Pi Mu Epsilon

& GAMECOCK MATH CLUB

Getting to Know Your 500-Level MATH Courses at the University of South Carolina

Event sponsored in part by

UNIVERSITY OF SOUTH CAROLINA

Department of Mathematics

MATH 511/STAT 511: Probability

Prerequisite: Grade of C or higher or concurrent enrollment in MATH 241

The purpose of this course is to give you an introduction to probablity theory and probablity distributions. The material presented will not only serve as a basis for the subsequent courses, STAT 512/513, but is also extremely useful and fascinating in its own right. STAT 511 has a prerequisite of a standard multivariable calculus course, and a strong familiarity with differentitation, integration, infinite series and sequences, and related facts, is necessary. This course is very important for those of you considering careers in actuarial sciences.

The course covers the axiomatic approach to probability, counting techniques, Bayes Theorem, random variables, probability distributions for discrete and continuous random variables, mathematical expectation, moment generating functions, joint and conditional distributions for multiple random variables, and measures of association (covariance and correlation). This course focuses on both theory and application. You will be expected to derive theoretical results using algebra and calculus and apply these results to problems from a multitude of applications.

Fall 2019 Professor:

Joshua Tebbs

MATH 514: Financial Mathematics I

Prerequisites: C or higher or concurrent enrollment in MATH 241 or consent of the Undergraduate Director

The most important calculus requirements for this course are basic differentiation and integration techniques (MATH 141), the exponential and logarithmic functions (MATH 141), and partial derivatives including the chain rule (MATH 241). No prior knowledge of probability or finance will be assumed. A calculator, preferably the TI83, is required.

Topics covered in this course include:

- Probability: Probability spaces. Outcomes and Events. Conditional probability. Random variables. Bernoulli and binomial random variables. Expected value. Variance and standard deviation.
- Continuous Random Variables: Probability density functions. Cumulative distribution functions. The normal distribution. Sums of independent normal random variables. Discussion of the Central Limit Theorem. Normal approximation to the binomial distribution. The lognormal distribution.
- Geometric Brownian Motion: The drift and volatility parameters. The standard model of stock price dynamics.
- Present Value Analysis: Interest Rates. Present value of an income stream. Abel summation and its application to present value analysis. Coupon and zero-coupon bonds. Yield to maturity and duration. Continuously varying interest rates and the yield curve.
- Arbitrage: The No Arbitrage Principle. The Law of One Price. Pricing via arbitrage arguments. Forward contracts. Futures contracts. Options. Simple bounds for options prices. Payoff diagrams. The Put-Call Option Parity Formula. Options Pricing Theory: Generalized options. The single period model. Risk-neutral valuation. The multi-period binomial model. Self-financing trading strategies. The Black-Scholes Formula. Partial derivatives.

Fall 2019 Professor:

Lili Ju

MATH 520: Ordinary Differential Equations

Prerequisite: Grade of C or better in MATH 344 or MATH 544

Upon completion of this course, students will be knowledgeable about and will be able to analyze solutions to differential equations of the first order and linear systems of ordinary differential equations. They will also be able to apply these ideas to determine elementary qualitative properties of nonlinear systems.

Differential equations is the language of science. Many basic scientific laws express the change in one quantity in terms of the values of the other quantities. These laws can be combined to create a mathematical model for the physical situation. Once the model is found the challenge is to understand the "solution" to the model – often without actually having explicit formulas. The primary focus of this course is the mathematical analysis of differential equations. Students will learn a few special techniques to find analytic (but not necessarily explicit) solutions to differential equations.

Fall 2019 Professor:

TBA

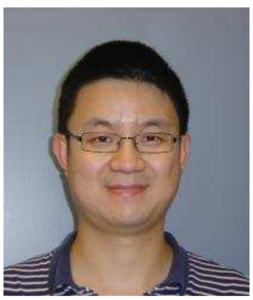
MATH 524: Nonlinear Optimization

Prerequisite: C or better in MATH 344 or 544 or consent of the Undergraduate Director

Upon successful completion of this course the student will be able to:
(1) State definitions and theorems and solve problems concerning unconstrained optimization.
(2) Describe and implement iterative computer algorithms for unconstrained optimization.
(3) State definitions and theorems and solve problems concerning least squares solutions of linear systems, and Lagrange multipliers for optimization subject to equality constraints.

Topics covered in this course include: Descent methods, conjugate direction methods, and Quasi-Newton algorithms for unconstrained optimization; globally convergent hybrid algorithm; primal, penalty, and barrier methods for constrained optimization. Computer implementation of algorithms.

Fall 2019 Professor:



Yi Sun

MATH 531: Foundations of Geometry

Prerequisite: C or better in MATH 300 or consent of the Undergraduate Director

This course is the study of geometry as a logical system based upon postulates and undefined terms. The fundamental concepts and relations of Euclidean geometry are developed rigorously on the basis of a set of postulates. Some topics from non-Euclidean geometry will also be included.

Successful students will master a variety of concepts in Euclidean geometry. In particular:

- Students will prove theorems about lines, circles, triangles, and other geometric shapes, and learn material substantially beyond what is taught in high school.
- Students will learn some of the axiomatic approach, which builds geometry from absolute scratch and does not rely on ``intuition''.
- Students will learn the **constructive** approach. Students will learn to construct geometric figures using ruler and straightedge and to explain their constructions to others.

In addition, students will also:

- Thoroughly understand what **definitions and theorems** are. The student will be able to precisely state definitions and theorems and understand how they are applied.
- Practice writing **proofs.** It is expected that the student will have some, but not a lot, of experience writing proofs. The student will gain more practice.
- Practice drawing **good pictures**. Diagrams are a very important part of the presentation of quantitative information, and geometry gives us an excellent opportunity to practice. It is expected that your pictures will be **not only correct**, but also **clear** and **as simple as possible**.

Fall 2019 Professor:

Matthew Boylan

MATH 544: Linear Algebra

Prerequisite: Grade of C or higher in MATH 300

Linear algebra is one of the fundamental topics in mathematics. Even if you do not know what linear algebra is, we have all been using many of the ideas for several years. While matrices will be common in this course, linear algebra is much more than "matrix algebra". A second and equally important objective of this course is the exposure to mathematical proofs. The early parts of the course emphasize manipulative aspects more than theoretical issues. As the course progresses, however, the same topics will be revisited – with more of an emphasis on the abstract theory of linear algebra. Students will master concepts and solve problems based on matrix algebra, solution of linear systems, notions of vector space, linear independence, basis, and dimension, linear transformations, change of basis, eigenvalues, eigenvectors, and diagonalization.

A solid knowledge of linear algebra – both manipulations and theory – will be helpful in almost any upper-division course in mathematics or any course that uses mathematics: differential equations, numerical analysis, optimization, etc.

Fall 2019 Professor:

Doug Meade

MATH 546: Algebraic Structures I

Prerequisite: Grade of C or higher in MATH 544

In this course, the student gets to experience mathematical thought beyond Calculus. As such, more sophistication is expected of the student. Most of the course will focus on group theory. Group theory is perhaps the area of mathematics with the fewest moving parts and the most ubiquity. Through studying group theory, each student will be exposed to the thought process involved in higher-level mathematics. Students will master concepts and solve problems based on permutation and abstract groups, subgroups, quotient groups, homomorphisms, isomorphisms, direct products, and rings.

This course is the first of a two-semester sequence. Both courses of the sequence are recommended for students planning to attend graduate school in mathematics.

Fall 2019 Professor:

Alex Duncan

MATH 550: Vector Analysis

Prerequisite: Grade of C or higher in MATH 241

This course is an extension of MATH 241 and has much the same problem solving character with a dose of theory and abstraction. Proofs will be given in class and you will be expected to do some computationally driven proofs on your own, but the course will not have the same proof oriented character as a course like MATH 554. This course makes a nice transition from calculus to higher-level theoretical math courses.

After a quick review of MATH 241, the main material of the course consists of the "Big Three" Theorems of Green, Stokes, and Gauss and how to use them. Students will demonstrate an understanding of vector functions by solving problems in the context of vector fields (e.g., by distinguishing gradient fields from non-gradient fields), line integrals, surface integrals, divergence and curl. Students will be able to exploit algebraic and geometric methods to compute integrals using the theorems of Green, Stokes, and Gauss, as well as direct computation using parameterizations.

Fall 2019 Professor:

Anton Schep

MATH 554: Analysis I

Prerequisite: Grade of C or higher in MATH 300 and at least one of MATH 511, 520, 534, 550, or 552

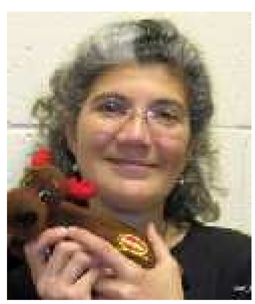
While most of science is based on inductive reasoning, mathematics is based on deductive reasoning. This means that new results are formed from logical combinations of hypothesis and statements accepted as true. Every result and technique learned in calculus (and other mathematics courses) is logically consistent and can be derived in a rigorous manner. In this course students begin to study some basic properties used to develop the fundamental calculus results including convergence of sequences, limit of a function, continuity (point-wise and uniform), derivative of a function, Rolle's theorem and the mean value theorem, L'Hospital's rule, inverse function theorem, Riemann integrals, Fundamental Theorem of Calculus, and derivatives of integrals. To be able to understand these results, and their proofs, it is necessary to develop a solid foundation in the real number system. It is also necessary to develop the ability to read, understand and write mathematical proofs. One of the most important steps in the creation of a mathematical proof is a solid understanding of the basic definitions. Unlike most previous courses you have taken, it is essential to pay attention to the details and technicalities. While this may be slightly unnatural, it is a skill that can be acquired through practice and patience.

Students will become knowledgeable about and will master concepts of real analysis. Students will improve their ability to write and read mathematical proofs, particularly those related to the least upper bound axiom, compactness, sequences, continuity, uniform continuity, differentiation, Riemann integration, and the Fundamental Theorem of Calculus.

This course is the first of a two-semester sequence. Both courses of the sequence are recommended for students planning to attend graduate school in mathematics.

Fall 2019 Professors:

Xinfeng Liu



Maria Girardi

MATH 574: Discrete Mathematics

Prerequisite: Grade of C or higher in MATH 300

Students will master concepts and solve problems in discrete mathematics, including basic set theory, counting, relations, and graphs. The use of the proof techniques learned earlier will be reinforced throughout the class. Students will master the concepts and be able to solve problems associated with enumeration, permutations and combinations, recurrence relations, and the groundwork for the more advanced topics of graph theory and game theory.

Fall 2019 Professors:

Laszlo Skekely

Lincoln Lu

MATH 580: Elementary Number Theory

Prerequisite: C or better in MATH 300 or consent of the Undergraduate Director

Topics for this course include: divisibility, primes, congruences, quadratic residues, numerical functions. Diophantine equations.

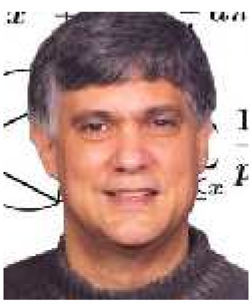
Successful students will:

- Master concepts which are foundational in number theory: congruences, Diophantine equations, and the like.
- Understand various properties of the integers, what they mean, where they come from, and why they are important. To that end you will learn about different systems of numbers: The integers, the rationals, the "Dudley numbers", the p-adic integers, finite fields, Gaussian integers, and the quaternions. These will be developed for their own interest, and you will also see stunning applications to classical problems involving the ordinary integers.
- Put some elements of "recreational math" on a firm footing. Do you know that if you want to test an integer for divisibility by 3, you can add the digits and test *that* for divisibility by 3? We will *prove it*.

In addition, students will also:

- Thoroughly understand what definitions and theorems are. The student will be able to precisely state definitions and theorems and understand how they are applied.
- Practice writing proofs. It is expected that the student will have some, but not a lot, of experience writing proofs. The student will gain more practice.
- Practice good mathematical writing. In mathematics, as indeed in everything else, it is important not only to be correct but to explain yourself clearly and as simply as possible.

Fall 2019 Professor:



Michael Filaseta

MATH 534: Elements of General Topology

Prerequisite: C or better in MATH 300 or consent of the Undergraduate Director

Students will master concepts and solve problems based upon the topics covered in the course, including the following concepts: topological space; metric space; continuous, open, and closed functions; homeomorphism; product topologies; compactness; connectedness; Hausdorff, regular, and normal space. Students will need to understand the generalizations of theorems such as the Heine-Borel Theorem, Bolzano-Weierstrass Theorem, and the Intermediate Value Theorem to arbitrary topological spaces.

Fall 2019 Professor:

TBA