MATHEMATICS (MATH)

MATH 1002 - PSSP Calculus Preparation and Quantitative Methods (3 Credits)
A brief review of pre-calculus (e.g., linear, power, exponential, logarithmic, and trigonometric functions). Emphasis will be on differential calculus (e.g., limits, continuity, the derivative, differentiation rules, trig functions, exponential and logarithmic) and applications of the derivative (e.g., tangent lines, velocity and acceleration, curve sketching, maximal/minimal analysis). Each student will have opportunities to engage with the course material at a depth that is appropriate to their math background. After completing MATH 1002, most students will enroll in either MATH 1106 (Modeling with Calculus for the Life Sciences) or MATH 1110 (Calculus I).
Prerequisites: A strong pre-calculus background and some calculus.
Last Four Terms Offered: Summer 2025, Summer 2024, Summer 2023, Summer 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 1003 - PSSP Statistics Preparation and Quantitative Methods (3 Credits)
A brief discussion of college algebra, set theory, and logic. Emphasis will be on topics in probability and statistics: e.g., descriptive statistics, linear regression, probability laws, and distributions. Each student will have opportunities to engage with the course material at a depth that is appropriate to their math background. After completing MATH 1003, most students will enroll in either MATH 1105 (Finite Mathematics for the Life and Social Sciences) or an applied introductory statistics course (e.g., AEM 2100, BTRY 3010, CRP 1200, ILRST/STSCI 2100, MATH 1710, PSYCH 2500, PUBPOL 2100, PUBPOL 2101, SOC 3010, STSCI 2150, or STSCI 2200).
Last Four Terms Offered: Summer 2025, Summer 2024, Summer 2023, Summer 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 1006 - Academic Support for MATH 1106 (1 Credit)
Reviews material presented in MATH 1106 lectures and provides further instruction for students who need reinforcement, including problem-solving techniques and tips as well as prelim review. Not a substitute for attending MATH 1106 lectures or discussions. Students should contact their college for the most up-to-date information regarding if and how credits for this course will count toward graduation, and/or be considered regarding academic standing.
Corequisites: MATH 1106.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 1011 - Academic Support for MATH 1110 (1 Credit)
Reviews material presented in MATH 1110 lectures and provides further instruction for students who need reinforcement, including problem-solving techniques and tips as well as prelim review. Not a substitute for attending MATH 1110 lectures or discussions. Students should contact their college for the most up-to-date information regarding if and how credits for this course will count toward graduation, and/or be considered regarding academic standing.
Corequisites: MATH 1110.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 1012 - Academic Support for MATH 1120 (1 Credit)
Reviews material presented in MATH 1120 lectures and provides further instruction for students who need reinforcement, including problem-solving techniques and tips as well as prelim review. Not a substitute for attending MATH 1120 lectures or discussions. Students should contact their college for the most up-to-date information regarding if and how credits for this course will count toward graduation, and/or be considered regarding academic standing.
Corequisites: MATH 1120.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 1021 - Academic Support for MATH 2210 (1 Credit)
Reviews material presented in MATH 2210 lectures and provides further instruction for students who need reinforcement, including problem-solving techniques and tips as well as prelim review. Not a substitute for attending MATH 2210 lectures or discussions. Students should contact their college for the most up-to-date information regarding if and how credits for this course will count toward graduation, and/or be considered regarding academic standing.
Corequisites: MATH 2210.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 1101 - Calculus Preparation (2 Credits)
Introduces topics in calculus: limits, rates of change, definition of and techniques for finding derivatives, relative and absolute extrema, and applications. The calculus content of the course is similar to 1/3 of the content covered in MATH 1106 and MATH 1110. In addition, the course includes a variety of topics of algebra, with emphasis on the development of linear, power, exponential, logarithmic, and trigonometric functions. Because of the strong emphasis on graphing, students will have a better understanding of asymptotic behavior of these functions.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 1105 - Finite Mathematics for the Life and Social Sciences (3 Credits)
Introduction to linear algebra, probability, and Markov chains that develops the parts of the theory most relevant for applications. Topics include equations of lines, the method of least squares, solutions of linear systems, matrices; basic concepts of probability, permutations, combinations, binomial distribution, mean and variance, and the normal approximation to the binomial distribution. Examples from biology and the social sciences are used.
Prerequisites: Three years of high school mathematics, including trigonometry and logarithms.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 1106 - Modeling with Calculus for the Life Sciences (4 Credits)
The goal of this course is to give students a strong basis in quantitative skills needed in the life and social sciences. We will focus on modeling using fundamental concepts from calculus developed in the course, including derivatives, integrals, and introductory differential equations. Examples from the life sciences are used throughout the course, including predator-prey populations. We will discuss mathematical models describing the evolution of these populations, analyze quantitative and qualitative properties to make predictions about these populations, and discuss assumptions and limitations of these models. Derivatives and integrals will be covered with a more applied focus than in MATH 1110 or a typical high school calculus course. Students who plan to take more than one semester of calculus should take MATH 1110 rather than MATH 1106.
Prerequisites: three years of high school mathematics, including trigonometry and logarithms, or a precalculus course (e.g., MATH 1101). No prior knowledge of calculus is required.
Forbidden Overlaps: MATH 1106, MATH 1110
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 1110 - Calculus I (4 Credits)
MATH 1110 can serve as a one-semester introduction to calculus or as part of a two-semester sequence in which it is followed by MATH 1120. Topics include functions and graphs, limits and continuity, differentiation and integration of algebraic, trigonometric, inverse trig, logarithmic, and exponential functions; applications of differentiation, including graphing, max-min problems, tangent line approximation, implicit differentiation, and applications to the sciences; the mean value theorem; and antiderivatives, definite and indefinite integrals, the fundamental theorem of calculus, and the area under a curve.
Prerequisites: three years of high school mathematics, including trigonometry and logarithms, or a precalculus course (e.g., MATH 1101).
Forbidden Overlaps: MATH 1106, MATH 1110
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Summer 2025, Spring 2025, Fall 2024, Summer 2024
Schedule of Classes (https://classes.cornell.edu/)

MATH 1120 - Calculus II (4 Credits)
Focuses on integration: applications, including volumes and arc length; techniques of integration, approximate integration with error estimates, improper integrals, differential equations and their applications.
Also covers infinite sequences and series: definition and tests for convergence, power series, Taylor series with remainder, and parametric equations.
Prerequisites: MATH 1110, excellent performance in MATH 1106, or equivalent AP credit.
Forbidden Overlaps: MATH 1120, MATH 1910
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 1300 - Mathematical Explorations (3 Credits)
For students who wish to experience how mathematical ideas naturally evolve. The course emphasizes ideas and imagination rather than techniques and calculations. Homework involves students in actively investigating mathematical ideas. Topics vary depending on the instructor. Some assessment through writing assignments.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 1340 - Strategy, Cooperation, and Conflict (3 Credits)
We apply mathematical reasoning to problems arising in the social sciences. We discuss game theory and its applications to questions of governing and the analysis of political conflicts. The problem of finding fair election procedures to choose among three or more alternatives is analyzed.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 1710 - Statistical Theory and Application in the Real World (4 Credits)
Introductory statistics course discussing techniques for analyzing data occurring in the real world and the mathematical and philosophical justification for these techniques. Topics include population and sample distributions, central limit theorem, statistical theories of point estimation, confidence intervals, testing hypotheses, the linear model, and the least squares estimator. The course concludes with a discussion of tests and estimates for regression and analysis of variance (if time permits). The computer is used to demonstrate some aspects of the theory, such as sampling distributions and the Central Limit Theorem. In the lab portion of the course, students learn and use computer-based methods for implementing the statistical methodology presented in the lectures.
Prerequisites: High school mathematics. No previous familiarity with computers presumed.
Forbidden Overlaps: AEM 2100, BTRY 3010, BTRY 6010, CRP 1200, ENGRD 2700, HADM 2010, HADM 2011, ILRST 2100, ILRST 6100, MATH 1710, PSYCH 2500, PUBPOL 2100, PUBPOL 2101, SOC 3010, STSCI 2100, STSCI 2150, STSCI 2200. In addition, no credit for MATH 1710 if taken after ECON 3130, ECON 3140, MATH 4720, or any other upper-level course focusing on the statistical sciences.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SDS-AS)
Last Four Terms Offered: Fall 2024, Spring 2024, Fall 2023, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 1890 - FWS: Writing in Mathematics (3 Credits)
How can you use writing to solve mathematical problems? Or even to discover problems that are worth solving? This course revisits high school mathematics with the goal of learning how mathematicians think about math. We will use writing to probe familiar math problems as well as discover new ones, and we will refine our ability to communicate their solutions. Readings will include excerpts from Lang's Basic Mathematics and works by Gelfand. (These are high school math textbooks written by mathematicians with research careers.) The class will culminate in a research project: you will use writing to develop, investigate, and present your progress on a problem.
Last Four Terms Offered: Fall 2020, Spring 2020, Spring 2018, Summer 2015
Schedule of Classes (https://classes.cornell.edu/)

MATH 1910 - Calculus for Engineers (4 Credits)
Essentially a second course in calculus and the first in a sequence designed for engineers that assumes familiarity with differential calculus at the level of MATH 1110. Topics include techniques of integration, finding areas and volumes by integration, exponential growth, partial fractions, infinite sequences and series, tests of convergence, and power series.
Prerequisites: Three years high school mathematics, including trigonometry and logarithms, and at least one course in differential and integral calculus (e.g., MATH 1110), or equivalent AP credit.
Forbidden Overlaps: MATH 1120, MATH 1910
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Summer 2025, Spring 2025, Fall 2024, Summer 2024
Schedule of Classes (https://classes.cornell.edu/)

MATH 1920 - Multivariable Calculus for Engineers (4 Credits)
Introduction to multivariable calculus. Topics include partial derivatives, double and triple integrals, line and surface integrals, vector fields, Green's theorem, Stokes' theorem, and the divergence theorem.
Prerequisites: MATH 1910 or equivalent AP credit.
Forbidden Overlaps: MATH 1920, MATH 2220, MATH 2240
Distribution Requirements: (MQL-AG, OPHLS-AG), (OCE-IL), (SMR-AS)
Last Four Terms Offered: Summer 2025, Spring 2025, Fall 2024, Summer 2024
Schedule of Classes (https://classes.cornell.edu/)

MATH 2210 - Linear Algebra (4 Credits)
An introduction to linear algebra for students who plan to major or minor in mathematics or a related field. Topics include vector algebra, linear transformations, matrices, determinants, orthogonality, eigenvalues, and eigenvectors. Applications are made to linear differential or difference equations. Lectures will introduce students to formal proofs, and students will be required to produce some proofs in their homework and on exams. For a more applied version of this course, see MATH 2310.
Prerequisites: MATH 1110-MATH 1120 with high performance, equivalent AP credit, or permission of department.
Forbidden Overlaps: MATH 2210, MATH 2230, MATH 2310, MATH 2940
Distribution Requirements: (MQL-AG, OPHLS-AG), (OCE-IL), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 2220 - Multivariable Calculus (4 Credits)
An introduction to multivariable calculus for students who plan to major or minor in mathematics or a related field. Topics include differential and integral calculus of functions in several variables, line and surface integrals as well as the theorems of Green, Stokes and Gauss.
Prerequisites: MATH 2210.
Forbidden Overlaps: MATH 1920, MATH 2220, MATH 2240
Distribution Requirements: (MQL-AG, OPHLS-AG), (OCE-IL), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 2230 - Theoretical Linear Algebra and Calculus (5 Credits)
Designed for students who have been extremely successful in their previous calculus courses and for whom the notion of solving very hard problems and writing careful proofs is highly appealing, MATH 2230-MATH 2240 provides an integrated treatment of linear algebra and multivariable calculus at a higher theoretical level than in MATH 2210-MATH 2220. Topics covered in MATH 2230 include vectors, matrices, and linear transformations; differential calculus of functions of several variables; inverse and implicit function theorems; quadratic forms, extrema, and manifolds; multiple and iterated integrals.
Prerequisites: MATH 1110-MATH 1120 with a grade of A- or better, equivalent AP credit, or permission of instructor.
Forbidden Overlaps: MATH 2210, MATH 2230, MATH 2310, MATH 2940
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 2240 - Theoretical Linear Algebra and Calculus (5 Credits)
Designed for students who have been extremely successful in their previous calculus courses and for whom the notion of solving very hard problems and writing careful proofs is highly appealing, MATH 2230-MATH 2240 provides an integrated treatment of linear algebra and multivariable calculus at a higher theoretical level than in MATH 2210-MATH 2220. Topics covered in MATH 2240 include vector fields; line integrals; differential forms and exterior derivative; work, flux, and density forms; integration of forms over parametrized domains; and Green's, Stokes', and divergence theorems.
Prerequisites: MATH 2230.
Forbidden Overlaps: MATH 1920, MATH 2220, MATH 2240
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 2310 - Linear Algebra for Data Science (4 Credits)
An introduction to linear algebra for students interested in applications to data science. The course diverges from traditional linear algebra courses by emphasizing data science applications while teaching similar concepts. Key topics include matrices as data tables, high-dimensional datasets, singular value decomposition for data compression, and linear transformations in computer graphics. Students who take MATH 2310 may need more foundational coursework before pursuing further study in mathematics.
Prerequisites: MATH 1106, MATH 1110, or equivalent AP credit.
Forbidden Overlaps: MATH 2210, MATH 2230, MATH 2310, MATH 2940
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 2930 - Differential Equations for Engineers (4 Credits)
An introduction to ordinary and partial differential equations. Topics include first-order equations (separable, linear, homogeneous, exact); mathematical modeling (e.g., population growth, terminal velocity); qualitative methods (slope fields, phase plots, equilibria and stability); numerical methods; second-order equations (method of undetermined coefficients, application to oscillations and resonance, boundary-value problems and eigenvalues); and Fourier series. A substantial part of this course involves partial differential equations, such as the heat equation, the wave equation, and Laplace's equation. MATH 2930 and MATH 2940 are independent and can be taken in either order; they should not be taken in the same semester.
Prerequisites: MATH 1920.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Summer 2025, Spring 2025, Fall 2024, Summer 2024
Schedule of Classes (https://classes.cornell.edu/)

MATH 2940 - Linear Algebra for Engineers (4 Credits)
Linear algebra and its applications. Topics include matrices, determinants, vector spaces, eigenvalues and eigenvectors, orthogonality and inner product spaces. Applications include brief introductions to difference equations, Markov chains, and systems of linear ordinary differential equations. May include computer use in solving problems. MATH 2930 and MATH 2940 are independent and can be taken in either order; they should not be taken in the same semester.
Prerequisites: MATH 1920.
Forbidden Overlaps: MATH 2210, MATH 2230, MATH 2310, MATH 2940
Distribution Requirements: (MQL-AG, OPHLS-AG), (OCE-IL), (SMR-AS)
Last Four Terms Offered: Summer 2025, Spring 2025, Fall 2024, Summer 2024
Schedule of Classes (https://classes.cornell.edu/)

MATH 3040 - Prove It! (4 Credits)
A useful course for students who wish to improve their skills in mathematical proof and exposition, or who intend to study more advanced topics in mathematics. The methodology of proof provides a central tool for confirming the validity of mathematical assertions, functioning much as the experimental method does in the physical sciences. We will study various methods of mathematical proof, starting with basic techniques in propositional and predicate calculus and in set theory and combinatorics, then moving to applications and illustrations of these via topics in one or more of the three main pillars of mathematics: algebra, analysis, and geometry. Because cogent communication of mathematical ideas is important in the presentation of proofs, the course emphasizes clear, concise exposition.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 3110 - Introduction to Analysis (4 Credits)
Provides a transition from calculus to real analysis. Topics include rigorous treatment of fundamental concepts in calculus: including limits and convergence of sequences and series, compact sets; continuity, uniform continuity and differentiability of functions. Emphasis is placed upon understanding and constructing mathematical proofs.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MATH 3110, MATH 4130
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 3210 - Manifolds and Differential Forms (4 Credits)
A manifold is a type of subset of Euclidean space that has a well-defined tangent space at every point. Such a set is amenable to the methods of multivariable calculus. After reviewing some relevant calculus, this course investigates manifolds and the structures they are endowed with, such as tangent vectors, boundaries, orientations, and differential forms. The notion of a differential form encompasses such ideas as area forms and volume forms, the work exerted by a force, the flow of a fluid, and the curvature of a surface, space or hyperspace. We re-examine the integral theorems of vector calculus (Green, Gauss, and Stokes) in the light of differential forms and apply them to problems in partial differential equations, topology, fluid mechanics, and electromagnetism.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 3270 - Introduction to Ordinary Differential Equations (3 Credits)
A one-semester introduction to the theory and techniques of ordinary differential equations. Topics may include first-order and second-order differential equations, systems of linear differential equations, initial-value and two-point boundary-value problems, Sturm-Liouville theory, Sturm oscillation and comparison theory, the basic existence and uniqueness theorems, series solutions, special functions, and Laplace transforms. Applications from science and engineering may be included at the instructor's discretion.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 3320 - Introduction to Number Theory (4 Credits)
An introductory course on number theory, the branch of algebra that studies the deeper properties of integers and their generalizations. Usually includes most of the following topics: the Euclidean algorithm, continued fractions, Pythagorean triples, Diophantine equations such as Pell's equation, congruences, quadratic reciprocity, binary quadratic forms, Gaussian integers, and factorization in quadratic number fields. May include a brief introduction to Fermat's Last Theorem.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 3340 - Abstract Algebra (4 Credits)
An introduction to structures of abstract algebra, including groups, rings, fields, factorization of polynomials and integers, congruences, and the structure of finite abelian groups. Additional topics include modules over Euclidean domain and Sylow theorems. Students considering graduate school in mathematics might consider taking MATH 4330 after MATH 3340.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Forbidden Overlaps: MATH 3340 and MATH 3360, nor for both MATH 3340 and MATH 4340
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2023, Spring 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 3360 - Applicable Algebra (4 Credits)
Introduction to the concepts and methods of abstract algebra that are of interest in applications. Covers the basic theory of groups, rings, and fields and their applications to such areas as public-key cryptography and error-correcting codes. Applications include the RSA cryptosystem and use of finite fields to construct error-correcting codes. Topics include elementary number theory, Euclidean algorithm, prime factorization, congruences, theorems of Fermat and Euler, elementary group theory, Chinese remainder theorem, factorization in the ring of polynomials, and classification of finite fields.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Forbidden Overlaps: MATH 3340, MATH 3360
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 3610 - Mathematical Modeling (4 Credits)
Introduction to the theory and practice of mathematical modeling. We compare and contrast different types of mathematical models (discrete vs. continuous, deterministic vs. stochastic), focusing on advantages, disadvantages, and limits of applicability for each approach. Case-study format covers a variety of application areas including economics, physics, sociology, traffic engineering, urban planning, robotics, and resource management. Students learn how to implement mathematical models on the computer and how to interpret/describe the results of their computational experiments.
Prerequisites: MATH 1110-MATH 1120 or equivalent.
Distribution Requirements: (SMR-AS)
Exploratory Studies: (CU-CEL)

Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 3810 - Deductive Logic (4 Credits)
Crosslisted with PHIL 3310, COGST 3310
A mathematical study of the formal languages of standard first-order propositional and predicate logic, including their syntax, semantics, and deductive systems. The basic apparatus of model theory will be presented. Various formal results will be established, most importantly soundness and completeness.
Prerequisites: PHIL 2310 or MATH 2210 or MATH 2230 or permission of instructor.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2024, Spring 2023, Fall 2021, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 3840 - Introduction to Set Theory (4 Credits)
Crosslisted with PHIL 3300
This will be a course on standard set theory (first developed by Ernst Zermelo early in the 20th century): the basic concepts of sethood and membership, operations on sets, functions as sets, the set-theoretic construction of the Natural Numbers, the Integers, the Rational and Real numbers; time permitting, some discussion of cardinality.Course was formerly titled Foundations of Mathematics.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Spring 2023, Fall 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 3850 - Modal Logic (3 Credits)
Crosslisted with PHIL 3340
Modal logic is a general logical framework for systematizing reasoning about qualified and relativized truth. It has been used to study the logic of possibility, time, knowledge, obligation, provability, and much more. This course will explore both the theoretical foundations and the various philosophical applications of modal logic. On the theoretical side, we will cover basic metatheory, including Kripke semantics, soundness and completeness, correspondence theory, and expressive power. On the applied side, we will examine temporal logic, epistemic logic, deontic logic, counterfactuals, two-dimensional logics, and quantified modal logic.
Prerequisites: PHIL 2310 or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2023, Spring 2023, Fall 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 4030 - History of Mathematics (4 Credits)
Development of mathematics from Babylon and Egypt and the Golden Age of Greece through its nineteenth century renaissance in the Paris of Cauchy and Lagrange and the Berlin of Weierstrass and Riemann. Covers basic algorithms underlying algebra, analysis, number theory, and geometry in historical order. Theorems and exercises cover the impossibility of duplicating cubes and trisecting angles, which regular polygons can be constructed by ruler and compass, the impossibility of solving the general fifth degree algebraic equation by radicals, and the transcendence of pi. Students will be expected to be comfortable writing proofs and will give presentations from original sources over 5000 years of mathematics.
Prerequisites: two mathematics courses above 3000, or permission of instructor.
Distribution Requirements: (SMR-AS)
Exploratory Studies: (EUAREA)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 4040 - Patterns, Proofs, and Problems (4 Credits)
Basic problem-solving techniques and strategies for contest problems. Contest problems differ from standard mathematical instruction in that they are "contextless": the problem does not tell you which field it is in and sometimes goes to great lengths to disguise it. Understanding how to solve contest problems has applications to research, where knowing how to work with unknown concepts, how to attack a problem fluidly from the perspective of multiple fields, and different tricks for simplifying problems is extremely useful. This course will cover topics that appear in standard competitions (e.g., the Putnam exam), including combinatorics, number theory, geometry, and calculus. It will also teach strategies for understanding and attacking problems, more advanced proof techniques, and effective proof writing.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Distribution Requirements: (SMR-AS)
Schedule of Classes (https://classes.cornell.edu/)

MATH 4130 - Honors Introduction to Analysis I (4 Credits)
Introduction to the rigorous theory underlying calculus, covering the real number system and functions of one variable. Topics typically include construction of the real number system, properties of the real number system, continuous functions, differential and integral calculus of functions of one variable, sequences and series of functions. Based entirely on proofs. The student is expected to know how to read and, to some extent, construct proofs before taking this course. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: high level of performance in a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MATH 3110, MATH 4130
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 4140 - Honors Introduction to Analysis II (4 Credits)
A proof-based introduction to further topics in analysis. Topics may include the Lebesgue measure and integration, functions of several variables, differential calculus, implicit function theorem, infinite dimensional normed and metric spaces, Fourier series, and ordinary differential equations.
Prerequisites: MATH 4130.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Exploratory Studies: (EAAREA)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4180 - Complex Analysis (4 Credits)
A theoretical and rigorous introduction to complex variable theory recommended for students who plan to attend graduate school in mathematics. Topics include complex numbers, differential and integral calculus for functions of a complex variable, including Cauchy's theorem and the calculus of residues, elements of conformal mapping. Students will be expected to be comfortable writing proofs. For applications of complex analysis, consider MATH 4220 rather than MATH 4180.
Prerequisites: MATH 2230-MATH 2240, MATH 3110, or MATH 4130, or permission of instructor.
Forbidden Overlaps: MATH 4180, MATH 4220, MATH 5220
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4200 - Differential Equations and Dynamical Systems (3 Credits)
Covers ordinary differential equations in one and higher dimensions: qualitative, analytic, and numerical methods. Emphasis is on differential equations as models and the implications of the theory for the behavior of the system being modeled and includes an introduction to bifurcations. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MAE 5790, MATH 4200, MATH 4210, MATH 5200
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4210 - Nonlinear Dynamics and Chaos (3 Credits)
An introduction to nonlinear dynamics with applications to physics, engineering, biology, and chemistry. Emphasizes analytical methods, concrete examples, and geometric thinking. Topics include one-dimensional systems; bifurcations; phase plane; nonlinear oscillators; and Lorenz equations, chaos, strange attractors, fractals, iterated mappings, period doubling, renormalization. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: high level of performance in a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MAE 5790, MATH 4200, MATH 4210, MATH 5200
Enrollment Information: Recommended prerequisite: MATH 2930 or equivalent preparation in differential equations.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4220 - Applied Complex Analysis (3 Credits)
Covers complex variables, Fourier transforms, Laplace transforms and applications to partial differential equations. Additional topics may include an introduction to generalized functions. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course. Undergraduates who plan to attend graduate school in mathematics should take MATH 4180 rather than MATH 4220.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MATH 4180, MATH 4220, MATH 5220
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4250 - Numerical Analysis and Differential Equations (4 Credits)
Crosslisted with CS 4210
Introduction to the fundamentals of numerical analysis: error analysis, approximation, interpolation, and numerical integration. In the second half of the course, we use these to build approximate solvers for ordinary and partial differential equations. Strong emphasis is placed on understanding the advantages, disadvantages, and limits of applicability for all the covered techniques. Computer programming is used to test the theoretical concepts throughout the course. Students will be expected to be comfortable writing proofs and have knowledge of programming. MATH 4250/CS 4210 and MATH 4260/CS 4220 can be taken independently from each other and in either order. Together they provide a comprehensive introduction to numerical analysis.
Prerequisites: MATH 2210, MATH 2230-MATH 2240, MATH 2310, or MATH 2940 or equivalent and one additional mathematics course numbered 3000 or above.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4260 - Numerical Analysis: Linear and Nonlinear Problems (4 Credits)
Crosslisted with CS 4220
Introduction to the fundamentals of numerical linear algebra: direct and iterative methods for linear systems, eigenvalue problems, singular value decomposition. In the second half of the course, the above are used to build iterative methods for nonlinear systems and for multivariate optimization. Strong emphasis is placed on understanding the advantages, disadvantages, and limits of applicability for all the covered techniques. Computer programming is required to test the theoretical concepts throughout the course.
Prerequisites: MATH 2210 or MATH 2940 or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4280 - Introduction to Partial Differential Equations (4 Credits)
Topics are selected from first-order quasilinear equations, classification of second-order equations, with emphasis on maximum principles, existence, uniqueness, stability, and Fourier series methods. Additional topics as time permits. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2930, MATH 3270, or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4310 - Linear Algebra (4 Credits)
Introduction to linear algebra, including the study of vector spaces, linear transformations, matrices, and systems of linear equations. Additional topics include quadratic forms and inner product spaces, canonical forms for various classes of matrices and linear transformations. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course. Undergraduates who plan to attend graduate school in mathematics should take MATH 4330 instead of MATH 4310.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Forbidden Overlaps: MATH 4310, MATH 4330
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 4330 - Honors Linear Algebra (4 Credits)
Honors version of a course in advanced linear algebra, which treats the subject from an abstract and axiomatic viewpoint. Topics include vector spaces, linear transformations, polynomials, determinants, tensor and wedge products, canonical forms, inner product spaces, and bilinear forms. Emphasis is on understanding the theory of linear algebra; homework and exams include at least as many proofs as computational problems. Strong proficiency in writing proofs is expected. More experience with proofs may be gained by first taking a 3000-level MATH course. MATH 4330-MATH 4340 is recommended for undergraduates who plan to attend graduate school in mathematics. For a less theoretical course that covers approximately the same subject matter as MATH 4330, see MATH 4310.
Prerequisites: high level of performance in MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Forbidden Overlaps: MATH 4310, MATH 4330
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4340 - Honors Introduction to Algebra (4 Credits)
Honors version of a course in abstract algebra, which treats the subject from an abstract and axiomatic viewpoint, including universal mapping properties. Topics include groups, groups acting on sets, Sylow theorems; rings, Euclidean domains, factorization, structure theorem of finitely generated modules over a principal ideal domain; fields, root adjunction, finite fields, introduction to Galois theory. The course emphasizes understanding the theory with proofs in both homework and exams. MATH 4330-MATH 4340 is recommended for undergraduates who plan to attend graduate school in mathematics. For a less theoretical course that covers subject matter similar to MATH 4340, see MATH 3340.
Prerequisites: MATH 4330.
Forbidden Overlaps: MATH 3340, MATH 4340
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4370 - Computational Algebra (3 Credits)
Introduction to algebraic geometry and computational algebra. Students will learn how to compute a Gröbner basis for polynomials in many variables. Covers the following applications: solving systems of polynomial equations in many variables, solving diophantine equations in many variables, 3-colorable graphs, and integer programming. Such applications arise, for example, in computer science, engineering, economics, and physics. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 4410 - Introduction to Combinatorics I (4 Credits)
Combinatorics studies discrete structures arising in mathematics, computer science, and many areas of application. Key topics include counting objects with specific properties (e.g., trees) and proving the existence of structures (e.g., matchings of all vertices in a graph). We cover basic questions in graph theory, including extremal graph theory (how large a graph must be to have a certain subgraph) and Ramsey theory (large objects are forced to have structure). An introduction to network flow theory and variations on matching theory, including theorems of Dilworth, Hall, König, and Birkhoff, are discussed. Methods of enumeration (inclusion/exclusion, Möbius inversion, and generating functions) are applied to problems of counting permutations, partitions, and triangulations. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4420 - Introduction to Combinatorics II (4 Credits)
Continuation of MATH 4410, although formally independent of the material covered there. The emphasis here is the study of certain combinatorial structures, such as Latin squares and combinatorial designs (which are of use in statistical experimental design), classical finite geometries and combinatorial geometries (also known as matroids, which arise in many areas from algebra and geometry through discrete optimization theory). We introduce partially ordered sets and lattices, including general Möbius inversion and its application, as well as the Polya theory of counting in the presence of symmetries. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2020, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MATH 4500 - Matrix Groups (4 Credits)
Matrix groups are central to mathematics and important in physics and engineering. The objects of study are classes of matrices (e.g., orthogonal, unitary, or symplectic) with both algebraic (groups) and geometric/topological (manifolds) structure. Thus the course is a mixture of algebra, geometry/topology, and a little analysis. Topics include Lie algebras (an extension of the notion of vector multiplication in three-dimensional space), the exponential mapping (a generalization of the exponential function of calculus), and representation theory (which studies different ways groups can be represented by matrices). Concrete examples will be emphasized. Background not included in the prerequisites will be developed as needed. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4520 - Classical Geometries and Modern Applications (4 Credits)
An introduction to projective, hyperbolic, and spherical geometry and their modern applications. The course will be divided into short modules with an emphasis on participation, discovery, and student projects and presentations. In addition to proving theorems, students will have the opportunity to make, build, 3D print, or program something related to the course material as a project component. We will cover classical theorems and techniques (e.g., stereographic projection and conics) and see how classical geometry is used in and relates to other areas of mathematics (e.g., topology, via Euler characteristic) and applications such as computer vision, networks, or architectural drawing. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MATH 4530 - Introduction to Topology (4 Credits)
Topology may be described briefly as qualitative geometry. This course begins with basic point-set topology, including connectedness, compactness, and metric spaces. Later topics may include the classification of surfaces (such as the Klein bottle and Möbius band), elementary knot theory, or the fundamental group and covering spaces. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4540 - Introduction to Differential Geometry (4 Credits)
Differential geometry involves using calculus to study geometric concepts such as curvature and geodesics. This introductory course focuses on the differential geometry of curves and surfaces. It may also touch upon the higher-dimensional generalizations, Riemannian manifolds, which underlie the study of general relativity. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4710 - Basic Probability (4 Credits)
An introduction to probability theory that prepares the student to take MATH 4720. The course begins with basics: combinatorial probability, mean and variance, independence, conditional probability, and Bayes formula. Density and distribution functions and their properties are introduced. The law of large numbers and central limit theorem are stated and their implications for statistics are discussed.
Prerequisites: MATH 1110-MATH 1120, or equivalent.
Forbidden Overlaps: BTRY 3080, ECON 3110, ECON 3130, ILRST 3080, ILRST 3110, MATH 4710, STSCI 3080, STSCI 3110
Enrollment Information: Recommended prerequisite: MATH 1920, MATH 2220, or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 4720 - Statistics (4 Credits)
Statistics have proved to be an important research tool in nearly all of the physical, biological, and social sciences. This course serves as an introduction to statistics for students who already have some background in calculus, linear algebra, and probability theory. Topics include parameter estimation, hypothesis testing, and linear regression. The course emphasizes both the mathematical theory of statistics and techniques for data analysis that are useful in solving scientific problems. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 4710 and linear algebra (MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent).
Forbidden Overlaps: BTRY 4090, ECON 3130, MATH 4720, STSCI 4090
Enrollment Information: Recommended prerequisite: MATH 1920, MATH 2220, or equivalent.
Distribution Requirements: (MQL-AG, OPHLS-AG), (SDS-AS, SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4740 - Stochastic Processes (4 Credits)
A one-semester introduction to stochastic processes which develops the theory together with applications. Covers Markov chains in discrete and continuous time and Poisson processes. Other topics may include queuing theory, martingales, Brownian motion, and option pricing. This course may be useful to graduate students in the biological sciences or other disciplines who encounter stochastic models in their work but who do not have the background for more advanced courses such as ORIE 6500. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 4710, BTRY 3080/ILRST 3080/STSCI 3080, ORIE 3500, or ECON 3130 and linear algebra (MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent).
Distribution Requirements: (MQL-AG, OPHLS-AG), (SMR-AS)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 4810 - Mathematical Logic (4 Credits)
Crosslisted with PHIL 4310
First course in mathematical logic providing precise definitions of the language of mathematics and the notion of proof (propositional and predicate logic). The completeness theorem says that we have all the rules of proof we could ever have. The Gödel incompleteness theorem says that they are not enough to decide all statements even about arithmetic. The compactness theorem exploits the finiteness of proofs to show that theories have unintended (nonstandard) models. Possible additional topics: the mathematical definition of an algorithm and the existence of noncomputable functions; the basics of set theory to cardinality and the uncountability of the real numbers. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking CS 2800 or a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Forbidden Overlaps: CS 4860, MATH 4810, MATH 4860, PHIL 4310
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2020, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 4820 - Topics in Logic and the Foundations of Mathematics (4 Credits)
Crosslisted with PHIL 4311
Advanced discussion of a topic in logic or foundational mathematics.
Prerequisites: PHIL 2310,PHIL 3310,PHIL 3300,MATH 3840, or permission of instructor. A background in logic is required.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2022, Spring 2022, Fall 2019, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 4860 - Applied Logic (3 Credits)
Crosslisted with CS 4860
Topics chosen from propositional logic, first-order logic, and higher-order logic, both classical and intuitionistic versions, including completeness, incompleteness, and compactness results. Natural deduction and tableaux style logics and connection to the lambda calculus and programming languages and logics, and program verification. Other topics chosen from equational logic, Herbrand universes and unification, rewrite rules and Knuth-Bendix method, and the congruence-closure algorithm and lambda-calculus reduction strategies. Modal logics, intuitionistic logic, computational logics and programming languages (e.g., LISP, ML, or Nuprl). Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Forbidden Overlaps: CS 4860, MATH 4810, MATH 4860, PHIL 4310
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 4870 - Set Theory (4 Credits)
Crosslisted with PHIL 4300
This course is a sequel to PHIL 3300/MATH 3840 but is also open to students who have not had the latter. After a brief review of the central ideas from the latter course, it will cover the construction of the real numbers, cardinality, the ordinal numbers, the cardinal numbers, the axiom of choice, and time permitting, another topic or two.
Prerequisites: at least one prior course in Philosophy or logic, or permission of instructor.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 4900 - Supervised Research (1-4 Credits)
An independent research course by arrangement with an individual professor. The goal is for the student to perform an independent investigation into a specific mathematical question. The student and professor will set expectations and grading policies at the beginning of the term.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 4901 - Supervised Reading (1-4 Credits)
An independent reading course by arrangement with an individual professor. The goal is for the student to master a body of mathematics outside the normal curriculum. The student and professor will set expectations and grading policies at the beginning of the term.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 4980 - Special Study for Mathematics Teaching (1-3 Credits)
Examines principles underlying the content of the secondary school mathematics curriculum, including connections with the history of mathematics, technology, and mathematics education research.
One credit is awarded for attending two Saturday workshops (see e.math.cornell.edu/classes/math5080) and writing a paper. Other credit options are available for students completing additional work, such as tutoring at a local middle school or completing a research paper or project. Does not count toward the math major or math minor and will not count as degree credits for A&S students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 4997 - Practical Training in Mathematics (1 Credit)
This independent study course offers math majors (i.e., undergraduates whose applications to affiliate with the math major have been approved) an opportunity to reflect on concepts from mathematics as they were encountered and applied in a recent internship. Students write a short paper describing their work experience and how it connects to the educational objectives of the mathematics major.
Enrollment Information: Primarily for: international undergraduate math majors whose application to affiliate has been approved.
Last Four Terms Offered: Fall 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 5080 - Special Study for Teachers (1 Credit)
Examines principles underlying the content of the secondary school mathematics curriculum, including connections with the history of mathematics, technology, and mathematics education research.
Enrollment Information: Primarily for: secondary mathematics teachers and others interested in issues related to teaching and learning secondary mathematics (e.g., mathematics pre-service teachers, mathematics graduate students, and mathematicians). Not open to: undergraduate students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 5200 - Differential Equations and Dynamical Systems (3 Credits)
Covers ordinary differential equations in one and higher dimensions: qualitative, analytic, and numerical methods. Emphasis is on differential equations as models and the implications of the theory for the behavior of the system being modeled and includes an introduction to bifurcations. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MAE 5790, MATH 4200, MATH 4210, MATH 5200
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 5220 - Applied Complex Analysis (3 Credits)
Covers complex variables, Fourier transforms, Laplace transforms and applications to partial differential equations. Additional topics may include an introduction to generalized functions. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MATH 4180, MATH 4220, MATH 5220
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 5250 - Numerical Analysis and Differential Equations (4 Credits)
Introduction to the fundamentals of numerical analysis: error analysis, approximation, interpolation, and numerical integration. In the second half of the course, we use these to build approximate solvers for ordinary and partial differential equations. Strong emphasis is placed on understanding the advantages, disadvantages, and limits of applicability for all the covered techniques. Computer programming is required to test the theoretical concepts throughout the course. Students will be expected to be comfortable writing proofs and have knowledge of programming.
Prerequisites: MATH 2210, MATH 2230-MATH 2240, MATH 2310, or MATH 2940 or equivalent, and one additional mathematics course numbered 3000 or above.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 5410 - Introduction to Combinatorics I (4 Credits)
Combinatorics studies discrete structures arising in mathematics, computer science, and many areas of application. Key topics include counting objects with specific properties (e.g., trees) and proving the existence of structures (e.g., matchings of all vertices in a graph). We cover basic questions in graph theory, including extremal graph theory (how large a graph must be to have a certain subgraph) and Ramsey theory (large objects are forced to have structure). An introduction to network flow theory and variations on matching theory, including theorems of Dilworth, Hall, König, and Birkhoff, are discussed. Methods of enumeration (inclusion/exclusion, Möbius inversion, and generating functions) are applied to problems of counting permutations, partitions, and triangulations. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, or MATH 2940, or equivalent.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 5420 - Introduction to Combinatorics II (4 Credits)
Continuation of MATH 5410, although formally independent of the material covered there. The emphasis here is the study of certain combinatorial structures, such as Latin squares and combinatorial designs (which are of use in statistical experimental design), classical finite geometries and combinatorial geometries (also known as matroids, which arise in many areas from algebra and geometry through discrete optimization theory). We introduce partially ordered sets and lattices, including general Möbius inversion and its application, as well as the Polya theory of counting in the presence of symmetries. Students will be expected to be comfortable writing proofs. More experience with proofs may be gained by first taking a 3000-level MATH course.
Prerequisites: MATH 2210, MATH 2230, MATH 2310, MATH 2940, or equivalent.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2024, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 6110 - Real Analysis (4 Credits)
MATH 6110-MATH 6120 are the core analysis courses in the mathematics graduate program. MATH 6110 covers abstract measure and integration theory, and related topics such as the Lebesgue differentiation theorem, the Radon-Nikodym theorem, the Hardy-Littlewood maximal function, the Brunn-Minkowski inequality, rectifiable curves and the isoperimetric inequality, Hausdorff dimension and Cantor sets, and an introduction to ergodic theory.
Prerequisites: strong performance in an undergraduate analysis course at the level of MATH 4140, or permission of instructor.
Forbidden Overlaps: MATH 6110, MATH 6210
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6120 - Complex Analysis (4 Credits)
MATH 6110-6120 are the core analysis courses in the mathematics graduate program. MATH 6120 covers complex analysis, Fourier analysis, and distribution theory.
Prerequisites: strong performance in an undergraduate analysis course at the level of MATH 4140, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 6150 - Partial Differential Equations (3 Credits)
This course emphasizes the "classical" aspects of partial differential equations (PDEs) — analytic methods for linear second-order PDEs and first-order nonlinear PDEs – without relying on more modern tools of functional analysis. The usual topics include fundamental solutions for the Laplace/Poisson, heat and wave equations in n dimensions, mean-value properties, maximum principles, energy methods, Duhamel's principle, and an introduction to nonlinear first-order equations, including shocks and weak solutions. Additional topics may include Hamilton-Jacobi equations, Euler-Lagrange equations, similarity solutions, transform methods, asymptotics, power series methods, homogenization, distribution theory, and the Fourier transform.
Prerequisites: MATH 4130, MATH 4140, or the equivalent, or permission of instructor.
Last Four Terms Offered: Fall 2023, Spring 2022, Fall 2019, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MATH 6160 - Partial Differential Equations (3 Credits)
This course highlights applications of functional analysis to the theory of partial differential equations (PDEs). It covers parts of the basic theory of linear (elliptic and evolutionary) PDEs, including Sobolev spaces, existence and uniqueness of solutions, interior and boundary regularity, maximum principles, and eigenvalue problems. Additional topics may include: an introduction to variational problems, Hamilton-Jacobi equations, and other modern techniques for non-linear PDEs.
Prerequisites: MATH 6110, MATH 6210, or the equivalent.
Last Four Terms Offered: Spring 2024, Fall 2022, Spring 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6210 - Measure Theory and Lebesgue Integration (3 Credits)
Covers measure theory, integration, and Lp spaces.
Prerequisites: undergraduate analysis and linear algebra at the level of MATH 4130 and MATH 4310.
Forbidden Overlaps: MATH 6110, MATH 6210
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6220 - Applied Functional Analysis (3 Credits)
Functional analysis is a branch of mathematical analysis that mainly focuses on the study of infinite-dimensional vector spaces and the operators acting upon them. It builds upon results and ideas from linear algebra and real and complex analysis to develop general frameworks that can be used to study analytical problems. Functional analysis plays a pivotal role in several areas of mathematics, physics, engineering, and even in some areas of computer science and economics. This course will cover the basic theory of Banach, Hilbert, and Sobolev spaces, as well as explore several notable applications, from analyzing partial differential equations (PDEs), numerical analysis, inverse problems, control theory, optimal transportation, and machine learning.
Prerequisites: a first course in real analysis, including exposure to Lebesgue integration (e.g., MATH 6110 or MATH 6210).
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6230 - Differential Games and Optimal Control (4 Credits)
This course is a self-contained introduction to the modern theory of optimal control and differential games. Dynamic programming uses Hamilton-Jacobi partial differential equations (PDEs) to encode the optimal behavior in cooperative and adversarial sequential decision-making problems. The same PDEs have an alternative interpretation in the context of front propagation problems. We show how both interpretations are useful in constructing efficient numerical methods. We also consider a wide range of applications, including robotics, computational geometry, path-planning, computer vision, photolithography, economics, seismic imaging, ecology, financial engineering, crowd dynamics, and aircraft collision avoidance. Assumes no prior knowledge of non-linear PDEs or numerical analysis.
Last Four Terms Offered: Fall 2024, Spring 2023, Fall 2019, Fall 2016
Schedule of Classes (https://classes.cornell.edu/)

MATH 6260 - Dynamical Systems (3 Credits)
Topics include existence and uniqueness theorems for ODEs; Poincaré-Bendixon theorem and global properties of two-dimensional flows; limit sets, nonwandering sets, chain recurrence, pseudo-orbits, and structural stability; linearization at equilibrium points: stable manifold theorem and the Hartman-Grobman theorem; and generic properties: transversality theorem and the Kupka-Smale theorem. Examples include expanding maps and Anosov diffeomorphisms; hyperbolicity: the horseshoe and the Birkhoff-Smale theorem on transversal homoclinic orbits; rotation numbers; Herman's theorem; and characterization of structurally stable systems. Prior exposure to topology (e.g., MATH 4530) will be helpful.
Prerequisites: MATH 4130-MATH 4140 or equivalent.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2020, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6270 - Applied Dynamical Systems (3 Credits)
Crosslisted with MAE 7760
Topics include review of planar (single-degree-of-freedom) systems; local and global analysis; structural stability and bifurcations in planar systems; center manifolds and normal forms; the averaging theorem and perturbation methods; Melnikov's method; discrete dynamical systems, maps and difference equations, homoclinic and heteroclinic motions, the Smale Horseshoe and other complex invariant sets; global bifurcations, strange attractors, and chaos in free and forced oscillator equations; and applications to problems in solid and fluid mechanics.
Prerequisites: MAE 6750, MATH 6260, or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2021, Spring 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6302 - Lattices: Geometry, Cryptography, and Algorithms (3 Credits)
Crosslisted with CS 6802
A mathematically rigorous course on lattices. Lattices are periodic sets of vectors in high-dimensional space. They play a central role in modern cryptography, and they arise naturally in the study of high-dimensional geometry (e.g., sphere packings). We will study lattices as both geometric and computational objects. Topics include Minkowski's celebrated theorem, the famous LLL algorithm for finding relatively short lattice vectors, Fourier-analytic methods, basic cryptographic constructions, and modern algorithms for finding shortest lattice vectors. We may also see connections to algebraic number theory.
Prerequisites: MATH 4310 or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2021
Learning Outcomes:

- Demonstrate algorithmic techniques such as basis reduction and sieving.
- Identify Regev's lattice-based public-key encryption scheme.
- Understand how Fourier-analytic methods can be used to study the geometry of lattices.

Schedule of Classes (https://classes.cornell.edu/)

MATH 6310 - Algebra (4 Credits)
MATH 6310-MATH 6320 are the core algebra courses in the mathematics graduate program. MATH 6310 covers group theory, especially finite groups; rings and modules; ideal theory in commutative rings; arithmetic and factorization in principal ideal domains and unique factorization domains; introduction to field theory; tensor products and multilinear algebra. (Optional topic: introduction to affine algebraic geometry.)
Prerequisites: strong performance in an undergraduate abstract algebra course at the level of MATH 4340, or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6320 - Algebra (4 Credits)
MATH 6310-MATH 6320 are the core algebra courses in the mathematics graduate program. MATH 6320 covers Galois theory, representation theory of finite groups, and introduction to homological algebra.
Prerequisites: MATH 6310, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 6330 - Noncommutative Algebra (3 Credits)
An introduction to the theory of noncommutative rings and modules. Topics vary by semester and include semisimple modules and rings, the Jacobson radical and Artinian rings, group representations and group algebras, characters of finite groups, representations of the symmetric group, central simple algebras and the Brauer group, representation theory of finite-dimensional algebras, and Morita theory.
Prerequisites: MATH 6310-MATH 6320, or permission of instructor.
Last Four Terms Offered: Fall 2022, Fall 2020, Spring 2015, Spring 2014
Schedule of Classes (https://classes.cornell.edu/)

MATH 6340 - Commutative Algebra with Applications in Algebraic Geometry (3 Credits)
Covers Dedekind domains, primary decomposition, Hilbert basis theorem, and local rings. May be taken concurrently with MATH 6310.
Prerequisites: modules and ideals (e.g., strong performance in MATH 4330 and either MATH 3340 or MATH 4340), or permission of instructor.
Last Four Terms Offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 6350 - Homological Algebra (3 Credits)
A first course on homological algebra. Topics will include a brief introduction to categories and functors, chain and cochain complexes, operations on complexes, (co)homology, standard resolutions (injective, projective, flat), classical derived functors, Tor and Ext, Yoneda's interpretation of Ext, homological dimension, rings of small dimensions, introduction to group cohomology.
Prerequisites: MATH 6310.
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6370 - Algebraic Number Theory (3 Credits)
An introduction to number theory focusing on the algebraic theory. Topics include, but are not limited to, number fields, Dedekind domains, class groups, Dirichlet's unit theorem, local fields, ramification, decomposition and inertia groups, and the distribution of primes.
Prerequisites: an advanced course in abstract algebra at the level of MATH 4340.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6390 - Lie Groups and Lie Algebras (3 Credits)
Lie groups, Lie algebras, and their representations play an important role in much of mathematics, particularly in number theory, mathematical physics, and topology. This is an introductory course, meant to be useful for more advanced topics and applications. The relationship between Lie groups and Lie algebras will be highlighted throughout the course. A different viewpoint is that of algebraic groups. We will endeavor to discuss this along with the smooth viewpoint. Some knowledge of differential and algebraic geometry are helpful.
Prerequisites: basic knowledge of algebra and linear algebra at the honors level (e.g., MATH 4330-MATH 4340).
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2023, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6410 - Enumerative Combinatorics (3 Credits)
An introduction to enumerative combinatorics from an algebraic, geometric and topological point of view. Topics include, but are not limited to, permutation statistics, partitions, generating functions and combinatorial species, various types of posets and lattices (distributive, geometric, and Eulerian), Mobius inversion, face numbers, shellability, and relations to the Stanley-Reisner ring.
Prerequisites: MATH 4410 or permission of instructor.
Last Four Terms Offered: Fall 2023, Spring 2022, Spring 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6510 - Algebraic Topology (4 Credits)
MATH 6510-MATH 6520 are the core topology courses in the mathematics graduate program. MATH 6510 is an introductory study of certain geometric processes for associating algebraic objects such as groups to topological spaces. The most important of these are homology groups and homotopy groups, especially the first homotopy group or fundamental group, with the related notions of covering spaces and group actions. The development of homology theory focuses on verification of the Eilenberg-Steenrod axioms and on effective methods of calculation such as simplicial and cellular homology and Mayer-Vietoris sequences. If time permits, the cohomology ring of a space may be introduced.
Prerequisites: strong performance in an undergraduate abstract algebra course at the level of MATH 4340 and point-set topology at the level of MATH 4530, or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 6520 - Differentiable Manifolds (4 Credits)
MATH 6510-MATH 6520 are the core topology courses in the mathematics graduate program. This course is an introduction to geometry and topology from a differentiable viewpoint, suitable for beginning graduate students. The objects of study are manifolds and differentiable maps. The collection of all tangent vectors to a manifold forms the tangent bundle, and a section of the tangent bundle is a vector field. Alternatively, vector fields can be viewed as first-order differential operators. We will study flows of vector fields and prove the Frobenius integrability theorem. We will examine the tensor calculus and the exterior differential calculus and prove Stokes' theorem. If time permits, de Rham cohomology, Morse theory, or other optional topics will be covered.
Prerequisites: strong performance in analysis (e.g., MATH 4130 and/or MATH 4140), linear algebra (e.g., MATH 4310), and point-set topology (e.g., MATH 4530), or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6530 - K-Theory and Characteristic Classes (3 Credits)
An introduction to topological K-theory and characteristic classes. Topological K-theory is a generalized cohomology theory which is surprisingly simple and useful for computation while still containing enough structure for proving interesting results. The class will begin with the definition of K-theory, Chern classes, and the Chern character. Additional topics may include the Hopf invariant 1 problem, the J-homomorphism, Stiefel-Whitney classes and Pontrjagin classes, cobordism groups and the construction of exotic spheres, and the Atiyah-Singer Index Theorem.
Prerequisites: MATH 6510, or permission of instructor.
Last Four Terms Offered: Fall 2022, Fall 2020, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MATH 6540 - Homotopy Theory (3 Credits)
This course is an introduction to some of the fundamentals of homotopy theory. Homotopy theory studies spaces up to homotopy equivalence, not just up to homeomorphism. This allows for a variety of algebraic techniques which are not available when working up to homeomorphism. This class studies the fundamentals and tools of homotopy theory past homology and cohomology. Topics may include computations of higher homotopy groups, simplicial sets, model categories, spectral sequences, and rational homotopy theory.
Prerequisites: MATH 6510 or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2022, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6620 - Riemannian Geometry (3 Credits)
Topics include linear connections, Riemannian metrics and parallel translation; covariant differentiation and curvature tensors; the exponential map, the Gauss Lemma and completeness of the metric; isometries and space forms, Jacobi fields and the theorem of Cartan-Hadamard; the first and second variation formulas; the index form of Morse and the theorem of Bonnet-Myers; the Rauch, Hessian, and Laplacian comparison theorems; the Morse index theorem; the conjugate and cut loci; and submanifolds and the Second Fundamental form.
Prerequisites: MATH 6520 or strong performance in analysis (e.g., MATH 4130 and/or MATH 4140), linear algebra (e.g., MATH 4310), and coursework on manifolds and differential geometry at the undergraduate level, such as both MATH 3210 and MATH 4540.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2021, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 6630 - Symplectic Geometry (3 Credits)
Symplectic geometry is a branch of differential geometry which studies manifolds endowed with a nondegenerate closed 2-form. The field originated as the mathematics of classical (Hamiltonian) mechanics, and it has connections to (at least!) complex geometry, algebraic geometry, representation theory, and mathematical physics. In this introduction to symplectic geometry, the class will begin with linear symplectic geometry, discuss canonical local forms (Darboux-type theorems), and examine related geometric structures including almost complex structures and Kähler metrics. Further topics may include symplectic and Hamiltonian group actions, the orbit method, the topology and geometry of momentum maps, toric symplectic manifolds, Hamiltonian dynamics, symplectomorphism groups, and symplectic embedding problems.
Prerequisites: MATH 6510 and MATH 6520, or permission of instructor.
Last Four Terms Offered: Spring 2024, Fall 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6640 - Hyperbolic Geometry (3 Credits)
An introduction to the topology and geometry of hyperbolic manifolds. The class will begin with the geometry of hyperbolic n-space, including the upper half-space, Poincare disc, Klein, and Lorentzian models. We will cover both synthetic and computational approaches. We will then discuss hyperbolic structures on surfaces and 3-manifolds, and the corresponding groups of isometries (i.e. Fuchsian and Kleinian groups). Additional topics may include: Geodesic and horocycle flows and their properties, counting closed geodesics and simple closed geodesics, Mostow rigidity, infinite area surfaces.
Prerequisites: Strong performance in undergraduate analysis (e.g., MATH 4130 or MATH 4180), topology/geometry (e.g., MATH 4520, MATH 4530, or MATH 4540), and algebra (e.g., MATH 4340), or permission of instructor.
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2019, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MATH 6670 - Algebraic Geometry (3 Credits)
A first course in algebraic geometry. Affine and projective varieties. The Nullstellensatz. Schemes and morphisms between schemes. Dimension theory. Potential topics include normalization, Hilbert schemes, curves and surfaces, and other choices of the instructor.
Prerequisites: MATH 6310 or MATH 6340, or equivalent.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 6710 - Probability Theory I (3 Credits)
Measure theory, independence, distribution of sums of iid random variables, laws of large numbers, and central limit theorem. Other topics as time permits.
Prerequisites: knowledge of Lebesgue integration theory, at least on real line. Students can learn this material by taking MATH 4130-MATH 4140 or MATH 6210.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6720 - Probability Theory II (3 Credits)
The second course in a graduate probability series. Topics include conditional expectation, martingales, Markov chains, Brownian motion, and (time permitting) elements of stochastic integration.
Prerequisites: MATH 6710.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 6730 - Mathematical Statistics I (3 Credits)
Crosslisted with STSCI 6730
This class will cover fundamental concepts in mathematical statistics, including both finite sample and asymptotic theory. Specific topics include: elements of risk optimality, Cramer-Rao-type bounds; M-estimation with an emphasis on Maximum Likelihood Estimation, asymptotic efficiency, asymptotic testing under fixed and local alternatives; multiple testing under FDR control; estimation in high dimensions and adaptation to sparsity, the analysis of Lasso-type estimators; elements of concentration inequalities.
Prerequisites: STSCI 4090/BTRY 4090, MATH 6710 or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 6740 - Mathematical Statistics II (3 Credits)
Crosslisted with STSCI 6740
Focuses on the foundations of statistical inference, with an emphasis on asymptotic methods and the minimax optimality criterion. In the first part, the solution of the classical problem of justifying Fisher's information bound in regular statistical models will be presented. This solution will be obtained applying the concepts of contiguity, local asymptotic normality and asymptotic minimaxity. The second part will be devoted to nonparametric estimation, taking a Gaussian regression model as a paradigmatic example. Key topics are kernel estimation and local polynomial approximation, optimal rates of convergence at a point and in global norms, and adaptive estimation. Optional topics may include irregular statistical models, estimation of functionals and nonparametric hypothesis testing.
Prerequisites: MATH 6710 (measure theoretic probability) and STSCI 6730/MATH 6730, or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 6810 - Logic (3 Credits)
Covers basic topics in mathematical logic, including propositional and predicate calculus; formal number theory and recursive functions; completeness and incompleteness theorems, compactness and Skolem-Loewenheim theorems. Other topics as time permits.
Prerequisites: an algebra course covering rings and fields (e.g., MATH 4310 or MATH 4330) or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2021, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6830 - Model Theory (3 Credits)
Introduction to model theory at the level of David Marker's text.
Prerequisites: rings and fields (e.g., MATH 4310 or MATH 4330) and a course in first-order logic at least at the level of MATH 4810/PHIL 4310, or permission of instructor.
Last Four Terms Offered: Fall 2023, Spring 2022, Spring 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 6840 - Recursion Theory (3 Credits)
Covers theory of effectively computable functions; classification of recursively enumerable sets; degrees of recursive unsolvability; applications to logic; hierarchies; recursive functions of ordinals and higher type objects; generalized recursion theory.
Prerequisites: A course in first-order logic (e.g., MATH 4810/PHIL 4310 or MATH 4860/CS 4860), or permission of instructor.
Last Four Terms Offered: Fall 2021, Fall 2019, Fall 2017, Fall 2015
Schedule of Classes (https://classes.cornell.edu/)

MATH 6870 - Set Theory (3 Credits)
First course in axiomatic set theory at the level of the book by Kunen.
Prerequisites: metric topology and measure theory (e.g., MATH 4130-MATH 4140 or MATH 6210) and a course in first-order logic (e.g., MATH 3840/PHIL 3300, MATH 4810/PHIL 4310, or MATH 6810), or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 7110 - Topics in Analysis (3 Credits)
Selection of advanced topics from analysis. Course content varies.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021, Fall 2017
Schedule of Classes (https://classes.cornell.edu/)

MATH 7120 - Topics in Analysis (3 Credits)
Selection of advanced topics from analysis. Course content varies.
Last Four Terms Offered: Spring 2022, Spring 2021, Spring 2019, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 7130 - Functional Analysis (3 Credits)
Covers topological vector spaces, Banach and Hilbert spaces, and Banach algebras. Additional topics selected by instructor.
Prerequisites: some basic measure theory, Lp spaces, and (basic) functional analysis (e.g., MATH 6110). Advanced undergraduates who have taken MATH 4130-MATH 4140 and linear algebra (e.g., MATH 4310 or MATH 4330), but not MATH 6110, will need permission of instructor.
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2019, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 7150 - Fourier Analysis (3 Credits)
An introduction to (mostly Euclidean) harmonic analysis. Topics usually include convergence of Fourier series, harmonic functions and their conjugates, Hilbert transform, Calderon-Zygmund theory, Littlewood-Paley theory, pseudo-differential operators, restriction theory of the Fourier transform, connections to PDE. Applications to number theory and/or probability theory may also be discussed, as well as Fourier analysis on groups.
Prerequisites: some basic measure theory, Lp spaces, and (basic) functional analysis (e.g., MATH 6110). Advanced undergraduates who have taken MATH 4130-MATH 4140, but not MATH 6110, need permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2023, Fall 2020, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 7160 - Topics in Partial Differential Equations (3 Credits)
Selection of advanced topics from partial differential equations. Content varies.
Last Four Terms Offered: Spring 2024, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 7280 - Topics in Dynamical Systems (3 Credits)
Selection of advanced topics from dynamical systems. Content varies.
Last Four Terms Offered: Fall 2023, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

MATH 7290 - Seminar on Scientific Computing and Numerics (1 Credit)
Crosslisted with CS 7290
Talks on various methods in scientific computing, the analysis of their convergence properties and computational efficiency, and their adaptation to specific applications.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MATH 7310 - Topics in Algebra (3 Credits)
Selection of advanced topics from algebra. Course content varies.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2019, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 7350 - Topics in Homological Algebra (3 Credits)
Selection of advanced topics from homological algebra. Course content varies.
Last Four Terms Offered: Fall 2022, Spring 2021, Fall 2018, Spring 2017
Schedule of Classes (https://classes.cornell.edu/)

MATH 7370 - Topics in Number Theory (3 Credits)
Selection of advanced topics from number theory. Course content varies.
Last Four Terms Offered: Spring 2025, Fall 2021, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 7390 - Topics in Lie Groups and Lie Algebras (3 Credits)
Topics will vary depending on the instructor and the level of the audience. They range from representation theory of Lie algebras and of real and p-adic Lie groups, geometric representation theory, quantum groups and their representations, invariant theory to applications of Lie theory to other parts of mathematics.
Prerequisites: a one-semester course in Lie groups.
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

MATH 7410 - Topics in Combinatorics (3 Credits)
Selection of advanced topics in combinatorics. Course content varies.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2021, Fall 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 7510 - Berstein Seminar in Topology (3 Credits)
A seminar on an advanced topic in topology or a related subject. Content varies. The format is usually that the participants take turns to present.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

MATH 7520 - Berstein Seminar in Topology (3 Credits)
A seminar on an advanced topic in topology or a related subject. Content varies. The format is usually that the participants take turns to present.
Last Four Terms Offered: Spring 2023, Spring 2021, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 7570 - Topics in Topology (3 Credits)
Selection of advanced topics from modern algebraic, differential, and geometric topology. Content varies.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2016, Fall 2014
Schedule of Classes (https://classes.cornell.edu/)

MATH 7580 - Topics in Topology (3 Credits)
Selection of advanced topics from modern algebraic, differential, and geometric topology. Content varies.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 7610 - Topics in Geometry (3 Credits)
Selection of advanced topics from modern geometry. Content varies.
Last Four Terms Offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 7620 - Topics in Geometry (3 Credits)
Selection of advanced topics from modern geometry. Content varies.
Last Four Terms Offered: Spring 2025, Spring 2022, Spring 2020, Spring 2019
Schedule of Classes (https://classes.cornell.edu/)

MATH 7670 - Topics in Algebraic Geometry (3 Credits)
Selection of topics from algebraic geometry. Content varies.
Last Four Terms Offered: Fall 2024, Spring 2024, Spring 2023, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 7710 - Topics in Probability Theory (3 Credits)
Selection of advanced topics from probability theory. Content varies.
Last Four Terms Offered: Fall 2024, Spring 2024, Fall 2022, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MATH 7720 - Topics in Stochastic Processes (3 Credits)
Selection of advanced topics from stochastic processes. Content varies.
Last Four Terms Offered: Spring 2023, Fall 2021, Spring 2021, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MATH 7740 - Statistical Learning Theory (3 Credits)
Learning theory has become an important topic in modern statistics. This course gives an overview of various topics in classification, starting with Stone's (1977) stunning result that there are classifiers that are universally consistent. Other topics include classification, plug-in methods (k-nearest neighbors), reject option, empirical risk minimization, Vapnik-Chervonenkis theory, fast rates via Mammen and Tsybakov's margin condition, convex majorizing loss functions, RKHS methods, support vector machines, lasso type estimators, low-rank multivariate response regression, random matrix theory, topic models, latent factor models, and interpolation methods in high dimensional statistics.
Prerequisites: basic mathematical statistics (STSCI 6730/MATH 6730 or equivalent) and measure theoretic probability (MATH 6710), or permission of instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

MATH 7810 - Seminar in Logic (3 Credits)
A twice weekly seminar in logic. Typically, a topic is selected for each semester, and at least half of the meetings of the course are devoted to this topic with presentations primarily by students. Opportunities are also provided for students and others to present their own work and other topics of interest.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

MATH 7820 - Seminar in Logic (3 Credits)
A twice weekly seminar in logic. Typically, a topic is selected for each semester, and at least half of the meetings of the course are devoted to this topic with presentations primarily by students. Opportunities are also provided for students and others to present their own work and other topics of interest.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MATH 7900 - Supervised Reading and Research (1-6 Credits)
Supervised research for the doctoral dissertation.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)