Mathematics

Subject: Mathematics

Mathematics ESPA

Emerging Scholars: Problem Solving Exploration (204095)

Dusty Grundmeier

2017 Fall (2 Credits) **Schedule:** TR 0900 AM - 0959 AM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

In his seminal work from 1945, How to Solve It, George Polya introduced principles of mathematical problem solving that are widely applicable to problems in science and engineering. This year-long class focuses on building a powerful and portable problem-solving and modeling tool kit while bridging the divide between mathematics and science courses. The second semester will be organized around projects in areas of student interest. Both Math ESPA and Math ESPB must be taken in the same academic year to receive credit.

Additional Course Attributes:

Attribute	Value(s)
Full Year Course	Indivisible Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students

Mathematics ESPB

Emerging Scholars: Problem Solving Exploration (204096)

Dusty Grundmeier

2018 Spring (2 Credits) **Schedule:** TR 0900 AM - 0959 AM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

In his seminal work from 1945, How to Solve It, George Polya introduced principles of mathematical problem solving that are widely applicable to problems in science and engineering. This year-long class focuses on building a powerful and portable problem-solving and modeling tool kit while bridging the divide between mathematics and science courses. The second semester will be organized around projects in areas of student interest. Both Math ESPA and Math ESPB must be taken in the same academic year to receive credit.

Additional Course Attributes:

Attribute	Value(s)
Full Year Course	Indivisible Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
Course Search Attributes	Display Only in Course Search
FAS Divisional Distribution	None

Mathematics MA Section: 01

Introduction to Functions and Calculus I (111161)

Brendan Kelly

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

The study of functions and their rates of change. Fundamental ideas of calculus are introduced early and used to provide a framework for the study of mathematical modeling involving algebraic, exponential, and logarithmic functions. Thorough understanding of differential calculus promoted by year long reinforcement. Applications to biology and economics emphasized according to the interests of our students.

Course Notes: This is a lecture course taught in small sections. In addition, participation in two one-hour workshops is required each week. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. This course, when taken together with Mathematics Mb, can be followed by Mathematics 1b. Mathamatics Ma and Mb together
cover all the material in Mathematics 1a (and more).

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Quantitative Reasoning

Mathematics MB

Introduction to Functions and Calculus II (113464)

Brendan Kelly

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Continued investigation of functions and differential calculus through modeling; an introduction to integration with applications; an introduction to differential equations. Solid preparation for Mathematics 1b.

Course Notes: This is a lecture course taught in small sections. In addition, participation in two one-hour workshops is required each week. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. This course, when taken together with Mathematics Ma, can be followed by Mathematics 1b. Mathematics Ma and Mathematics Mb together cover all the material in Mathematics 1a (and more).

Class Notes:

Spring Section Times: M., W., F., at 10; M. W., F., at 11; M., W., F., at 12 (with sufficient enrollment); and a twice weekly lab session to be arranged.

Brendan Kelly, Sarah Chisholm, Karen Edwards, Stepan Paul, Caroline Junkins, Matthew Demers, and members of the Department.

Requirements: Prerequisite: Mathematics MA

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Core Curriculum	Quantitative Reasoning
FAS: Course Level	Primarily for Undergraduate Students

Mathematics 1A

Introduction to Calculus (123680)

Emily Braley

2018 Spring (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

The development of calculus by Newton and Leibniz ranks among the greatest achievements of the past millennium. This course will help you see why by introducing: how differential calculus treats rates of change; how integral calculus treats accumulation; and how the fundamental theorem of calculus links the two. These ideas will be applied to problems from many other disciplines.

Course Notes: In the fall, Math 1a is taught in sections of 20-30 students. In the spring, Math 1a is taught in a larger lecture format. Participation in a weekly 90-minute workshop is required. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. Mathematics Ma and Mb together cover all of the material in Mathematics 1a (and more).

Class Notes: Spring section time: M.W.F. at 10 and weekly lab section to be arranged.

Emily Braley

Recommended Prep: A solid background in precalculus.

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
FAS: General Education	Empirical and Mathematical Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 1A

Introduction to Calculus (123680)

Neha Gupta

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

The development of calculus by Newton and Leibniz ranks among the greatest achievements of the past millennium. This course will help you see why by introducing: how differential calculus treats rates of change; how integral calculus treats accumulation; and how the fundamental theorem of calculus links the two. These ideas will be applied to problems from many other disciplines.

Course Notes: In the fall, Math 1a is taught in sections of 20-30 students. In the spring, Math 1a is taught in a larger lecture format. Participation in a weekly 90-minute workshop is required. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. Mathematics Ma and Mb together cover all of the material in Mathematics 1a (and more).

Class Notes: Required first meeting in fall: Wednesday, August 30, 8:00 am, Science Center D.

Fall section times: M.W.F.at 9 (with sufficient enrollment); M.W.F.at 10, M.W.F. at 11; M.W.F.at 12 (with sufficient enrollment); Tu.Th. 10-11:30; Tu Th 11:30-1, and a weekly lab section to be arranged.

Neha Gupta, Emily Braley, Hakim Walker, and members of the Department.

Recommended Prep: A solid background in precalculus.

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Quantitative Reasoning

Mathematics 1B

Calculus, Series, and Differential Equations (111010)

Robin Gottlieb

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Speaking the language of modern mathematics requires fluency with the topics of this course: infinite series, integration, and differential equations. Model practical situations using integrals and differential equations. Learn how to represent interesting functions using series and find qualitative, numerical, and analytic ways of studying differential equations. Develop both conceptual understanding and the ability to apply it.

Course Notes: This is a lecture taught in small sections. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes:

Spring section times: M.W.F. at 10; M.W.F. at 11; M.W.F. at 12; Tu.Th. 10-11:30 (with sufficient enrollment); Tu Th 11:30-1 (with sufficient enrollment).

Robin Gottlieb, Neha Gupta, Jameel Al-Aidroos, Hakim Walker, Emily Braley, Hiro Tanaka, and members of the Department.

Recommended Prep: Mathematics 1a or Ma and Mb; or 5 on the AB advanced placement test; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS: Core Curriculum	Quantitative Reasoning
FAS: General Education	Empirical and Mathematical Reasoning

Mathematics 1B

Calculus, Series, and Differential Equations (111010)

Cliff Taubes

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Speaking the language of modern mathematics requires fluency with the topics of this course: infinite series, integration, and differential equations. Model practical situations using integrals and differential equations. Learn how to represent interesting functions using series and find qualitative, numerical, and analytic ways of studying differential equations. Develop both conceptual understanding and the ability to apply it.

Course Notes: This is a lecture taught in small sections. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes: Required first meeting in Fall: Wednesday, August 30, 8:30 am, Science Center C.

Fall section times: M.W.F. at 9 (with sufficient enrollment); M.W.F.at 10; M.W.F.at 11; M.W.F. at 12 (with sufficient enrollment); Tu.Th. 10-11:30; Tu.Th. 11:30-1.

Clifford Taubes, Rosalie Belanger-Rioux, Hakim Walker, Mandy Cheung, Caroline Junkins, and members of the Department

Recommended Prep: Mathematics 1a or Ma and Mb; or 5 on the AB advanced placement test; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS: General Education	Empirical and Mathematical Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Quantitative Reasoning

Mathematics 18

Multivariable Calculus for Social Sciences (125396)

Yu-Wen Hsu

2017 Fall (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Focus on concepts and techniques of multivariable calculus most useful to those studying the social sciences, particularly economics: functions of several variables; partial derivatives; directional derivatives and the gradient; constrained and unconstrained optimization, including the method of Lagrange multipliers. Covers linear and polynomial approximation and integrals for single variable and multivariable functions; modeling with derivatives. Covers topics from Math 21a most useful to social sciences.

Course Notes: Mathematics 21b can be taken before or after Mathematics 18. Examples draw primarily from economics and the social sciences, though Mathematics 18 may be useful to students in certain natural sciences. Students whose main interests lie in the physical sciences, mathematics, or engineering should consider Math or Applied Math 21a. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: Mathematics 1b or equivalent, or a 5 on the BC Advanced Placement Examination in Mathematics.

Requirements: Anti-Requisite: Not to be taken in addition to Mathematics 21a or Applied Mathematics 21a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Core Curriculum	Quantitative Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students

Mathematics 19A

Modeling and Differential Equations for the Life Sciences (110596)

John Cain

2017 Fall (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Considers the construction and analysis of mathematical models that arise in the life sciences, ecology and environmental life science. Introduces mathematics that include multivariable calculus, differential equations in one or more variables, vectors, matrices, and linear and non-linear dynamical systems. Taught via examples from current literature (both good and bad).

Course Notes: This course is recommended over Math 21a for those planning to concentrate in the life sciences and ESPP. Can be taken with or without Mathematics 21a,b. Students with interests in the social sciences and economics might consider Mathematics 18. This course can be taken before or after Mathematics 18. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: A course in one variable calculus preferably at the level of Mathematics 1b.

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Core Curriculum	Quantitative Reasoning

All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 19B

Linear Algebra, Probability, and Statistics for the Life Sciences (122219)

Rosalie Belanger-Rioux

2018 Spring (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Probability, statistics and linear algebra with applications to life sciences, chemistry, and environmental life sciences. Linear algebra includes matrices, eigenvalues, eigenvectors, determinants, and applications to probability, statistics, dynamical systems. Basic probability and statistics are introduced, as are standard models, techniques, and their uses including the central limit theorem, Markov chains, curve fitting, regression, and pattern analysis.

Course Notes: This course is recommended over Math 21b for those planning to concentrate in the life sciences and ESPP. Can be taken with Mathematics 21a. Students who have seen some multivariable calculus can take Math 19b before Math 19a. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: A course in one variable calculus preferably at the level of Mathematics 1b.

Requirements: Not to be taken in addition to Mathematics 21b or Applied Mathematics 21b.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Core Curriculum	Quantitative Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 21A

Multivariable Calculus (119196)

John Cain

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

To see how calculus applies in practical situations described by more than one variable, we study: Vectors, lines, planes, parameterization of curves and surfaces, partial derivatives, directional derivatives and the gradient, optimization and critical point analysis, including constrained optimization and the Method of Lagrange Multipliers, integration over curves, surfaces and solid regions using Cartesian, polar, cylindrical, and spherical coordinates, divergence and curl of vector fields, and the Green's, Stokes's, and Divergence Theorems.

Course Notes: This is a lecture taught in small sections. May not be taken for credit by students who have passed Applied Mathematics 21a. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. Activities using computers to calculate and visualize applications of these ideas will not require

programming experience.

Class Notes:

Spring section times: M.W.F. at 9 (with sufficient enrollment); M.W.F. at 10; M.W.F. at 11; M.W.F. at 12 (with sufficient enrollment).Tu.Th 10-11:30; Tu.Th. 11:30-1 (with sufficient enrollment).

John Cain, Kate Penner, Brendan Kelly, Yu-Wen Hsu, Rosalie Belanger-Rioux, Neha Gupta, and members of the Department.

Recommended Prep: Mathematics 1b or an equivalent background in mathematics.

Requirements: Anti-requisite: Not to be taken in addition to AM21a.

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Core Curriculum	Quantitative Reasoning

Mathematics 21A

Multivariable Calculus (119196)

Oliver Knill

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

To see how calculus applies in practical situations described by more than one variable, we study: Vectors, lines, planes, parameterization of curves and surfaces, partial derivatives, directional derivatives and the gradient, optimization and critical point analysis, including constrained optimization and the Method of Lagrange Multipliers, integration over curves, surfaces and solid regions using Cartesian, polar, cylindrical, and spherical coordinates, divergence and curl of vector fields, and the Green's, Stokes's, and Divergence Theorems.

Course Notes: This is a lecture taught in small sections. May not be taken for credit by students who have passed Applied Mathematics 21a. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. Activities using computers to calculate and visualize applications of these ideas will not require programming experience.

Class Notes: Required first meeting in fall: Wednesday, August 30, 8:30 am, Science Center B

Fall section times: M.W.F. at 9; M.W.F. at 10; M.W.F. at 11; M.W.F. at 12; Tu.Th. 10-11:30; Tu. Th. 11:30-1.

Oliver Knill, Jameel Al-Aidroos, Stepan Paul, Matthew Demers, Aukosh Jagannath, Sebastian Vasey, and members of the department.

Recommended Prep: Mathematics 1b or an equivalent background in mathematics.

Requirements: Anti-requisite: Not to be taken in addition to AM21a.

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 21B

Linear Algebra and Differential Equations (110989)

Oliver Knill

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Matrices provide the algebraic structure for solving myriad problems across the sciences. We study matrices and related topics such as linear transformations and linear spaces, determinants, eigenvalues, and eigenvectors. Applications include dynamical systems, ordinary and partial differential equations, and an introduction to Fourier series.

Course Notes: This is a lecture taught in small sections. May not be taken by students who have passed Applied Mathematics 21b. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes:

Spring section times: M.W.F. at 9 (with sufficient enrollment), M.W.F. at 10, M.W.F. at 11, M.W.F. at 12, Tu.Th. 10-11:30, Tu.Th. 11:30-1.

Oliver Knill, Yu-Wen Hsu, Hakim Walker, Stepan Paul, Caroline Junkins, Matthew Demers, Ben Knudsen, Philip Engle, Ana Balibanu, Sander Coopers, and members of the Department.

Recommended Prep: Mathematics 1b or an equivalent background in mathematics. Mathematics 21a is commonly taken before Mathematics 21b, but is not a prerequisite, although familiarity with partial derivatives is useful.

Requirements: Anti-requisite: Not to be taken in addition to Math 19b or AM 21b.

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Core Curriculum	Quantitative Reasoning

Mathematics 21B

Linear Algebra and Differential Equations (110989)

Janet Chen

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Matrices provide the algebraic structure for solving myriad problems across the sciences. We study matrices and related topics such as linear transformations and linear spaces, determinants, eigenvalues, and eigenvectors. Applications include dynamical systems, ordinary and partial differential equations, and an introduction to Fourier series.

Course Notes: This is a lecture taught in small sections. May not be taken by students who have passed Applied Mathematics 21b. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes: Required first meeting in fall: Wednesday, August 30, 8:00 am, Science Center A..

Fall section times: M.W.F. at 9 (with sufficient enrollment), M.W.F. at 10, MWF at 11, MWF at 12 (with sufficient enrollment).

Janet Chen, Yu-Wen Hsu, Stepan Paul, Allison Miller, and members of the Department.

Recommended Prep: Mathematics 1b or an equivalent background in mathematics. Mathematics 21a is commonly taken before Mathematics 21b, but is not a prerequisite, although familiarity with partial derivatives is useful.

Requirements: Anti-requisite: Not to be taken in addition to Math 19b or AM 21b.

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
FAS: General Education	Empirical and Mathematical Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 23A

Linear Algebra and Real Analysis I (111695)

Paul Bamberg

2017 Fall (4 Credits) **Schedule:** R 0300 PM - 0359 PM

Instructor Permissions: Instructor **Enrollment Cap:** 36

Linear algebra: vectors, linear transformations and matrices, scalar and vector products, basis and dimension, eigenvectors and eigenvalues, including an introduction to the R scripting language. Single-variable real analysis:

sequences and series, limits and continuity, derivatives, inverse functions, power series and Taylor series. Multivariable real analysis and calculus: topology of Euclidean space, limits, continuity, and differentiation in n dimensions, inverse and implicit functions, manifolds, Lagrange multipliers, path integrals, div, grad, and curl. Emphasis on topics that are applicable to fields such as physics, economics, and computer science, but students are also expected to learn how to prove key results.

Course Notes: Students are expected to watch videos of the lectures from Fall 2015 before attending class. Weekly two-hour classes will consist of a one-hour seminar in which students present key definitions and proofs and a one-hour activity-based session in which students work in small groups to solve problems. Students are expected to continue in either Mathematics 23b (recommended for students who are thinking of concentrating in mathematics, the physical sciences, or engineering) or Mathematics 23c (recommended for students who are not sure of their concentration, or who are thinking about a concentration in the social sciences, economics, computer science, life sciences or data science). Either alternative will provide a solid foundation for a concentration in mathematics or any field that uses mathematics. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: Mathematics 1b or a grade of 4 or 5 on the Calculus BC Advanced Placement Examination, plus an interest both in proving mathematical results and in using them. No background in linear algebra, real analysis, or multivariable calculus is assumed.

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Quantitative Reasoning
FAS: Course Level	Primarily for Undergraduate Students

Mathematics 23A Section: 002

Linear Algebra and Real Analysis I (111695)

Paul Bamberg

2017 Fall (4 Credits) **Schedule:** F 0100 PM - 0159 PM

Instructor Permissions: Instructor **Enrollment Cap:** 48

Linear algebra: vectors, linear transformations and matrices, scalar and vector products, basis and dimension, eigenvectors and eigenvalues, including an introduction to the R scripting language. Single-variable real analysis: sequences and series, limits and continuity, derivatives, inverse functions, power series and Taylor series. Multivariable real analysis and calculus: topology of Euclidean space, limits, continuity, and differentiation in n dimensions, inverse and implicit functions, manifolds, Lagrange multipliers, path integrals, div, grad, and curl. Emphasis on topics that are applicable to fields such as physics, economics, and computer science, but students are also expected to learn how to prove key results.

Course Notes: Students are expected to watch videos of the lectures from Fall 2015 before attending class. Weekly two-hour classes will consist of a one-hour seminar in which students present key definitions and proofs and a one-hour activity-based session in which students work in small groups to solve problems. Students are expected to continue in either Mathematics 23b (recommended for students who are thinking of concentrating in

mathematics, the physical sciences, or engineering) or Mathematics 23c (recommended for students who are not sure of their concentration, or who are thinking about a concentration in the social sciences, economics, computer science, life sciences or data science). Either alternative will provide a solid foundation for a concentration in mathematics or any field that uses mathematics. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: Mathematics 1b or a grade of 4 or 5 on the Calculus BC Advanced Placement Examination, plus an interest both in proving mathematical results and in using them. No background in linear algebra, real analysis, or multivariable calculus is assumed.

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 23B

Linear Algebra and Real Analysis II (145010)

Paul Bamberg

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

A rigorous, integrated treatment of linear algebra and multivariable calculus. Topics: Riemann and Lebesgue integration, determinants, change of variables, volume of manifolds, differential forms, and exterior derivative. Stokes's theorem is presented both in the language of vector analysis (div, grad, and curl) and in the language of differential forms.

Course Notes: Mathematics 23b is a sequel to Mathematics 23a, recommended for students who are thinking of concentrating in mathematics, the physical sciences, or engineering. Students are expected to watch videos of the lectures from spring 2016 before attending class. Weekly two-hour classes will consist of a one-hour seminar in which students present key definitions and proofs and a one-hour activity-based session in which students work in small groups to solve problems. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes: Section times: Friday 12-2, Friday 1-3

Recommended Prep: Mathematics 23a.

Requirements: Prerequisite: MATH 23A OR (MATH 21A AND MATH 21B) AND (Not to be taken in addition to MATH 23C)

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning

FAS: Core Curriculum	Quantitative Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students

Mathematics 23C

Mathematics for Computation, Statistics, and Data Science (205386)

Paul Bamberg

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Proof strategies and logic. Sets, countability, sigma fields, and axiomatic foundations of probability. Summation of series and evaluation of multiple integrals, with emphasis on calculation of expectation and variance. Abstract vector spaces and inner product spaces, with applications to analysis of large datasets. Key functions and theorems of mathematical statistics. A brief introduction to classical vector calculus as used in electromagnetic theory. Students will learn to use some of the statistical and graphical display tools in the R scription language.

Course Notes: This course is a sequel to Mathematics 23a, recommended for students who are not sure of their concentration or who are thinking about a concentration in the social sciences, economics, computer science, life sciences or data science. Graduate students wishing to take this course for credit should speak with Dr. Bamberg to arrange enrollment in Mathematics 370 instead.

Recommended Prep: Mathematics 23a or Mathematics 21a and 21b. The latter option is for seniors who are preparing for graduate programs in statistics, computer science, or data science.

Requirements: Prerequisite: MATH 23A OR (MATH 21A AND MATH 21B) AND (Not to be taken in addition to MATH 23B)

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 25A

Honors Linear Algebra and Real Analysis I (110808)

Bena Tshishiku

2017 Fall (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

A rigorous treatment of linear algebra. Topics include: Construction of number systems; fields, vector spaces and linear transformations; eigenvalues and eigenvectors, determinants and inner products. Metric spaces, compactness and connectedness.

Course Notes: For students with a strong interest and background in mathematics. Expect to spend a lot of time doing mathematics. May not be taken for credit after Mathematics 23. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes: Only for students with a strong interest and background in mathematics. There will be a heavy workload. May not be taken for credit after Mathematics 23.

Recommended Prep: 5 on the Calculus BC Advanced Placement Examination and some familiarity with writing proofs, or the equivalent as determined by the instructor.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Quantitative Reasoning
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: General Education	Empirical and Mathematical Reasoning

Mathematics 25B

Honors Linear Algebra and Real Analysis II (110855)

Bena Tshishiku

2018 Spring (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

A rigorous treatment of basic analysis. Topics include: convergence, continuity, differentiation, the Riemann integral, uniform convergence, the Stone-Weierstrass theorem, Fourier series, differentiation in several variables. Additional topics, including the classical results of vector calculus in two and three dimensions, as time allows.

Course Notes: Expect to spend a lot time doing mathematics. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Class Notes: There will be a heavy workload.

Requirements: Prerequisite: Mathematics 25A OR Mathematics 55A

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 55A

Honors Abstract Algebra (113627)

Noam D. Elkies

2017 Fall (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

A rigorous introduction to abstract algebra, including group theory and linear algebra. This course covers the equivalent of Mathematics 25a and Mathematics 122, and prepares students for Mathematics 123 and other advanced courses in number theory and algebra. (A course in analysis such as Mathematics 25b or 55b is recommended for Spring semester.)

Course Notes: Mathematics 55a is an intensive course for students having significant experience with abstract mathematics. Every effort will be made to accommodate students uncertain of whether the course is appropriate for them; in particular, Mathematics 55a and 25a will be closely coordinated for the first three weeks of instruction. Students can switch between the two courses during the first three weeks without penalty. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: Commitment to a demanding course, strong interest in mathematics, and familiarity with proofs and abstract reasoning.

Additional Course Attributes:

Attribute	Value(s)
FAS: Core Curriculum	Quantitative Reasoning
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: General Education	Empirical and Mathematical Reasoning

Mathematics 55B

Honors Real and Complex Analysis (112871)

Noam D. Elkies

2018 Spring (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

A rigorous introduction to real and complex analysis. This course covers the equivalent of Mathematics 25b and Mathematics 113, and prepares students for Mathematics 114 and other advanced courses in analysis.

Course Notes: Mathematics 55b is an intensive course for students having significant experience with abstract mathematics. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Requirements: Prerequisite: Mathematics 55A

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students
FAS: Core Curriculum	Quantitative Reasoning
FAS: General Education	Empirical and Mathematical Reasoning
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 60R

Reading Course for Senior Honors Candidates (123883)

Jacob Lurie

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Advanced reading in topics not covered in courses.

Course Notes: Limited to candidates for honors in Mathematics who obtain the permission of both the faculty member under whom they want to work and the Director of Undergraduate Studies. May not count for concentration in Mathematics without special permission from the Director of Undergraduate Studies. Graded Sat/Unsat only.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Not Available for Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 60R

Reading Course for Senior Honors Candidates (123883)

Jacob Lurie

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Advanced reading in topics not covered in courses.

Course Notes: Limited to candidates for honors in Mathematics who obtain the permission of both the faculty member under whom they want to work and the Director of Undergraduate Studies. May not count for concentration in Mathematics without special permission from the Director of Undergraduate Studies. Graded Sat/Unsat only.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Not Available for Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 91R

Supervised Reading and Research (111297)

Jacob Lurie

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: None **Enrollment Cap:** n/a

Programs of directed study supervised by a person approved by the Department.

Course Notes: May not ordinarily count for concentration in Mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Undergraduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 91R

Supervised Reading and Research (111297)

Jacob Lurie

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Programs of directed study supervised by a person approved by the Department.

Course Notes: May not ordinarily count for concentration in Mathematics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 91R Section: 002

Supervised Reading and Research (111297)

Barry Mazur

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Programs of directed study supervised by a person approved by the Department.

Course Notes: May not ordinarily count for concentration in Mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 91R Section: 003

Supervised Reading and Research (111297)

Joseph D. Harris

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Programs of directed study supervised by a person approved by the Department.

Course Notes: May not ordinarily count for concentration in Mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 99R

Tutorial (117647)

Jacob Lurie

2018 Spring (4 Credits) **Schedule:** MW 0400 PM - 0529 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Supervised small group tutorial. Topics to be arranged.

Course Notes: May be repeated for course credit with permission from the Director of Undergraduate Studies. Only one tutorial may count for concentration credit.

Class Notes: Jacob Lurie and members of the Department

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Undergraduate Students

Mathematics 99R

Tutorial (117647)

Jacob Lurie

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Supervised small group tutorial. Topics to be arranged.

Course Notes: May be repeated for course credit with permission from the Director of Undergraduate Studies. Only one tutorial may count for concentration credit.

Class Notes: Jacob Lurie and members of the Department

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students

All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 101

Sets, Groups and Topology (122943)

Janet Chen

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to rigorous mathematics, axioms, and proofs, via topics including set theory, symmetry groups, and low-dimensional topology.

Course Notes: Familiarity with algebra, geometry and/or calculus is desirable. Students who have already taken Mathematics 23a,b, 25a,b or 55a,b should not take this course for credit. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. This course given fall term and repeated spring term.

Recommended Prep: An interest in mathematical reasoning. Acquaintance with algebra, geometry and/or calculus is desirable. Students who have already taken Math 25a,b or 55a,b should not take this course for credit.

Requirements: Anti-Req: Not to be taken in addition to Mathematics 23a,b or 25a,b or 55a,b.

Additional Course Attributes:

Attribute	Value(s)
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Core Curriculum	Quantitative Reasoning
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 101

Sets, Groups and Topology (122943)

Brooke Ullery

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to rigorous mathematics, axioms, and proofs, via topics including set theory, symmetry groups, and low-dimensional topology.

Course Notes: Familiarity with algebra, geometry and/or calculus is desirable. Students who have already taken Mathematics 23a,b, 25a,b or 55a,b should not take this course for credit. This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning. This course given fall term and repeated spring term.

Recommended Prep: An interest in mathematical reasoning. Acquaintance with algebra, geometry and/or calculus is desirable. Students who have already taken Math 25a,b or

55a,b should not take this course for credit.

Requirements: Anti-Req: Not to be taken in addition to Mathematics 23a,b or 25a,b or 55a,b.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Core Curriculum	Quantitative Reasoning
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 110

Vector Space Methods for Differential Equations (126610)

Dusty Grundmeier

2018 Spring (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Develops the theory of inner product spaces, both finite-dimensional and infinite-dimensional, and applies it to a variety of ordinary and partial differential equations. Topics: existence and uniqueness theorems, Sturm-Liouville systems, orthogonal polynomials, Fourier series, Fourier and Laplace transforms, eigenvalue problems, and solutions of Laplace's equation and the wave equation in the various coordinate systems.

Recommended Prep: Mathematics 23a,b or 25a,b or Mathematics 19a,b or 21a,b plus any Mathematics course at the 100 level; or an equivalent background in Mathematics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 112

Introductory Real Analysis (109817)

William Boney

2018 Spring (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to mathematical analysis and the theory behind calculus. An emphasis on learning to understand and construct proofs. Covers limits and continuity in metric spaces, uniform convergence and spaces of functions, the Riemann integral.

Recommended Prep: Mathematics 19a,b or 21a,b and either an ability to write proofs or concurrent enrollment in Mathematics 101; or an equivalent background in mathematics.

Requirements: Anti-Req: Not to be taken in addition to Mathematics 23a,b or 25a,b or 55a,b.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 113

Analysis I: Complex Function Theory (113608)

William Boney

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Analytic functions of one complex variable: power series expansions, contour integrals, Cauchy's theorem, Laurent series and the residue theorem. Some applications to real analysis, including the evaluation of indefinite integrals. An introduction to some special functions.

Recommended Prep: Mathematics 23a,b or 25a,b or 112, or an equivalent background in mathematics.

Requirements: Anti-Req: Not to be taken in addition to Mathematics 55b.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 114

Analysis II: Measure, Integration and Banach Spaces (123227)

Horng-Tzer Yau

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Lebesgue measure and integration; general topology; introduction to L^p spaces, Banach and Hilbert spaces, and duality.

Recommended Prep: Mathematics 23a,b or 25a,b or 55a,b or 112; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 115

Methods of Analysis (111065)

Hansol Hong

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Complex functions; Fourier analysis; Hilbert spaces and operators; Laplace's equations; Bessel and Legendre functions; symmetries; Sturm-Liouville theory.

Course Notes: Mathematics 115 is especially for students interested in physics.

Recommended Prep: Mathematics 23a,b or 25a,b or 55a,b or 112; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 116

Real Analysis, Convexity, and Optimization (118302)

Paul Bamberg

2018 Spring (4 Credits) **Schedule:** M 0200 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Develops the theory of convex sets, normed infinite-dimensional vector spaces, and convex functionals and applies it as a unifying principle to a variety of optimization problems such as resource allocation, production planning, and optimal control. Topics include Hilbert space, dual spaces, the Hahn-Banach theorem, the Riesz representation theorem, calculus of variations, and Fenchel duality. Students will be expected to understand and invent proofs of theorems in real and functional analysis. This course will not be offered in 2018-19.

Recommended Prep: Mathematics 23a,b or 25a,b or 55a,b; or Mathematics 21a,b plus at least one other more advanced course in mathematics; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 118R

Dynamical Systems (118429)

John Cain

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Introduction to dynamical systems theory with a view toward applications. Topics include existence and uniqueness theorems for flows, qualitative study of equilibria and attractors, iterated maps, and bifurcation theory.

Recommended Prep: Mathematics 19a,b or 21a,b or Math 23a,b or Math 25a,b or Math 55a,b; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 121

Linear Algebra and Applications (120228)

Fabian Haiden

2017 Fall (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Real and complex vector spaces, linear transformations, determinants, inner products, dual spaces, and eigenvalue problems. Applications to geometry, systems of linear differential equations, optimization, and Markov processes.

Recommended Prep: Mathematics 19b or 21b or an equivalent background in mathematics.

Requirements: Anti-Req: Not to be taken in addition to Mathematics 23a or 25a or 55a.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 122

Algebra I: Theory of Groups and Vector Spaces (122603)

Hiro Tanaka

2017 Fall (4 Credits) **Schedule:** MWF 0200 PM - 0259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Groups and group actions, vector spaces and their linear transformations, bilinear forms and linear representations of finite groups.

Recommended Prep: Mathematics 23a or 25a or 101 or 121; or an equivalent background in mathematics.

Requirements: Anti-Req: Not to be taken in addition to Mathematics 55a.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 123

Algebra II: Theory of Rings and Fields (116503)

Mark Kisin

2018 Spring (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Rings and modules. Polynomial rings. Field extensions and the basic theorems of Galois theory. Structure theorems for modules.

Requirements: Prerequisite: Mathematics 122 or Mathematics 55a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 124

Number Theory (111533)

Ana Balibanu

2017 Fall (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Factorization and the primes; congruences; quadratic residues and reciprocity; continued fractions and approximations; Pell's equation; selected Diophantine equations; theory of integral quadratic forms.

Recommended Prep: Mathematics 101 or 122; or 55a which can be taken concurrently; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 129

Number Fields (115734)

Barry Mazur

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Algebraic number theory: number fields, unique factorization of ideals, finiteness of class group, structure of unit group, Frobenius elements, local fields, ramification, weak approximation, adeles, and ideles.

Recommended Prep: Knowledge of the material in Mathematics 123.

Requirements: Prerequisite: Mathematics 123

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 130

Classical Geometry (123211)

Man-Wai Cheung

2018 Spring (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Presents several classical geometries, these being the affine, projective, Euclidean, spherical and hyperbolic geometries. They are viewed from many different perspectives, some historical and some very topical. Emphasis on reading and writing proofs.

Recommended Prep: Mathematics 19a,b or 21a,b or 23a or 25a or 55a which may be taken concurrently; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 131

Topology I: Topological Spaces and the Fundamental Group (111458)

Dennis Gaitsgory

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

First, an introduction to abstract topological spaces and their properties; and then, an introduction to algebraic topology and in particular homotopy theory, fundamental groups and covering spaces.

Recommended Prep: Some acquaintance with metric space topology as taught in Mathematics 23a,b, 25a,b, 55a,b, 101, or 112; and with groups as taught in Mathematics 101, 122 or 55a.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 132

Topology II: Smooth Manifolds (123212)

Michael Hopkins

2018 Spring (4 Credits) **Schedule:** MWF 0200 PM - 0259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Differential manifolds, smooth maps and transversality. Winding numbers, vector fields, index and degree. Differential forms, Stokes' theorem, introduction to cohomology.

Recommended Prep: Mathematics 23a,b or 25a,b or 55a,b or 112; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 136

Differential Geometry (111133)

Tristan Collins

2017 Fall (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

The course is an introduction to Riemannian geometry with the focus (for the most part) being the Riemannian geometry of curves and surfaces in space where the fundamental notions can be visualized.

Recommended Prep: Mathematics 19a,b or 21a,b or 23a or 25a or 55a (may be taken concurrently); or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 137

Algebraic Geometry (116452)

Brooke Ullery

2018 Spring (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Affine and projective spaces, plane curves, Bezout's theorem, singularities and genus of a plane curve, Riemann-Roch theorem.

Recommended Prep: Knowledge of the material in Mathematics 123.

Requirements: Prerequisite: Mathematics 123

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 143R

Set Theory (117626)

Peter Koellner

2017 Fall (4 Credits) **Schedule:** WF 1200 PM - 0129 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to descriptive set theory and the study of definable sets of reals. In the context of *definable* sets of reals it is natural to replace the axiom of choice (AC) with the axiom of determinancy (AD)- the assertion that all infinite, two players perfect information games on integers are determined. Begins with basic framework: Polish spaces, hierarchy of Borel sets, hierarchy of projective sets. Consequences of AD: measurability, perfect set theorem, Baire category. Proof of Borel determinancy. If time permits, relationship with large cardinals: analytic determinancy and measurable cardinals.

Recommended Prep: Mathematics 25 or 101.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 145B

Set Theory II (156120)

W. Hugh Woodin

2018 Spring (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to large cardinals and their inner models, with special emphasis on Woodin's recent advances toward finding an ultimate version of Godel's L. Topics include: Weak extender models, the HOD Dichotomy Theorem, and the HOD Conjecture.

Requirements: Prerequisite: Mathematics 145A

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 152

Discrete Mathematics (116191)

Paul Bamberg

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: Instructor **Enrollment Cap:** 16

An introduction to sets, logic, finite groups, finite fields, finite geometry, finite topology, combinatorics and graph theory. A recurring theme of the course is the symmetry group of the regular icosahedron. Elementary category theory will be introduced as a unifying principle. Taught in a seminar format: students will gain experience in presenting proofs at the blackboard.

Course Notes: Covers material used in Computer Science 121 and Computer Science 124. Enrollment limited to16.

Recommended Prep: Mathematics 19b or 21b or 23a or 25a or 55a (may be taken concurrently) or an equivalent background in mathematics. Previous experience with proofs is not required.

Requirements: Not to be taken in addition to Computer Science 20, Mathematics 55 or Mathematics 122.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 153

Mathematical Biology-Evolutionary Dynamics (119502)

Martin Nowak

2017 Fall (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Introduces basic concepts of mathematical biology and evolutionary dynamics: evolution of genomes, quasi-species, finite and infinite population dynamics, chaos, game dynamics, evolution of cooperation and language, spatial models, evolutionary graph theory, infection dynamics, somatic evolution of cancer.

Recommended Prep: Mathematics 19a,b or 21a,b or 23a,b or 25a,b or 55a,b; or an equivalent background in mathematics.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 154

Probability Theory (113811)

Sebastien Vasey

2018 Spring (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to probability theory. Discrete and continuous random variables; distribution and density functions for one and two random variables; conditional probability. Generating functions, weak and strong laws of large numbers, and the central limit theorem. Geometrical probability, random walks, and Markov processes.

Course Notes: This course, when taken for a letter grade, meets the General Education requirement for Empirical and Mathematical Reasoning.

Recommended Prep: A previous mathematics course at the level of Mathematics 19ab, 21ab, or a higher number. For students from 19ab or 21ab, previous or concurrent enrollment in Math 101 or 112 may be helpful. Freshmen who did well in Math 23a, 25a or 55a fall term are also welcome to take the course.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	For Undergraduate and Graduate Students
FAS: General Education	Empirical and Mathematical Reasoning
FAS: Core Curriculum	Quantitative Reasoning

Mathematics 155R

Combinatorics (116196)

Hector Pasten Vasquez

2018 Spring (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to counting techniques and other methods in finite mathematics. Possible topics include: the inclusion-exclusion principle and Mobius inversion, graph theory, generating functions, Ramsey's theorem and its variants, probabilistic methods.

Recommended Prep: The ability to write proofs and some knowledge of linear algebra will be needed.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

FAS: Course Level	For Undergraduate and Graduate Students

Mathematics 157

Mathematics in the World (159763)

Joseph D. Harris

2018 Spring (4 Credits) **Schedule:** TR 0200 PM - 0329 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An interactive introduction to problem solving with an emphasis on subjects with comprehensive applications. Each class will be focused around a group of questions with a common topic: logic, information, number theory, probability, and algorithms.

Recommended Prep: Mathematics 19b or 21b or 23a; or an equivalent background in mathematics. More importantly, students should have a broad mathematical curiosity and be eager to brainstorm during in-class problem solving sessions.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 162

Introduction to the Mathematics of Quantum Computing (204980)

Cliff Taubes

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

This course will introduce the mathematics for quantum computation. This includes basic notions from quantum mechanics, linear algebra, probability theory and number theory. No a priori knowledge of linear algebra is required except for a familiarity with basic facts about complex numbers and 2x2 matrices; in particular, what is taught in Mathematics 21b suffices. No a priori knowledge of either number theory or probability is needed.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 212A

Real Analysis (116137)

Yum Tong Siu

2017 Fall (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Measure theory, functional analysis, Sobolev spaces and introduction to harmonic analysis.

Recommended Prep: Knowledge of the material in Mathematics 114.

Requirements: Prerequisite: Mathematics 114

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 212BR

Advanced Real Analysis (120929)

Yum Tong Siu

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Parabolic evolution equations and links to probability. Kolmogorov's forward and backward equations. Generators of Markov processes in Euclidean space. Estimates and well-posedness for variable coefficient PDE and integrodifferential equations. Probabilistic representations. Ergodic theory and long time estimates for solutions. If time permits, selected topics in nonlinear parabolic equations, introduction to stochastic control and viscosity solutions.

Recommended Prep: Knowledge of the material in Mathematics 212a.

Requirements: Prerequisite: Undergrads Require Mathematics 212A

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 213A

Advanced Complex Analysis (110880)

Curtis McMullen

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Fundamentals of complex analysis, and further topics such as elliptic functions, canonical products, conformal mapping, harmonic measure and capacity.

Prerequisites: Basic complex analysis, topology of covering spaces, differential forms.

Recommended Prep: Basic complex analysis, topology of covering spaces, differential forms.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration

FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 221

Algebra (123232)

Hiro Tanaka

2017 Fall (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

A first course in Algebra: Noetherian rings and modules, Hilbert basis theorem, Cayley-Hamilton theorem, integral dependence, Galois theory, Noether normalization, the Nullstellensatz, localization, primary decomposition. Representation theory of finite groups. Introduction to Lie groups and Lie algebras: definitions, the exponential maps, semi-simple Lie algebras, examples.

Recommended Prep: Mathematics 123.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Mathematics 223A Section: LECT

Algebraic Number Theory (123239)

Alison Miller

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

A graduate introduction to algebraic number theory. Topics: the structure of ideal class groups, groups of units, a study of zeta functions and L-functions, local fields, Galois cohomology, local class field theory, and local duality.

Recommended Prep: Knowledge of the material in Mathematics 129.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None

Mathematics 223B Section: LECT

Algebraic Number Theory (123240)

Alison Miller

2018 Spring (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Continuation of Mathematics 223a. Topics: adeles, global class field theory, duality, cyclotomic fields. Other topics may include: Tate's thesis or Euler systems.

Recommended Prep: Knowledge of the material in Mathematics 223a.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 224 Section: LECT

Representations of Reductive Lie Groups (125563)

Dennis Gaitsgory

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Structure theory of reductive Lie groups, unitary representations, Harish Chandra modules, characters, the discrete series, Plancherel theorem.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 229X Section: LECT

Introduction to Analytic Number Theory (123242)

Hector Pasten Vasquez

2017 Fall (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Fundamental methods, results, and problems of analytic number theory. Riemann zeta function and the Prime Number Theorem; Dirichlet's theorem on primes in arithmetic progressions; lower bounds on discriminants from functional equations; sieve methods, analytic estimates on exponential sums, and their applications.

Recommended Prep: Knowledge of the material in Mathematics 113 and 123.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Mathematics 230A

Differential Geometry (113369)

Tristan Collins

2017 Fall (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Smooth manifolds (vector fields, differential forms, and their algebraic structures; Frobenius theorem), Riemannian geometry (metrics, connections, curvatures, geodesics, flatness, and manifolds of constant curvature), symplectic geometry, Lie groups, principal bundles.

Recommended Prep: Knowlledge of the material in Mathematics 132 and 136.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 230BR

Advanced Differential Geometry (115039)

Karsten Gimre

2018 Spring (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

A continuation of Mathematics 230a. Topics in differential geometry: Analysis on manifolds. Laplacians. Hodge theory. Spin structures. Clifford algebras. Dirac operators. Index theorems. Applications.

Recommended Prep: Knowledge of the material in Mathematics 230a.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 231A

Algebraic Topology (123243)

Joseph D. Harris

2017 Fall (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Covering spaces and fibrations. Simplicial and CW complexes, Homology and cohomology, universal coefficients and Künneth formulas. Hurewicz theorem. Manifolds and Poincaré duality.

Recommended Prep: Knowledge of the material in Mathematics 131 and 132.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 231BR

Advanced Algebraic Topology (123433)

Alexander Kupers

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Continuation of Mathematics 231a. Vector bundles and characteristic classes. Bott periodicity. K-theory, cobordism and stable cohomotopy as examples of cohomology theories.

Recommended Prep: Knowledge of the material in Mathematics 231a.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

Mathematics 232A

Introduction to Algebraic Geometry I (123441)

Fabian Haiden

2017 Fall (4 Credits) **Schedule:** MWF 0200 PM - 0259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Introduction to complex algebraic curves, surfaces, and varieties.

Recommended Prep: Knowledge of the material in Mathematics 123 and 132 and 137.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science

Mathematics 232BR

Algebraic Geometry II (123444)

Fabian Haiden

2018 Spring (4 Credits) **Schedule:** MWF 0200 PM - 0259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

The course will cover the classification of complex algebraic surfaces.

Recommended Prep: Knowledge of the material in Mathematics 232a.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 233A Section: LECT

Theory of Schemes I (123445)

Joseph D. Harris

2018 Spring (4 Credits) **Schedule:** MWF 1000 AM - 1059 AM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to the theory and language of schemes. Textbooks: Algebraic Geometry by Robin Hartshorne and Geometry of Schemes by David Eisenbud and Joe Harris. Weekly homework will constitute an important part of the course.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Mathematics 243

Evolutionary Dynamics (119511)

Martin Nowak

2018 Spring (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Advanced topics of evolutionary dynamics. Seminars and research projects.

Recommended Prep: Experience with mathematical biology at the level of Mathematics 153.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	Science & Engineering & Applied Science
FAS: Course Level	Primarily for Graduate Students

Mathematics 252X

Configuration Spaces in Algebraic Topology (204921)

Benjamin Knudsen

2017 Fall (4 Credits) **Schedule:** MWF 0200 PM - 0259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to configuration spaces emphasizing both their intrinsic geometric interest and their connections to other areas. Possible topics: computations of (co)homology and homotopy groups, cell decompositions, homological stability, failure of homotopy invariance, and stable splittings of mapping spaces.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 253

Dynamics and Rigidity (205200)

Simion Filip

2018 Spring (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

After an introduction to the basic techniques of dynamics and ergodic theory, the course will develop applications, ranging from classical to more recent developments. Possible topics: Margulis super-rigidity and arithmeticity of lattices in Lie groups, measure rigidity theorems (Ratner, Benoist-Quint), dynamical systems in algebraic geometry.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Undergraduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 255

Classification Theory for Tame Abstract Elementary Classes (204946)

William Boney

2017 Fall (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Starting from the definition of Abstract Elementary Classes (AECs), we will develop nonforking and classification theory for tame AECs. These classes are general enough to encompass interesting examples of nonelementary classes, but have enough structure to develop a reasonable classification theory. We will cover the construction of good frames and other nonforking notions in tame AECs; examples of tame AECs; and the impact of set theory and large cardinals.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 268X

Hodge Theory (204947)

Wilfried Schmid

2017 Fall (4 Credits) **Schedule:** TR 0230 PM - 0359 PM

Instructor Permissions: None **Enrollment Cap:** n/a

"Classical Hodge theory, including the "Kahler package"; mixed Hodge structures on singular and incomplete varieties; geometric and abstract variations of Hodge structure; the orbit theorems of Variation of Hodge structure; an introduction to Mixed Hodge Modules.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 269X

Model Theory for Abstract Elementary Classes (204948)

Sebastien Vasey

2018 Spring (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

Abstract elementary classes are a kind of concrete categories with all directed colimits whose morphisms are monomorphisms. They generalize the model theory of classes axiomatized by a first-order theory or certain infinitary logics, and encompass many algebraic classes of objects such as valued fields or locally finite groups. A presentation of both basic model-theoretic results (the presentation theorem, model-homogeneous is saturated, closure under infinitary elementary equivalence) and generalizations of stability theory to this setup, with a focus on free (nonforking) amalgamation (generalizing linear independence of vector spaces and algebraic independence in fields).

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

Mathematics 270

Isometric Embedding and Geometric Analysis (204949)

Karsten Gimre

2017 Fall (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

The course will cover the isometric embedding problem in all its forms, including the contributions of Weyl, Cartan, Nash, Kuiper, Nirenberg, and Gromov. This will include lengthy digressions into some of the pieces of mathematics originally inspired by isometric embedding, including the Nash-Moser implicit function theorem, convex integration, and pseudoholomorphic curves. We will also cover the modern application of isometric embedding to measuring

gravitational enerby in general relativity.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Primarily for Graduate Students

Mathematics 272X

Diffeomorphisms of Disks (204950)

Alexander Kupers

2017 Fall (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

A discussion of classical results and recent advances in the study of groups of diffeomorphisms of disks. Topics: the results of Smale and Hatcher, the relation to exotic spheres and smoothing theory, the relation to cobordism categories and the relation to algebraic K-theory. If time permits, a discussion of the relation to configuration space integrals.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 275Z

Topics in Mean Field Spin Glasses (204940)

Aukosh Jagannath

2018 Spring (4 Credits) **Schedule:** TR 1000 AM - 1129 AM

Instructor Permissions: None **Enrollment Cap:** n/a

We will introduce basic ideas from the mathematics of Mean Field Spin Glasses. Possible topics: i.i.d.extreme value theory, exchangeable representations, the cavity method, the Parisi formula, applications to combinatorial optimization, phase transitions.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 278X

Categorical Logic (204951)

Jacob Lurie

2018 Spring (4 Credits) **Schedule:** MWF 0200 PM - 0259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

In the early 1960's, Grothendieck introduced the notion of a topos (a category satisfying certain properties). Topos theory can be regarded as a simultaneous generalization of point-set topology and first-order logic, and has been applied with spectacular success to problems in algebraic geometry. This course will be an introduction to topos theory which emphasizes its connections to mathematical logic (particularly model theory).

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Primarily for Graduate Students

Mathematics 279

Representation Theory, Geometry, and the Wonderful Compactification (204952)

Ana Balibanu

2018 Spring (4 Credits) **Schedule:** TR 0100 PM - 0229 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to the construction and properties of the wonderful compactification, and to its geometry. Possible topics: the DeConcini-Procesi construction, Mumford's GIT, the Vinberg monoid and the total coordinate ring of a projective variety, toric varieties, spherical and wonderful varieties, Poisson geometry and the logarithmic cotangent bundle, Hamiltonian reduction.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Primarily for Graduate Students

Mathematics 281X

Arakelov Theory on Arithmetic Surfaces (204941)

Hector Pasten Vasquez

2018 Spring (4 Credits) **Schedule:** MWF 0100 PM - 0159 PM

Instructor Permissions: None **Enrollment Cap:** n/a

Integral models of curves. Arakelov theory on arithmetic surfaces: adjunction formula, Hodge index theorem, Riemann-Roch theorem, applications.

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Primarily for Graduate Students

Mathematics 283 Section: LEC

Instanton Floer Homology (204942)

Peter Kronheimer

2018 Spring (4 Credits) **Schedule:** MWF 1100 AM - 1159 AM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to Floer's instanton homology, as a tool to study 3-manifolds, knots in 3-manifolds, and embedded spatial graphs.

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Primarily for Graduate Students

Mathematics 285

Combinatorial Methods in Algebraic Geometry (204943)

Philip Engel

2017 Fall (4 Credits) **Schedule:** TR 1130 AM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

This course gives examples of two central ways in which combinatorial structures arise in algebraic geometry. The first is via "tropicalization"- replacing a variety of dimension n with a real manifold of dimension n that encodes a stratification into subvarieties. For instance, we discuss how to encode toric varieties by lattice polyhedra, nodal curves by graphs, degenerations of abelian varieties and K3 surfaces by polyhedral decompositions of tori and spheres. Then we use combinatorial techniques to extract information about the original object, The second way is via representation theory. For instance, the representation theory of the symmetric group, and thus partitions, play a fundamental role in Hurwitz theory. We will give a gentle introduction to the tools involved, such as Fock space. These ideas have particularly beautiful application in the enumeration of covers of P^1 or an elliptic curve.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 287X

Mirror Symmetry and Tropical Geometry (204944)

Man-Wai Cheung

2018 Spring (4 Credits) **Schedule:** MWF 1200 PM - 1259 PM

Instructor Permissions: None **Enrollment Cap:** n/a

An introduction to mirror symmetry from the algebrao-geometric point of view. The main theme is the Gross-Siebert program. Possible topics: toric geometry, toric degeneration, tropical curves, theta functions, tropic vertex group.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Primarily for Graduate Students
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 300

Teaching Undergraduate Mathematics (124821)

Jameel Al-Aidroos

Robin Gottlieb

2017 Fall (4 Credits) **Schedule:** T 0100 PM - 0229 PM

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Become an effective instructor. This course focuses on observation, practice, feedback, and reflection providing insight into teaching and learning. Involves iterated videotaped micro-teaching sessions, accompanied by individual consultations. Required of all mathematics graduate students.

Class Notes: Robin Gottlieb and Brendan Kelly

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Not Available for Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 303

Topics in Diophantine Problems (156038)

Hector Pasten Vasquez

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 303

Topics in Diophantine Problems (156038)

Hector Pasten Vasquez

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 304

Topics in Algebraic Topology (121078)

Michael Hopkins

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 304

Topics in Algebraic Topology (121078)

Michael Hopkins

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 316

Topics in Algebraic Geometry (203255)

Arnav Tripathy

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 316

Topics in Algebraic Geometry (203255)

Arnav Tripathy

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 318

Topics in Number Theory (121353)

Barry Mazur

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 318

Topics in Number Theory (121353)

Barry Mazur

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 320

Topics in Geometric Representation Theory (205137)

Ana Balibanu

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 320

Topics in Geometric Representation Theory (205137)

Ana Balibanu

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 321

Topics in Mathematical Physics (118656)

Arthur Jaffe

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 321

Topics in Mathematical Physics (118656)

Arthur Jaffe

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 327

Topics in Several Complex Variables (113647)

Yum Tong Siu

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Class Notes:

Yum Tong Siu 7550

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 327

Topics in Several Complex Variables (113647)

Yum Tong Siu

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Class Notes:

Yum Tong Siu 7550

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 332

Topics in Geometry and Topology (205138)

Alexander Kupers

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 332

Topics in Geometry and Topology (205138)

Alexander Kupers

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 333

Topics in Complex Analysis, Dynamics and Geometry (126825)

Curtis McMullen

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 333

Topics in Complex Analysis, Dynamics and Geometry (126825)

Curtis McMullen

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 335

Topics in Differential Geometry and Analysis (116319)

Cliff Taubes

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 335

Topics in Differential Geometry and Analysis (116319)

Cliff Taubes

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 340

Topics in Model Theory (205139)

Sebastien Vasey

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 340

Topics in Model Theory (205139)

Sebastien Vasey

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 343

Topics in Complex Geometry (156037)

Tristan Collins

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 343

Topics in Complex Geometry (156037)

Tristan Collins

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 345

Topics in Geometry and Topology (113664)

Peter Kronheimer

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 345

Topics in Geometry and Topology (113664)

Peter Kronheimer

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 346Y

Topics in Analysis: Quantum Dynamics (121102)

Horng-Tzer Yau

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course

FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 346Y

Topics in Analysis: Quantum Dynamics (121102)

Horng-Tzer Yau

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 348

Topics in Representation Theory (159643)

Fabian Haiden

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 348

Topics in Representation Theory (159643)

Fabian Haiden

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 352

Topics in Algebraic Number Theory (125869)

Mark Kisin

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 352

Topics in Algebraic Number Theory (125869)

Mark Kisin

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 356

Topics in Harmonic Analysis (118827)

Wilfried Schmid

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 356

Topics in Harmonic Analysis (118827)

Wilfried Schmid

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 357

Topics in Model Theory (159644)

William Boney

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 357

Topics in Model Theory (159644)

William Boney

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 359

Topics in Probability and Analysis (205140)

Aukosh Jagannath

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 359

Topics in Probability and Analysis (205140)

Aukosh Jagannath

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 362

Topics in Number Theory (156036)

Alison Miller

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 362

Topics in Number Theory (156036)

Alison Miller

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 364

Topics in Algebraic Geometry (203316)

Brooke Ullery

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 364

Topics in Algebraic Geometry (203316)

Brooke Ullery

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 365

Topics in Differential Geometry (114080)

Shing-Tung Yau

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 365

Topics in Differential Geometry (114080)

Shing-Tung Yau

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 370 Section: 01

Topics in Linear Algebra and Multivariable Calculus; and Their Applications (205357)

Paul Bamberg

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Course Notes: This course is for graduate students only.

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 373

Topics in Algebraic Topology (125871)

Jacob Lurie

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 373

Topics in Algebraic Topology (125871)

Jacob Lurie

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 381

Introduction to Geometric Representation Theory (121082)

Dennis Gaitsgory

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 381

Introduction to Geometric Representation Theory (121082)

Dennis Gaitsgory

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 382

Topics in Algebraic Geometry (111210)

Joseph D. Harris

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 382

Topics in Algebraic Geometry (111210)

Joseph D. Harris

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 385

Topics in Set Theory (110218)

W. Hugh Woodin

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 385

Topics in Set Theory (110218)

W. Hugh Woodin

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 387

Topics in Mathematical Physics: Bridgeland Stability Conditions (109693)

Hiro Tanaka

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course

Mathematics 387

Topics in Mathematical Physics: Bridgeland Stability Conditions (109693)

Hiro Tanaka

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 388

Topics in Mathematics and Biology (118701)

Martin Nowak

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 388

Topics in Mathematics and Biology (118701)

Martin Nowak

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None
FAS: Course Level	Graduate Course

Mathematics 389

Topics in Number Theory (119721)

Noam D. Elkies

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Class Notes:

Noam D. Elkies 2604

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS Divisional Distribution	None

Mathematics 389

Topics in Number Theory (119721)

Noam D. Elkies

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Class Notes:

Noam D. Elkies 2604

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None

Mathematics 395

Topics in Cluster Algebra (205141)

Man-Wai Cheung

2018 Spring (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS: Course Level	Graduate Course
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration

Mathematics 395

Topics in Cluster Algebra (205141)

Man-Wai Cheung

2017 Fall (4 Credits) **Schedule:** TBD

Instructor Permissions: Instructor **Enrollment Cap:** n/a

Requirements: Prerequisite: Graduate Students Only

Additional Course Attributes:

Attribute	Value(s)
FAS Divisional Distribution	None
All: Cross Reg Availability	Available for Harvard Cross Registration
FAS: Course Level	Graduate Course