Course descriptions, Spring 2025

The following courses are tentatively being offered for the Spring 2025 semester. Descriptions have been given by some instructors; more may be added over time.

MATH 5103 Mathematical Models
Instructor: Nikola Petrov

Description: Since nonlinear ODEs do not satisfy the Superposition Principle, finding their general solution is difficult and often impossible. Because of this, one can instead try to describe the qualitative behavior of the solutions of the system.

In this class we will derive nonlinear ODEs occurring in some simple biological or mechanical problems, and will analyze the behavior of their solutions. We will develop some methods for studying their bifurcations, i.e., situations in which the solutions of the system change their qualitative behavior dramatically for a small change of some parameter. We will study the phase portraits of autonomous linear systems, some bifurcations occurring in such systems (saddle-node, transcritical, pitchfork, Hopf), presence or absence of certain types of asymptotic behavior of the solutions, limit cycles, hysteresis, Poincare maps, etc. We will also introduce some concepts related to highly iterated maps.

This course should be of interest to students of Mathematics, Physics, Chemistry, Biology, Engineering, and Economics.

MATH 5163 Partial Differential Equations
Instructor: Weinan Wang

Description: This is a first course in the theory of partial differential equations (PDE). We will start by introducing some concepts and methods that are common through all types of PDEs, such as the notion of well-posedness, strong/weak solutions, method of characteristics, fundamental solutions etc. Then we will take a glance at each of the important types of PDEs: elliptic, parabolic, hyperbolic/dispersive. The contents we cover will depend on the progress. The textbook will be "Partial Differential Equations" by Lawrence Evans.

MATH 5263 Issues and Problems in Mathematics Pedagogy
Instructor: Sepideh Stewart

Description: In this course, we will study a selection of literature on mathematics education research.
Assessment:

- Literature Review on Mathematics Education Research: 35%
- Writing a Lesson Plan: 40%
- Presentation: 15%
- Class participation: 10%

Choose a mathematics topic you would like to work on and write a comprehensive review of available mathematics education literature on the state of pedagogical research on your chosen topic. Outside sources will be required. A Rubric will be provided.

Using your knowledge of mathematics education literature and your beliefs on teaching, prepare a lesson plan working on some area of mathematics that you may have found challenging to learn or teach. Use the mathematics education theories you learned to support your claims.

I recommend bouncing ideas off a mathematician and including them in your essay. I will provide a general model of a lesson plan and some examples in class.

Textbook: None. A selection of papers for the course will be provided on Canvas.

MATH 5333 Topics in Number Theory
Instructor: Kimball Martin

Course Catalog: Prerequisite: at least one mathematics course numbered above 3000, other than 4232. May be repeated with change of content; maximum credit nine hours. Topics may include congruencies, arithmetic functions, quadratic reciprocity, continued fractions, diophantine equations, primality testing, factorization methods, cryptography, quadratic forms and quadratic fields, computational number theory, additive number theory, coding theory, p-adic numbers.

MATH 5363 Abstract Algebra II
Instructor: Ameya Pitale

Description: qualifying exam course.

MATH 5373 Abstract Linear Algebra
Instructor: Noel Brady

Course Catalog: (Slashlisted with 4373) Prerequisite: 3333. Vector spaces over arbitrary fields, bases, dimension, linear transformations and matrices, similarity and its canonical forms (rational, Jordan), spectral theorem and diagonalization of quadratic forms.

MATH 5383 Applied Modern Algebra
Instructor: Greg Muller

Course Catalog: (Slashlisted with MATH 4383) Prerequisite: MATH 3333. Topics from the theory of error correcting codes, including Shannon's theorem, finite fields, families of linear codes such as Hamming, Golay, BCH, and Reed-Solomon codes. Other topics such as Goppa codes, group codes, and cryptography as time permits.

MATH 5443 Intro to Analysis II
Instructor: tba

Course Catalog: (Slashlisted with 4443) Prerequisite: 4433. Integration of functions of a single variable. Series of real numbers. Series of functions. Differentiation of functions of more than one variable.

MATH 5463 Real Analysis II
Instructor: Murad Özaydın

Description: qualifying exam course.

MATH 5693 Topics in Geometry and Combinatorics
Instructor: Murad Özaydın

Description: This course will be a fairly straight Combinatorics course, mostly Enumerative Combinatorics, i.e., counting: Rota's 12-fold way, inclusion-exclusion, generating functions, etc. But we will touch

on Existential (e.g., Ramsey Theory) and Constructive (e.g., Hopcroft-Tarjan algorithm and/or Garcia-Milne involution principle) Combinatorics. The main prerequisite is linear algebra, familiarity with power series and very basic group theory.The only geometry may be some geometric methods we'll use. Online sources will be used as text(s).

MATH 5743 Intro to Mathematical Statistics
Instructor: Alex Grigo

Course Catalog: (Slashlisted with 4743) Prerequisite: 4733. Mathematical development of basic concepts in statistics: estimation, hypothesis testing, sampling from normal and other populations; regression, goodness of fit. No student may earn credit for both 4743 and 5743.

MATH 5793 Advanced Applied Statistics
Instructor: Wayne Stewart

Description: MATH 5793 covers Advanced Statistics which is basically an introduction to multivariate statistics via the multivariate normal distribution. This is essentially an application of linear algebra and matrix methods. Topics such as tests for population mean differences, principal components, factor analysis and various clustering algorithms are typically covered. Throughout the course there is a heavy emphasis on R computing, package making and advanced techniques with functions and SHINY apps.

MATH 5803 Topics in Mathematics (Mathematics of Data)
Instructors: Alejandro Chávez-Domínguez, Keri Kornelson, and Miro Kramár

Description: (Slashlisted with MATH 4803) The ways in which humans want to understand, manipulate, and learn from data are growing every day. As our computing abilities grow, we discover new ways to collect more and more data in higher and higher dimensions. Mathematical theory leads us to discover how to process and understand data in more detailed, higher-order, and/or faster ways.

In The Mathematics of Data, we will introduce students to the mathematical theory of various aspects of data and image processing. The main themes will include least squares approximation, gradient descent, support vector machines, machine learning, singular value decomposition and principle component analysis. This class will be a mix of theory and application. Students will learn to use Python packages that perform some algorithms in each section. Students will also learn the mathematical underpinnings of the algorithms, using what they have learned in linear algebra, differential equations, and – if they have taken these courses - analysis and topology. Participants will gain experience with some of the most rapidly-growing and important applications of mathematics - the applications to data and image processing.

Although this is a Mathematics topics course, undergraduate and graduate students from other disciplines who have the required mathematical background of linear algebra (MATH 3333 or equivalent) are encouraged to enroll. No prior programming experience is required.

MATH 5863 Topology II
Instructor: Yan Mary He

Description: qualifying exam course.

MATH 5920 Algebra and Representation Theory Seminar
Instructor: n/a

Description: By signing up for one credit hour, you will be expected to attend the seminar every week. If you sign up for two credit hours, you are also promising to give a talk.

MATH 5930 Geometry and Topology Seminar
Instructor: n/a

Description: By signing up for one credit hour, you will be expected to attend the seminar every week. If you sign up for two credit hours, you are also promising to give a talk.

MATH 6383 Algebraic Geometry
Instructor: András Lőrincz

Course Catalog: Prerequisite: 6373. Hilbert's Nullstellensatz, the correspondence between ideals and algebraic sets, Zariski topology, irreducible algebraic sets, ringed spaces, morphisms, affine varieties, algebraic varieties, regular maps, sub-varieties and products, bi-rational equivalence, local rings and tangent spaces, differentials, non-singular points.

MATH 6483 Functional Analysis II
Instructor: Keri Kornelson

Course Catalog: Prerequisite: 6473. Banach algebras and harmonic analysis, representations of symmetric rings, unitary representations of a group, rings of operators in Hilbert space, decomposition of ring operators. Introduction to the theory of distributions.

MATH 6493 Topics in Analysis (Probability)
Instructor: Alex Grigo

Description: This course will be similar to a first course on probability theory for graduate students. No prior exposure to probability is expected from the students (and, in fact, it is likely going to be beneficial not to have seen probability theory before). Topics covered are (1) foundations of the mathematical theory of probability theory, (2) *useful* tools like characteristic functions, martingales, (3) basic limit theorem like law of large numbers (ergodic theorem), central limit theorem, law of small numbers, (3) markov chains on general state space, (4) *useful* metrics on probabilities. Depending on time and student's interests we could include additional material.

MATH 6803 Literacy in Topology
Instructors: Justin Malestein, Nicholas Miller, Greg Muller

Descriptions: tba

MATH 6823 Algebraic Topology II
Instructor: Nicholas Miller

Course Catalog: Prerequisite: 6813. Topics in cohomology and homology theory, universal coefficient theorems, orientation and duality on manifolds. Further topics may include: obstruction theory, cohomology operations, fibre bundles and characteristic classes, theory of sheaves, Eilenberg-MacLane spaces and Postnikov systems, spectral sequences.

MATH 6910 Analysis Seminar
Instructor: n/a

Description: By signing up for one credit hour, you will be expected to attend the seminar every week. If you sign up for two credit hours, you are also promising to give a talk.