Math 5044: Introduction to Numerical Analysis II  
TR 12:30-1:50  
Prof. G. Queisser  

**Topics Covered:** This course provides a rigorous introduction to numerical methods for ordinary differential equations, establishing both knowledge and understanding of modern and efficient methods, as well as tools of analysis to understand when and why different methods work (or fail). Particular topics: Runge-Kutta, multistep, and Taylor series methods. Deferred correction. Convergence and stability. Error analysis. Stiff problems. Boundary value problems. Finite differences. Stochastic ODEs.  

**Course Goals:** Provide a rigorous mathematical basis for numerical methods for ordinary differential equations, and lay the groundwork for more advanced courses on numerical differential equations. Provide insight and intuition to fundamental challenges inherent to many problems in computational science and engineering.  


**Further recommended reads:**  

Math 8008: Introduction to Methods in Applied Mathematics II  
TR 3:30-4:50  
Prof. I. Klapper  

This introductory level course gives a general overview of mathematical concepts and tools for applied mathematics. Topics to be covered include dynamical systems and bifurcation theory; asymptotic analysis and perturbation theory; systems of hyperbolic conservation laws. Material is independent of Math 8007.  

**Prerequisites:** Undergraduate level Calculus III and Ordinary differential equations.  

**Textbooks:**  
(1) M. H. Holmes, Introduction to Perturbation Methods, Springer, 1995;  
(2) S. H. Strogatz, Nonlinear dynamics and chaos, Westview Press, 2001
Math 8012: Abstract Algebra II  
TR 11:00-12:20  
Prof. Martin Lorenz

This course, the second semester of a year-long graduate-level introduction to abstract algebra, will start where the previous fall semester finished. I expect that I may have to wrap up finite Galois theory at the beginning of the semester. This will be followed by a thorough discussion of Galois extensions that are not necessarily finite. The next part of the course will be devoted to a deeper study of rings and modules. Topics to be covered in this part include noetherian rings and modules and the structure of modules over principal ideal domains. If time permits, an introduction to tensor products and other constructions of modern multilinear algebra will be given at the end of the semester.

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 8011 or equivalent or permission of instructor.


Math 8042: Real Analysis II  
MW 9:00-10:20  
Prof. C. Gutierrez

This is the second semester of a year long course covering the core areas of analysis. Emphasis will be on exercises and problems. The course will prepare students to take the Real Analysis section of the qualifying exam.

Topics to be covered:
(1) Abstract measures and integration  
(2) Differentiation of measures  
(3) Hausdorff measures  
(4) Basic functional analysis, Hilbert spaces, $L^p$-spaces  
(5) Fourier series and transforms


An electronic version of the book is available from Temple library. A paper copy of the book may be purchased from Amazon or the Temple bookstore.

Additional references:
(1) An Introduction to Measure Theory, Terence Tao, AMS, 2011.  

Prerequisites: Basic knowledge of real variables and Euclidean topology, sequences of functions, and Riemann integration; Lebesgue measure and integration.
Math 8062: Differential Geometry & Topology II  
TR 9:30–10:50  
Prof. R. Gupta  

This will be a standard course in algebraic topology. We will study the fundamental group, covering space theory and homology theory in detail. We will also aim to get a glimpse of cohomology theory leading up to Poincaré duality. This will cover most of Chapters 1 and 2, plus part of Chapter 3 of the textbook Algebraic Topology by Allen Hatcher.  
Prerequisites: Math 8061 or permission of instructor.  

Math 8141: Partial Differential Equations II  
MW 10:30-11:50  
Prof. M. Ignatova  

This course is a continuation of PDEs I (Fall 2020). It introduces fundamental concepts and results in the theory of elliptic, parabolic and hyperbolic differential equations. The following topics will be covered:  
(1) Second-order elliptic equations;  
(2) Linear evolution equations;  
(3) Nonlinear PDEs.  
Other good books on PDEs:  
• G. Folland: Introduction to PDEs, 2nd edition;  
• F. John: Partial Differential Equations, 4th edition;  
• Gilbarg and Trudinger: Elliptic Partial Differential Equations of Second Order
Math 8210: Topics in Applied Mathematics II. Survey of Fluid Dynamics
TR 10:30-11:50
Prof. I. Klapper

This course is designed as an introduction to and survey of basic ideas of fluid dynamics, a core subject of applied mathematics, for graduate students including those already engaged in dissertation research in related subjects. Topics covered will be chosen from below, depending on student interest.

1. CONSERVATION LAWS, CONSTITUTIVE LAWS, AND KINEMATICS. Basic principles of continuum mechanics and general consequences, conservation and constitutive laws, Bernoulli laws, vorticity and circulation, helicity.
2. INCOMPRESSIBLE FLOW. Navier-Stokes equations, scaling and dimensional analysis, standard solutions, Stokes equations and Stokes drag, boundary layers, turbulence.
3. 1D COMPRESSIBLE FLOW. Wave equations, acoustics, isentropic flow, gas dynamics, shocks and rarefactions, Riemann problems.
4. MISCELLANEOUS TOPICS. e.g. rotating fluids, stability, water waves, solitons, polymeric fluids.

Textbooks: Elementary Fluid Dynamics, D.J. Acheson. Other suggested references: Fluid Mechanics, Landau & Lifschitz; An Introduction to Fluid Dynamics, Batchelor.

Prerequisites: Previous experience with PDE and some physics is helpful but not required.

Math 9031: Advanced Probability Theory
MW 1:00-2:20
Prof. A. Yilmaz

This course is a continuation of MATH 8031. Topics to be covered: Introduction to stochastic processes; Poisson process; Markov chains; conditional expectations and martingales; ergodic theory; Brownian motion; continuous-time Markov processes; stochastic integrals and the Itô formula.

Math 9053: Harmonic Analysis. Techniques for Elliptic PDEs
TR 4:00-5:20
Prof. I. Mitrea

The course will provide an introduction to singular integral operator techniques for the treatment of elliptic boundary value problems in non-smooth domains. Topics will include:

- Characterizations of Lipschitz domains in terms of the uniform cone property.
- The Melnikov-Verdera geometric proof of the $L^2$ boundedness of the Cauchy integral operator on Lipschitz curves.
- Function spaces: Lebesgue spaces, Hardy spaces, BMO, VMO, Besov spaces.
- Singular integral operators of layer potential type.
- Nontangential maximal operators and nontangential traces.
- Well-posedness of boundary value problems for second order equations and systems via the layer potential method.

Prerequisites: Real Analysis, Lebesgue integration, PDEs.
Math 9072: Differential Topology II. Hyperbolic manifolds.
MW 10:30-11:50
Prof. M. Stover

This course will be an introduction to discrete groups and hyperbolic manifolds via explicit topological constructions. We will begin with the basics of discrete groups of isometries and hyperbolic 2-manifolds. Then we will consider geometric structures on knot complements, Thurston’s hyperbolic Dehn surgery theorem, and related explicit constructions of hyperbolic 3-manifolds.

Prerequisites: Differential Geometry and Topology (Math 8061–62) or consent of the instructor.

TR 3:30-4:50
Prof. V. Dolgushev

This a one semester course that connects some aspect of topology of Riemann surfaces to algebraic geometry of curves. Here is the outline of the course:

1. Brief interlude on categories. We will talk about categories, functors, natural transformations and equivalences of categories.
2. Limits of functors. Profinite groups. Basic facts about the profinite completion of a group will be explained.
4. Brief review of the fundamental group and covering spaces.
5. Riemann surfaces. This part will involve: the uniformization theorem and its consequences, embeddings of Riemann surfaces into complex projective spaces, Riemann’s existence theorem and the relationship between finite degree coverings of Riemann surfaces and extensions of the field of meromorphic function.
6. Background in commutative algebra. This part will involve integral dependence, Dedekind domains, Noether’s normalization theorem and its consequences.
8. The algebraic fundamental group and the outer Galois action on the algebraic fundamental group.

The plan is to follow Tamas Szamuely’s book “Galois Groups and Fundamental Groups” focusing on the first 4 chapters.

Prerequisites: Math 8012, Math 8051, Math 8062.