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: Probability (3 Credits)
Probability and independence; discrete and continuous random variables; joint, marginal, and conditional densities, moment generating functions; laws of large numbers; binomial, Poisson, gamma, univariate, and bivariate normal distributions.
Prerequisite or Corequisite: C or better in MATH 241.
Cross-listed course: STAT 511

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 2025 Professor:

Dewei Wang

MATH 514: Financial Mathematics I (3 Credits)
Probability spaces. Random variables. Mean and variance. Geometric Brownian Motion and stock price dynamics. Interest rates and present value analysis. Pricing via arbitrage arguments. Options pricing and the Black-Scholes formula.
Prerequisites: C or better in MATH 241.
Cross-listed course: STAT 522

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 2025 Professor:

Lili Ju

MATH 520: Ordinary Differential Equations (3 Credits)
Differential equations of the first order, linear systems of ordinary differential equations, elementary qualitative properties of nonlinear systems.
Prerequisites: 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 2025 Professor:

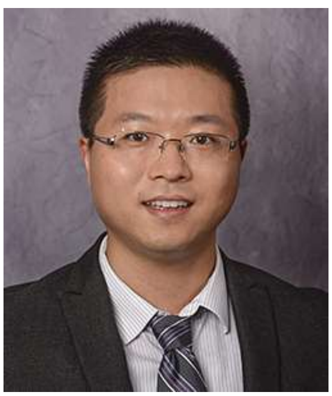
Mitchel Colebank

MATH 524: Nonlinear Optimization (3 Credits)
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.
Prerequisites: C or better in MATH 241 and one of MATH 344 or MATH 544.

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 2025 Professor:



Zhu Wang

MATH 529: Introduction to Deep Neural Networks (3 Credits)
Review of relevant concepts of linear algebra, Fourier transform and convolution, Fast Fourier Transform (FFT), mean and variance, covariance matrices and joint probabilities, gradient descent and stochastic gradient descent, structure of deep neural networks and convolutional neural networks, applications to image processing.
Prerequisites: C or better in MATH 344 or MATH 544.

MATH 529 is a pivotal Major Elective within the B.S. degree in Data Science program at the University of South Carolina, offering essential knowledge and skills for aspiring data scientists.

This course delves into the intricacies of deep neural networks, encompassing forward deep neural networks, convolutional networks, residual networks, graph neural networks, and generative adversarial networks. It places a significant emphasis on understanding their mathematical foundations and practical applications across supervised, unsupervised, and reinforcement learning paradigms. The primary objective is to empower students to grasp the fundamental concepts and effectively employ deep neural networks in novel applications where conventional solutions may be lacking.

The course aims to be self-contained, offering introductions to key concepts and materials such as linear algebra, probability and statistics, and optimization techniques. These foundational topics provide essential groundwork for exploring the complexities of deep neural networks and their practical implementations.

Fall 2025 Professor:

Peter Binev

MATH 531: Foundations of Geometry (3 Credits)
The study of geometry as a logical system based upon postulates and undefined terms. The fundamental concepts and relations of Euclidean geometry developed rigorously on the basis of a set of postulates.
Prerequisites: C or better in MATH 300.

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.

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.
- Learn some of the axiomatic approach, which builds geometry from absolute scratch and does not rely on ``intuition''.
- Learn the **constructive** approach. Students will learn to construct geometric figures using ruler and straightedge and to explain their constructions to others.
- 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 2025 Professor:

Daniel Savu

MATH 534: Elements of General Topology (3 Credits)
Elementary properties of sets, functions, spaces, maps, separation axioms, compactness, completeness, convergence, connectedness, path connectedness, embedding and extension theorems, metric spaces, and compactification.
Prerequisites: C or better in MATH 241 and MATH 300.

The class will be a gentle introduction to topology focusing on metric spaces. We will study continuity of functions defined on metric spaces, and completeness, connectedness, and compactness of metric spaces. The class will have a significant overlap with Analysis, (Math 554), but it is more elementary than Math 554. In particular, if you are planning to take Math 554, this class will help you to do better in Math 554!

Fall 2025 Professor:

Alex Duncan

MATH 544: Linear Algebra (3 Credits)
Vectors, vector spaces, and subspaces; geometry of finite dimensional Euclidean space; linear transformations; eigenvalues and eigenvectors; diagonalization. Throughout there will be an emphasis on theoretical concepts, logic, and methods. MATH 544L is an optional laboratory course where additional applications will be discussed.
Prerequisites: C or better in MATH 241 and 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 2025 Professor:

Andrew Kustin

MATH 546: Algebraic Structures I (3 Credits)
Permutation groups; abstract groups; introduction to algebraic structures through study of subgroups, quotient groups, homomorphisms, isomorphisms, direct product; decompositions; introduction to rings and fields.
Prerequisites: C or better in MATH 300 and 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 2025 Professor:

Adela Vraciu

MATH 550: Vector Analysis (3 Credits)
Vector fields, line and path integrals, orientation and parametrization of lines and surfaces, change of variables and Jacobians, oriented surface integrals, theorems of Green, Gauss, and Stokes; introduction to tensor analysis.
Prerequisites: C or better in MATH 241.

This is a continuation of Math 241 — Vector Calculus. The main objective is to understand, and apply, the three most important integral theorems of vector analysis: Green's, Stokes', and Gauss' Theorems. In preparation for these, there will be a brief review of paths, curves, vector fields, directional derivatives, gradients, divergence, and curl. Next, we will cover maps, change of variables, multiple integration, and parameterized surfaces as well as line, path, and surface integrals. By the end of the semester, students will be able to exploit algebraic and geometric methods to compute integrals using the three big theorems.

Fall 2025 Professor:

Xinfeng Liu

MATH 554: Analysis I (3 Credits)
Least upper bound axiom, the real numbers, compactness, sequences, continuity, uniform continuity, differentiation, Riemann integral and fundamental theorem of calculus.
Prerequisites: C or better in MATH 241 and two 500-level classes requiring MATH 300: MATH 525, MATH 531, MATH 532, MATH 533, MATH 534, MATH 540, MATH 541, MATH 544, MATH 546, MATH 548, MATH 551, MATH 561, MATH 570, MATH 574, MATH 575, or MATH 580.

In this course, you will learn the proofs of concepts you used in the computations done in Calculus I and II. Thus, in this course you will be writing many proofs (thus the prerequisite).

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 2025 Professors:


Maria Girardi


Kyle Liss

MATH 570 - Discrete Optimization (3 Credits)
Discrete mathematical models. Applications to such problems as resource allocation and transportation. Topics include linear programming, integer programming, network analysis, and dynamic programming.
Prerequisites: C or better in MATH 300 and in one of MATH 544 or MATH 344.

This course provides an introduction to linear programming and discrete optimization. The first half of the course will cover linear programming, including the simplex method and linear programming duality. The second half will cover the basics of discrete optimization, including integer linear programming and network analysis. Time permitting, we may cover additional topics like dynamic programming and approximation algorithms.

Fall 2025 Professor:

Josh Cooper

MATH 574: Discrete Mathematics I (3 Credits)
Mathematical models; mathematical reasoning; enumeration; induction and recursion; tree structures; networks and graphs; analysis of algorithms.
Prerequisites: C or better 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 2025 Professor:

George Brooks

MATH 580: Elementary Number Theory (3 Credits)
Divisibility, primes, congruences, quadratic residues, numerical functions. Diophantine equations.
Prerequisites: C or better in MATH 300.

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

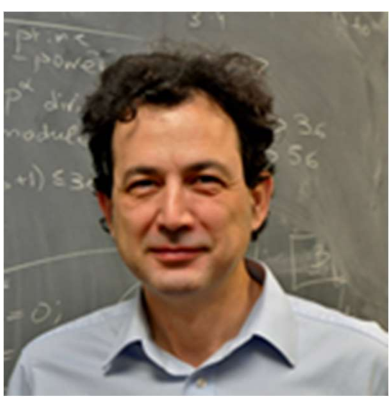
Successful students will:

- 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 2025 Professor:



Ognian Trifonov