Math 5000: Special Topics (High-Dimensional Probability)
TR 12:30-1:50
Prof. B. Rider

This course provides a self-contained introduction to the area of high-dimensional probability and statistics from a non-asymptotic perspective, aimed at students across the mathematical sciences. It will include a focus on core methodology and theory (tail bounds, concentration of measure, random matrices, random graphs and networks) as well as in-depth exploration of various applications (to statistical learning theory, sparse linear and graphical models, community detection, as examples).

Textbook: Material will be drawn from
- *High-Dimensional Probability: An Introduction with Applications in Data Science*, by Roman Vershynin. (Cambridge University Press)
- *Probability in High Dimensions*, by Ramon van Handel. (Lecture Notes, Princeton University)

Math 5043: Introduction to Numerical Analysis
TR 2:00-3:20
Prof. D. Szyld

During the first semester of this course, the student is introduced to basic concepts in numerical analysis and scientific computing. In this discipline, algorithms for the solution of specific problems arising in science and engineering using computers, are presented and analyzed. The goal is to learn algorithms which approximate the solutions, in other words, one wants to guarantee that the answer produced by the computer code resembles the true solution. At the same time, one wants to produce algorithms which converge to the solution in a reasonable amount of time.

Some of the specific methods which will be studied include: Finding roots of non-linear equations. Approximation and interpolation of functions. Numerical integration. In addition, we will study how computers store and manipulate data, so we can study how errors produced by the use of non-exact arithmetic are generated and propagated in the specific algorithms. Stability of the algorithms will be studied as well.


Math 8011: Abstract Algebra I
TR 11:00-12:20
Prof. Martin Lorenz

This course, the first semester of a year-long graduate-level introduction to abstract algebra, is roughly organized into three main parts: Groups (Chapters 1-6 of the textbook), Rings & Modules (Chapters 7-12), and Fields (Chapter 13). The indicated chapters from the textbook contain more material than can be covered in one semester; so a selection will be made. Also, the last part (fields) will likely not be completed in the fall semester and continue in the spring, when the main topic will be Galois Theory. My approach and conventions will occasionally differ from those adopted in the textbook, but I will post complete classnotes for my lectures shortly after each lecture so that a record of the material as covered in class will be available to students.

The abstract algebra sequence Math 8011/8012 is a prerequisite for many of the higher-level graduate courses in pure mathematics and it provides the background needed for the PhD qualifying exam in Algebra.

Prerequisites: Math 3098 or equivalent or permission of instructor.

**Math 8041: Real Analysis I**  
TR 9:30-10:50  
Prof. K. Morgan

This course covers the classical theory of Lebesgue integral and its applications. Closely related topics such as functions of bounded variation, the Riemann-Stieltjes integral, Fubini’s theorem, and $L^p$-classes will also be discussed.

**Prerequisites:** Math 5041 or basic knowledge of real variables and Euclidean topology, sequences of functions, Riemann integration.


**Additional References:**
- M. Spivak, *Calculus on Manifolds* (ebook)

**Math 8061: Differential Geometry & Topology I**  
MW 9:00-10:20  
Prof. M. Stover

This course is an introduction to the basic theory of smooth manifolds that will prepare students for that portion of the PhD qualifying exam in geometry and topology. Topics include smooth manifolds and maps, transversality, vectors fields, and differential forms. If there is time, we will cover additional topics like vector bundles or de Rham cohomology.

**Prerequisites:** Abstract Algebra (Math 8011). Abstract Algebra can be taken concurrently.

**Textbook:** L. Tu, *An Introduction to Manifolds*.

**Math 8200: Topics in Applied Mathematics: Multiscale Modeling and Methods**  
MW 10:30-11:50  
Prof. B. Seibold

Many real-world systems possess a variety of scales, with the micro-scale dynamics of the constitutive particles (such as atoms in materials, biological cells in organisms, or vehicles in traffic flow) shaping emergent structures on the macroscopic laboratory scale in non-trivial ways. This course provides a trip into the world of mathematical multiscale methods that enable the systematic traversing of these scales. Besides introducing applications in materials, traffic flow, and the life-sciences, the course covers analytical multiscale methods (such as continuum dynamics from molecular dynamics, averaging methods, homogenization, Mori-Zwanzig formalism, kinetic theory, moment methods, and uncertainty quantification) as well as discusses important computational multiscale methodologies (such as multigrid methods, the fast multipole method, and adaptive mesh refinement).

**Textbooks:** Materials will be drawn from a variety of available resources, which will be announced or provided in class.
Math 9003: Modular Functions  
TR 2:00-3:20  
Prof. J. Lang

This course will introduce students to the basic algebraic theory of modular forms. The plan is to thoroughly cover the basics of Eisenstein series, modular curves, dimension formulae, and Hecke operators. We hope to reach, in some form, the Eichler–Shimura relation and the construction of the Galois representation attached to a weight-2 eigenform. In particular, by the end of the class, we will be able to state the modularity theorem of Wiles, which completed the proof of Fermat's Last Theorem. The class will regularly use results from complex analysis and the graduate algebra sequence. Other useful courses to have taken include elliptic curves, algebraic number theory, Riemannian geometry (just surfaces), and algebraic geometry, though these will not be assumed.

Textbook: A first course in modular forms, by Diamond and Shurman.

Math 9041: Functional Analysis I  
TR 11-12:20  
Prof. M. Ignatova

Functional Analysis provides the foundation for high dimensional geometry, analysis and probability. This one-semester course will introduce the fundamental concepts and methods of functional analysis with emphasis on concrete examples. The course will cover the Baire category theorem and applications, in particular to principles of Banach space theory (uniform boundedness principle, open mapping theorem, closed graph theorem). Different notions of convergence, weak topology, duality and convexity will be discussed. The course will provide an introduction to linear operator theory, including spectral theory for compact operators, selfadjointness, Fredholm theory and applications.

Prerequisites: linear algebra, advanced calculus, and real analysis.

Math 9071: Differential Topology / Mapping Class Groups  
MW 10:30-11:50  
Prof. S. Taylor

Homeomorphisms of surfaces play a central role throughout low-dimension topology and geometry. The mapping class group of a surface $S$, the group of such homeomorphisms, modulo homotopy, itself has a rich algebraic and geometric structure that can be studied using various tools throughout mathematics.

In this course, we will begin with the basic theory of the mapping class group (e.g. finite generation) and then move to understand it from a geometric point of view. Along the way, we will develop the theory of the mapping class groups action on the space of hyperbolic surfaces (Teichmüller space) and graphs that encode the combinatorics of curves on the surface (e.g. the curve complex.) Our emphasis throughout will be to learn about the structure of the mapping class group via the geometry of its actions.