that the students will encounter during their first year of graduate studies.

The course is provisionally organized by lessons which should take a day each, but this scheme is flexible and will be subject to changes as the course advances. Some extra topics will be covered in the recitation by the Teaching Assistant.

1. **Real Analysis** - 4 lectures

- (a) Preliminaries (Wade, Ch. 1, Sundaram, Ch. 1)
- (b) Sequences on  $\mathbb{R}$  (Wade, Ch. 2)
- (c) Continuity on  $\mathbb{R}$  (Wade, Ch. 3)
- (d) Sequences of functions (Wade, Ch. 7.1)
- (e) Topology of  $\mathbb{R}^n$  (Wade, Ch. 10)

2. **Convex Analysis** - 3 Lectures

- (a) Convex sets (Sundaram, Ch. 1, Rockafellar, Ch. 1-3)
- (b) Convex and concave functions (Sundaram, Ch. 7)
- (c) Quasi-Convex and quasi-concave functions (Sundaram, Ch. 8)

3. **Optimization** - 3 Lectures

- (a) Unconstrained optimization (Sundaram, Ch. 2-4)
- (b) Constrained Optimization (Sundaram, Ch. 5-6)
- (c) Convexity and Optimization (Sundaram, Ch. 7-8)

4. **Parametrized Optimization** - 3 Lectures

- (a) Correspondences (Sundaram, Ch. 9, SLP, Ch. 3)
- (b) Theorem of the Maximum (Sundaram, Ch. 9, SLP, Ch. 3)
- (c) The Envelope Theorem (Milgrom and Segal, 2002)

## 5. Dynamic Programming - 4 Lectures

- (a) Contraction Mapping Theorem (SLP, Ch. 3)
- (b) The Bellman Equation (SLP, Ch 4)
- (c) Applications

## 6. Probability and Measure Theory - 3 Lectures

- (a) Measure (SLP, Ch 7, Kolmogorov, Ch 7)
- (b) Measurable functions (SLP, Ch 7, Kolmogorov, Ch 8)
- (c) The Lebesgue integral (SLP, Ch 7, Kolmogorov, Ch 8)
- (d) Markov Processes (SLP, Ch 8)

**Homework** The course does not assign a formal grade but practice of the concepts covered in class is crucial to mastering them and understanding their applicability in economics. Because of this there will be problem sets assigned twice a week. The problem sets will be graded and discussed in the recitation.

**References:** The material for the course is selected from several books and handouts will be made available to students in a regular basis providing a summary of the topics covered in class. The books are Wade (2010) for real analysis, Sundaram (1996) for convex analysis and optimization and Stokey et al. (1989) for dynamic programming and measure theory. These books are complemented with selections from Rockafellar (1997), and Kolmogorov and Fomin (2012). None of the books is mandatory for the students; however, a detailed study of the material in Sundaram (1996) will yield high returns in the near future for students enrolled in graduate level economics courses.

## References

- Irigoyen, C., Rossi-Hansberg, E., and Wright, M. (2009). *Solutions Manual for 'Recursive Methods in Economic Dynamics'*. Harvard University Press.
- Kolmogorov, A. and Fomin, S. (1999). *Elements of the Theory of Functions and Functional Analysis*. Number v. 1 in Dover books on mathematics. Dover.
- Kolmogorov, A. and Fomin, S. (2012). *Introductory Real Analysis*. Dover Books on Mathematics. Dover Publications.
- Mas-Colell, A., Whinston, M. D., and Green, J. R. (1995). *Microeconomic Theory*. Oxford University Press.
- Milgrom, P. and Segal, I. (2002). Envelope Theorems for Arbitrary Choice Sets. *Econometrica*, 70(2):583-601.
- Rockafellar, R. (1997). *Convex Analysis*. Convex Analysis. Princeton University Press.
- Stokey, N., Lucas, R., and Prescott, E. (1989). *Recursive Methods in Economic Dynamics*. Harvard University Press.
- Sundaram, R. (1996). *A First Course in Optimization Theory*. Cambridge University Press.
- Wade, W. (2010). *An Introduction to Analysis*. Featured Titles for Real Analysis Series. Prentice Hall/Pearson.