Math Camp

Advanced Studies Program

Kiel Institute for the World Economy

Richard Schnorrenberger
Institute for Statistics and Econometrics Kiel University
Olshausenstr. 40, WSP7, D-24098 Kiel
Email: richard.schn@stat-econ.uni-kiel.de

Course Description

Mathematics has become the language of modern analytical economics, providing the tools necessary to quantify relationships between economic variables and among economic agents. This intensive course is designed to equip participants with a solid foundation in the essential mathematical tools for advanced study and research in economics. The course will cover key topics in real analysis, calculus, linear algebra, optimization, probability theory, and estimation.

Theoretical concepts will be introduced using slides, ensuring a clear understanding of the mathematical principles underlying each topic. This discussion will be followed by extensive hands-on sessions. Participants will apply abstract mathematical reasoning to real-world economic examples and work through Matlab code samples in interactive notebooks on their laptops. Each module also includes problem sets that allow participants to practice and solidify their understanding of the material through concrete examples. By the end of the course, participants will have a comprehensive grasp of the mathematical skills necessary to engage with advanced economic models and conduct rigorous economic research.

List of Topics

1. Introduction and Foundations of Real Analysis
   (a) Mathematics in Economic Theory
   (b) Sequences and Series
   (c) Limits of Functions, Limit Theorems and Continuity
2. Calculus Fundamentals
   (a) Differentiation
   (b) Derivatives in Use: Implicit Differentiation and Implicit Function Theorem
   (c) Linear Approximation and Taylor's Theorem
   (d) Riemann Integral and Fundamental Theorem of Calculus

3. Linear Algebra
   (a) Matrix Algebra
   (b) Determinants and Matrix Inversion
   (c) Eigenvalues and Eigenvectors
   (d) Rules of Matrix Calculus
4. Optimization
   (a) Concave and Convex Functions
   (b) Unconstrained and Constrained Optimization
   (c) Linear and Nonlinear Programming
5. Probability Theory and Estimation
   (a) Random Variables and Probability Distributions
   (b) Essential Asymptotics: Law of Large Numbers, Central Limit Theorem, Consistency and Convergence in Probability and Distribution, Preservation of Convergence and Slutsky's Theorem
   (c) Least Squares Regression, Maximum Likelihood, Bootstrap, Gradient Descent, EM algorithm, and Bayesian Simulation Techniques

Prerequisites: Participants are expected to have a solid understanding of undergraduate-level calculus, linear algebra, and probability theory. Prior experience with basic programming, especially in Matlab, is also recommended for effectively engaging with the coding exercises and interactive notebooks.

Credits: 22.5 hours lectures and classes (over two weeks).

Assessment: a two-hour final exam. The precise time and location of the exam will be circulated during the course.

Planned Course Structure:
The daily coverage might change as it depends on the progress of the class. However, students are expected to keep up with the lecture content and assignments.

Day	Content
Sep 9th	• Introduction and Foundations of Real Analysis – Mathematics in Economic Theory – Sequences and Series – Limits of Functions, Limit Theorems and Continuity • Brief Review of Matlab's Building Blocks • Calculus Fundamentals – Differentiation – Take-Home Reading Assignment and Problem Set
Sep 10th	• Calculus Fundamentals – Derivatives in Use: Implicit Differentiation and Implicit Function Theorem – Linear Approximation and Taylor's Theorem – Riemann Integral and Fundamental Theorem of Calculus – Take-Home Reading Assignment and Problem Set
Sep 16th	• Linear Algebra – Matrix Algebra – Determinants and Matrix Inversion – Eigenvalues and Eigenvectors – Rules of Matrix Calculus – Take-Home Reading Assignment and Problem Set
Sep 17th	• Optimization – Concave and Convex Functions – Unconstrained and Constrained Optimization – Linear and Nonlinear Programming – Take-Home Reading Assignment and Problem Set
Sep 18th	• Probability Theory and Estimation – Random Variables and Probability Distributions – Essential Asymptotics: Law of Large Numbers, Central Limit Theorem, Consistency and Convergence in Probability and Distribution, Preservation of Convergence and Slutsky's Theorem – Least Squares Regression, Maximum Likelihood, Bootstrap, Gradient Descent, EM algorithm, and Bayesian Simulation Techniques – Review for Exam – Take-Home Reading Assignment and Problem Set