Mathematical Sciences, PhD

Except as noted, all courses are 3 credits. With the exception of Topics courses and Problem seminars, the first semester of any two-semester course will comprise a survey of the important topics in the course. The second semester, offered only upon sufficient student demand, will consist of a deeper treatment of topics covered in the first semester.

Elementary Theory of Numbers
MAT 5115
Divisibility, congruence, quadratic reciprocity, elementary results in quadratic forms, diophantine equations, and rational approximation to irrationals. Applications to cryptology and data security.

Linear Algebra
MAT 5117
Vector spaces, basis, dimension, direct sums, factor spaces; linear transformations,

Ordinary Differential Equations
MAT 5209

MAT 5261
Definition and elementary properties of Lie groups and Lie algebras; vector bundles and connections. Morse theory. Elements of Hodge theory. Applications to high-energy physics and gauge-field theory.

Topology I, II
MAT 5262, 5263
A rigorous introductory treatment of point-set topology, differential topology, homotopy and homology.

Functions of a Real Variable
MAT 5265
Fundamentals of real analysis and applications. Lebesgue measure and integral. Integrals on sigma algebras. Probability measures. Introduction to Hilbert spaces and LP-spaces. Applications to Fourier series and to Fourier and more general transforms.

Mathematical Statistics
MAT 5266
Development of statistical models as corollaries of theorems in probability, and a rigorous presentation of topics related to the practice of statistics and data analysis.

Convex Optimization
MAT 5267
Convex analysis in finite dimensions; linear programming; convex optimization with constraints; vector (multi-criteria) optimization problems from theoretical and computational perspectives. Applications to finance and economics, including convex risk measures, portfolio optimization and utility maximization problems.

Data Science: Fundamentals and Applications
MAT 5270
Statistical and computational fundamentals that form the basis for contemporary data science applications in biomedical science, finance and other cognate 'big data' disciplines are introduced. Core components include data exploration, data modeling, the use of data mining technologies and application examples. Course material will be complemented by hands-on programming experience, using the iPython programming environment, to allow the class to gain a hands-on experience of data science analytics.

Applied Data Science: Contexts and Methodologies
MAT 5272
Examination of exemplar data science publications from the domains of biomedical science, quantitative finance, geoscience and the astronomical sciences.

Topics and Problems in Analysis
MAT 5301, 5302

Techniques of problem-solving and estimation, and related concepts in real and complex analysis. An introduction to working analysis in distinction to theoretical analysis. Financial and engineering applications are emphasized.

Topics in Partial Differential Equations I, II
MAT 5310, 5311
General theory of linear partial differential equations. Semilinear, quasilinear, and fully nonlinear equations. Variational theory. Cauchy and boundary value problems, Estimates and regularity of solutions. Topics will be chosen from contemporary application to geometry, finance, continuum mechanics, plasma physics, and engineering.

Mathematical Logic and Computability Theory
MAT 5312
Boolean logics, truth functions, quantification theory, Turing machines. Horn algebras, lattices, quasivarities. Applications to computer science and, in particular, artificial intelligence.

Readings in Mathematical Logic
MAT 5315
Topics to be arranged, depending on the interests and backgrounds of the students. Given only by arrangement with the instructor.

Readings in Linear/Modern Algebra
MAT 5317