Logistics

**Instructors:** Atara Oliver, sao5@rice.edu, Kirill Evdokimov, kirill.evdokimov@rice.edu

**Schedule:** May 27 - July 19, MTWThF, 20 Lectures

**Time:** Two-hour Online Lecture (one hour per day) MTWThF

**Exam:** Week of July 28, exact time will be announced later

**Location:** Canvas Platform, https://canvas.rice.edu

**Office Hours:** 9am - 10am and 9pm - 10pm (Central Daylight Time), Canvas, T/Th

Course Outline

The aim of this course is to introduce/remind you of the mathematics required for Ph.D. courses in economics. Specifically, in this course, we will learn/remember standard tools and cookbook procedures that are required for the first year Ph.D. courses.

We divide the lectures into five parts: Real Analysis, Linear Algebra, Calculus, Optimization, and Difference & Differential Equations. There will be one homework for each part, and there will be questions to be answered following the online lectures to measure your attendance. You should expect to study two hours on average for reviewing the material and doing the homeworks. The homeworks can be completed individually or in groups of two students. There will also be a quiz on each part, which must be completed individually and is closed book. Quizzes will typically not be proctored, although we may proctor some quizzes.

There will be an exam at the end of the course. The final exam will be proctored. We will designate times in which we will proctor the exam by webcam, or if you would prefer you can choose to take the exam in a test center. We may consider allowing other individuals to proctor the exam at my discretion.
In addition, there will be daily office hours twice a day. The attendance to the office hours is not mandatory but highly encouraged. We will be available to answer your questions and you will have opportunity to interact with your classmates.

The weights of attendance at the lectures, homeworks, quizzes, and the exam are 10%, 40%, 20 %, and 30% respectively.

General Readings:


I. Real Analysis (Lectures 1-4)

(a) Sets:

- Algebra of Sets
- Families of Sets
- Cartesian Product
- Binary Relations and Ordered Sets, Supremum and Infimum
- Functions and Correspondences

Extra Reading:


(b) Metric Spaces:

- Metric Spaces, Euclidean Spaces
- Topological Properties of Sets: Open, Closed, Compact, Dense and Connected Sets; Interior, Closure and Boundary of Sets
- Topological Properties of Sequences: Convergence, Subsequences, Cauchy Sequences, Upper and Lower Limits, Complete Metric Space, Series and Absolute Convergence
- Topological Properties of Functions and Correspondences: Continuity, Upper and Lower Semicontinuity
- Continuity, Compactness and Connectedness

Readings:


II. Linear Algebra (Lectures 5-9)

(a) Linear Algebra:
- Vectors, Vector Operations
- Linear Dependence
- Basis, Vector Spaces and Subspaces
- Matrices and Matrix Algebra
- Inner Product and Projection
- Linear Transformations
- Rank and Determinant
- Solutions to Systems of Linear Equations: Gaussian Elimination and Cramer’s Rule

Reading:


(b) Convexity:
- Convex Set, Convex Hull, Extreme Points and Convex Cone
- Carathedory’s Theorem
- Convex, Concave, Quasiconvex and Quasiconcave Functions
- Separating Hyperplane Theorems

Reading:


III. Calculus: (Lectures 10-12)

Differentiation and Integration:
- The Derivative of a Real Function
- Mean Value Theorems
- L'Hospital's Rule and Taylor's Theorem
- Integral of a Real Valued Function
- Integration and Differentiation: The Fundamental Theorem of Calculus
- Integration by Parts and Leibniz Integral Rule
- The Inverse Function Theorem and The Implicit Function Theorem

Readings:


IV. Optimization (Lectures 13-17)

Static Optimization:
- Linear Programming, Duality Theorems and Simplex Method
- Weierstrass Theorem: Existence of a Maximizer
- Unconstrained Optimization: Fermat’s Theorem, First and Second Order Conditions
- Constrained Optimization: Constraint Set, Lagrangean, KT-conditions
- Convexity and Optimization: Necessity and Sufficiency
- Saddle Point Theorem, The Envelope Theorem and the Theorem of the Maximum

Readings:


V. Difference and Differential Equations (Lectures 18-20)

Difference and Differential Equations:
- Difference Equations
- Cobweb Diagram
- First and Second Order Linear Differential Equations
- Homogenous and Nonhomogenous Differential Equations
- Phase Diagram
- System of Differential Equations
- Existence and Stability of Rest Points

Reading: