MAJOR IN MATHEMATICS

The major in Mathematics is designed to meet two goals: to introduce some of the central ideas in a variety of areas of mathematics and statistics, and to develop problem-solving ability by teaching students to combine creative thinking with rigorous reasoning. Mathematics is a gateway to many career paths including statistics, teaching, consulting, business, engineering, finance, actuarial studies and applied mathematics. Students are strongly encouraged to consult with the department faculty on choosing courses appropriate to an individualized program of study.

REQUIREMENTS (9 courses plus colloquium)

The major in Mathematics consists of nine courses taken at Williams plus the colloquium requirement. Mathematics is highly cumulative, and students should plan a route to completing the major that ensures the proper sequencing and prerequisites for all needed courses. Note that not all upper level courses are offered every year.

Calculus (2 courses)

Mathematics 140 Calculus II
Mathematics 150 or 151 Multivariable Calculus
Applied/Discrete Mathematics/Statistics (1 course)

or Mathematics 210 Mathematical Methods for Scientists (Same as Physics 210)

or Mathematics 200 Discrete Mathematics

or Statistics 201 Statistics and Data Analysis

Mathematics 309 Differential Equations

or a more advanced applied/discrete/statistics course with prior department approval

Core Courses (3 courses)

Mathematics 250 Linear Algebra

Mathematics 350 Real Analysis or Mathematics 351 Applied Real Analysis

Mathematics 355 Abstract Algebra

Completion (3 courses plus colloquium)

Two mathematics or statistics electives from courses numbered 300 and above

One Senior Seminar: Any mathematics or statistics course numbered between 400 and 479, taken in the junior or senior year.

Participation in the Department Colloquium, in which all senior majors present a talk on a mathematical or statistical topic of their choice. Each major must attend at least 20 colloquia (reduced to 15 during the Academic Year 2020-2021), and up to 5 attendances may be counted in their junior year. Students engaged in study away may petition the department in advance to count up to 5 suitable colloquia attendances from their study away program.

Pass/Fail policies during the Academic Year 2020-2021

Information about the Department of Mathematics and Statistics Pass/Fail policies during the Academic Year 2020-2021 can be found here.

ADVANCED PLACEMENT

Students who come to Williams with advanced placement will be moved up in the Mathematics major, and should consult with faculty to be placed in the best class reflecting their experience and background. A student who places out of a course substitutes another course of equal or higher level in Mathematics or Statistics to complete the nine course major. Students should select courses best suited to their preparation and goals, and consult with the department faculty concerning appropriate courses and placement. The department reserves the right to refuse registration in any course for which the student is overqualified.

For Example, a student starting in MATH 130 might take MATH 130 and 140 the first year, MATH 150 and MATH 200 the second year, MATH 250 and MATH 350 the third year, MATH 355 and a senior seminar the fourth year, plus the two required electives some time. Students are encouraged to consult freely with any math faculty about course selection and anything else.

CALCULUS PLACEMENT

Recommended placement for students who have taken an Advanced Placement Examination in Calculus (AB or BC) is:

BC 1, 2 or AB 2, 3 Math 140

AB 4 or 5 Math 150

BC 3, 4 or 5 Math 151

Consult with department faculty for any Calculus or Statistics placement questions. Students who have had calculus in high school, whether or not they took the Advanced Placement Examination, are barred from 130 unless they obtain permission from the instructor.

NOTES

Substitutions, Study Abroad, and Transfer Credit: In some cases, and with prior permission of the Mathematics and Statistics Department, appropriate courses from other institutions or a course from another Williams department may be substituted for electives. Programs like the “Budapest Semester in Mathematics” are recommended for majors who wish to focus on mathematics away. The department, though, normally accommodates students who select other study away programs. The department offers its core courses in both the fall and the spring to allow students to spend more easily a semester away.

Double Counting: No course may count towards two different majors.

Planning Courses: Core courses Mathematics 350/351 and 355, are normally offered every year. Most other 300-level topics are offered in alternate years. Topology, Complex Analysis, and second courses in real analysis and abstract algebra are normally offered at least every other year.
Each 400-level topic is normally offered every two to four years. Students should check with the department before planning far into the future.

**Course Admission:** Courses are normally open to all students meeting the prerequisites, subject to any course caps. Students with questions about the level at which courses are conducted are invited to consult department faculty.

**FAQ**

Students MUST contact departments/programs BEFORE assuming study away credit will be granted toward the major or concentration.

**Can your department or program typically pre-approve courses for major/concentration credit?**

Yes, in many cases, though students should be sure to contact the department.

**What criteria will typically be used/required to determine whether a student may receive major/concentration credit for a course taken while on study away?**

- Course title and description, and complete syllabus including readings/assignments.
- Does your department/program place restrictions on the number of major/concentration credits that a student might earn through study away?
  - No.
- Does your department/program place restrictions on the types of courses that can be awarded credit towards your major?
  - Yes. They have to be approved MATH/STAT courses.
- Are there specific major requirements that cannot be fulfilled while on study away?
  - Yes. Colloquium requirement, Senior Seminar requirement.
- Are there specific major requirements in your department/program that students should be particularly aware of when weighing study away options? (Some examples might include a required course that is always taught in one semester, laboratory requirements.)
  - Yes. The highly cumulative structure of the major.
- Give examples in which students thought or assumed that courses taken away would count toward the major or concentration and then learned they wouldn’t:
  - None to date.

**THE DEGREE WITH HONORS IN MATHEMATICS**

The degree with honors in Mathematics is awarded to the student who has demonstrated outstanding intellectual achievement in a program of study which extends beyond the requirements of the major. The principal considerations for recommending a student for the degree with honors will be: Mastery of core material and skills, breadth and, particularly, depth of knowledge beyond the core material, ability to pursue independent study of mathematics or statistics, originality in methods of investigation, and, where appropriate, creativity in research.

An honors program normally consists of two semesters (MATH/STAT 493 and 494) and a winter study (WSP 031) of independent research, culminating in a thesis and a presentation. Under certain circumstances, the honors work can consist of coordinated study involving a one semester (MATH/STAT 493 or 494) and a winter study (WSP 030) of independent research, culminating in a “minithesis” and a presentation. Note that during the Academic Year 2020-2021 the winter study requirement for thesis and “minithesis” is waved. At least one semester should be in addition to the major requirements, and thesis courses do not count as 400-level senior seminars.

An honors program in actuarial studies requires significant achievement on four appropriate examinations of the Society of Actuaries.

Highest honors will be reserved for the rare student who has displayed exceptional ability, achievement or originality. Such a student usually will have written a thesis, or pursued actuarial honors and written a mini-thesis. An outstanding student who writes a mini-thesis, or pursues actuarial honors and writes a paper, might also be considered. In all cases, the award of honors and highest honors is the decision of the Department.

**APPLIED MATHEMATICS TRACK**

Students interested in applied mathematics, engineering, or other sciences should consider:

- Mathematics 140 Calculus II
- Mathematics 150 or 151 Multivariable Calculus
- Statistics 201 Statistics and Data Analysis
- Mathematics 250 Linear Algebra
- Mathematics 351 Applied Real Analysis
- Mathematics 355 Abstract Algebra
Some programming or numerical analysis (e.g. MATH 361, 318T, or anything if you’ve had CSCI 134)

MATH 309 or Post-core Differential Equations/Numerical Methods

Senior seminar (e.g. Math Ecology MATH 410T or Mathematical Modeling MATH 433)

Other recommended courses: complex analysis, discrete mathematics (e.g. combinatorics or graph theory), operations research, optimization, probability, statistics, appropriate courses in Biology, Chemistry, Computer Science, Economics, Neuroscience, Physics, etc.

Williams has exchange and joint programs with good engineering schools. Interested students should consult the section on engineering near the beginning of the Bulletin and the Williams pre-engineering advisor for further information.

GRADUATE SCHOOL TRACK

Students interested in continuing their study of mathematics in graduate school should consider:

Mathematics 140 Calculus II

Mathematics 150 or 151 Multivariable Calculus

Mathematics 250 Linear Algebra

Mathematics 350 Real Analysis

Mathematics 355 Abstract Algebra

Complex Analysis

Topology

Some second semester analysis

Some second semester algebra

Some post-core geometry

Thesis

[With prior permission, in unusual circumstances, senior seminar can be waived in favor of harder post-core electives.]

Students headed for graduate school generally take more than this relatively small number of courses required for a liberal arts major. Reading knowledge of a foreign language (French, German, or Russian) can be helpful.

Students interested in studying statistics in graduate school should take STAT 201, 346, 360, a 400 level statistics course and MATH 350/351 and 341 in addition to their other math requirements.

OTHER CAREER PATHS

Other Graduate and Professional Schools: An increasing number of graduate and professional schools require mathematics and statistics as a prerequisite to admission or to attaining their degree. Students interested in graduate or professional training in business, medicine, economics, or psychology are advised to find out the requirements in those fields early in their college careers.

Statistics and Actuarial Science: Students interested in statistics or actuarial science should consider Mathematics 341, Statistics courses, and Economics 255. Additionally, students should consider taking some number of the actuarial exams given by the Society of Actuaries, which can constitute part of an honors program in actuarial studies (see section on honors above).

Teaching: Students interested in teaching mathematics at the elementary or secondary school level should consider courses on teaching, number theory, geometry, statistics, and practice as a tutor or teaching assistant. Winter study courses that provide a teaching practicum are also highly recommended. Consult the Program in Teaching (Professor Susan Engel) and the Office of Career Counseling.

Business and Finance: Students interested in careers in business or finance should consider Mathematics 333 and Statistics courses. Since these courses address different needs, students should consult with the instructors to determine which seem to be most appropriate for individuals.

There are three types of 300-level courses. There are the core courses: Real Analysis, MATH 350/351, and Abstract Algebra Math 355. There are the “precore” courses, which do not have the core courses as prerequisites and have numbers 300-349. Finally, there are those courses that have an Abstract Algebra or Real Analysis prerequisite, which are numbered 360-399.
MATH 102 (F) Foundations in Quantitative Skills
This course will strengthen a student's foundation in quantitative reasoning in preparation for the science curriculum and QFR requirements. The material will be at the college algebra/precalculus level, and covered in a tutorial format with students working in small groups with the professor. Access to this course is limited to placement by a quantitative skills counselor.

Requirements/Evaluation: homework, presentations during the tutorial meetings, and projects
Prerequisites: access to the course is limited to placement by a quantitative skills counselor
Enrollment Limit: 10
Enrollment Preferences: students who need most help with the quantitative reasoning
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3)

Fall 2021
TUT Section: T1 TBA Thursday Org Mtg 8:30 pm - 9:00 pm Mihai Stoiciu

MATH 110 (F) Logic and Likelihood (QFR)
How best can we reason in the face of uncertainty? We will begin with an examination of rationality and the reasoning process including a survey of formal logic. Starting with uncertainty from a psychological and philosophical viewpoint, we will move to a careful theory of likelihood and how to reason with probabilistic models. The course will conclude with a consideration of observation and information, how to test hypotheses, and how we update our beliefs to incorporate new evidence.

Requirements/Evaluation: homework, essays, presentations, exams, and participation
Prerequisites: none
Enrollment Limit: 25
Enrollment Preferences: first-year students
Expected Class Size: 25
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This course will be covering formal logic and probability theory at sufficient depth to place this course on level with other QFR designated courses.
Not offered current academic year

MATH 113 (S) The Beauty of Numbers (QFR)
Have you ever wondered what keeps your credit card information safe everytime you buy something online? Number theory! Number Theory is one of the oldest branches of mathematics. In this course, we will discover the beauty and usefulness of numbers, from ancient Greece to modern cryptography. We will look for patterns, make conjectures, and learn how to prove these conjectures. Starting with nothing more than basic high school algebra, we will develop the logic and critical thinking skills required to realize and prove mathematical results. Topics to be covered include the meaning and content of proof, prime numbers, divisibility, rationality, modular arithmetic, Fermat's Last Theorem, the Golden ratio, Fibonacci numbers, coding theory, and unique factorization.

Requirements/Evaluation: projects, homework assignments, and exams
Prerequisites: MATH 102 (or demonstrated proficiency on a diagnostic test) or permission of instructor
Enrollment Limit: 25
Expected Class Size: 25
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Not offered current academic year
MATH 119 (F) The Mathematics of Pandemics: From the Spread of Infections to Cost-Benefit Analyses of Responses  (QFR)

The goal of the class is to help students learn to ask the right questions, and to gather and analyze the data needed to answer them, to understand the covid pandemic and the worldwide responses. Through local experts and numerous guest speakers playing key roles in these problems, we will discuss numerous aspects, from mathematical models for virus propagation to analyzing the economic, educational, social and emotional consequences of lockdowns and social distancing; from moral and legal dilemmas created by the pandemic and responses to the international political scene and relations between countries. Offered as Math 119 or Math 312 (those taking as Math 312 will have some of the readings replaced with more technical modeling papers and subsequent homework). Pre-requisites: None for Math 119; for Math 312 linear algebra is recommended.

Requirements/Evaluation: Homework, writing, class participation.

Prerequisites: None

Enrollment Limit: 30

Enrollment Preferences: all students will have an equal chance; if possible none will be turned away.

Expected Class Size: 30

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: We will discuss mathematical models and use statistics to analyze data.

Not offered current academic year

MATH 130 (FiS) Calculus I  (QFR)

Calculus permits the computation of velocities and other instantaneous rates of change by a limiting process called differentiation. The same process also solves "max-min" problems: how to maximize profit or minimize pollution. A second limiting process, called integration, permits the computation of areas and accumulations of income or medicines. The Fundamental Theorem of Calculus provides a useful and surprising link between the two processes. Subtopics include trigonometry, exponential growth, and logarithms.

Requirements/Evaluation: Weekly homework and quizzes, 2 exams during the semester, and one final

Prerequisites: MATH 102 (or demonstrated proficiency on a diagnostic test); this is an introductory course for students who have not seen calculus before

Enrollment Limit: 30

Enrollment Preferences: first-year students

Expected Class Size: 20

Grading: yes pass/fail option, yes fifth course option

Unit Notes: students who have previously taken a calculus course may not enroll in MATH 130 without the permission of instructor

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This a calculus course.

Fall 2021
LEC Section: 01  TR 9:55 am - 11:10 am  Pamela E. Harris
LEC Section: 02  TR 11:20 am - 12:35 pm  Pamela E. Harris

Spring 2022
LEC Section: 01  TR 11:20 am - 12:35 pm  Pamela E. Harris

MATH 140 (FiS) Calculus II  (QFR)

Calculus answers two basic questions: how fast is something changing (the derivative) and how much is there (the integral). This course is about integration, and the miracle that unites the derivative and the integral (the Fundamental Theorem of Calculus.) Understanding calculus requires in part the understanding of methods of integration. This course will also solve equations involving derivatives ("differential equations") for population growth or pollution levels. Exponential and logarithmic functions and trigonometric and inverse functions will also play an important role. This course is the right starting point for students who have seen derivatives, but not necessarily integrals, before.

Requirements/Evaluation: homework, quizzes, and/or exams
**Prerequisites:** MATH 130 or equivalent; students who have received the equivalent of advanced placement of AB 4, BC 3 or higher may not enroll in MATH 140 without the permission of instructor

**Enrollment Limit:** 50

**Enrollment Preferences:** based on who needs calculus the soonest

**Expected Class Size:** 30

**Grading:** yes pass/fail option, yes fifth course option

**Unit Notes:** students who have higher advanced placement must enroll in MATH 150 or above

**Distributions:** (D3) (QFR)

**Quantitative/Formal Reasoning Notes:** This is a math class

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**Fall 2021**

LEC Section: 01    TR 9:55 am - 11:10 am    Thomas A. Garrity

LEC Section: 02    TR 11:20 am - 12:35 pm    Thomas A. Garrity

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**Spring 2022**

LEC Section: 01    MWF 9:00 am - 9:50 am    Steven J. Miller

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**MATH 150 (F)(S) Multivariable Calculus** (QFR)

Applications of calculus in mathematics, science, economics, psychology, the social sciences, involve several variables. This course extends calculus to several variables: vectors, partial derivatives, multiple integrals. There is also a unit on infinite series, sometimes with applications to differential equations.

**Requirements/Evaluation:** Problem sets and exams

**Prerequisites:** MATH 140 or equivalent, such as satisfactory performance on an Advanced Placement Examination

**Enrollment Limit:** 50

**Enrollment Preferences:** Preference will be given to prospective math and stats majors, or students who need this as a course to serve as a prerequisite for other courses.

**Expected Class Size:** 40

**Grading:** yes pass/fail option, yes fifth course option

**Unit Notes:** students with the equivalent of advanced placement of AB 4 or above should enroll in MATH 150, students with a BC 3 or higher should enroll in Math 151 when it is being offered, and Math 150 otherwise.

**Distributions:** (D3) (QFR)

**Quantitative/Formal Reasoning Notes:** mathematics

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**Fall 2021**

SEM Section: 01    MWF 10:00 am - 10:50 am    Julie C. Blackwood

SEM Section: 02    MWF 11:00 am - 11:50 am    Julie C. Blackwood

SEM Section: 03    MWF 12:00 pm - 12:50 pm    Julie C. Blackwood

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**Spring 2022**

SEM Section: 01    MWF 10:00 am - 10:50 am    Steven J. Miller

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**MATH 151 (F) Multivariable Calculus** (QFR)

Applications of calculus in mathematics, science, economics, psychology, the social sciences, involve several variables. This course extends calculus to several variables: vectors, partial derivatives and multiple integrals. The goal of the course is Stokes Theorem, a deep and profound generalization of the Fundamental Theorem of Calculus. The difference between this course and MATH 150 is that MATH 150 covers infinite series instead of Stokes Theorem. Students with the equivalent of BC 3 or higher should enroll in MATH 151, as well as students who have taken the equivalent of an integral calculus and who have already been exposed to infinite series. For further clarification as to whether MATH 150 or MATH 151 is appropriate, please consult a member of the math/stat department.
**MATH 197 (F) Independent Study: Mathematics**

Directed 100-level independent study in Mathematics.

- **Requirements/Evaluation:** decided by the department
- **Prerequisites:** permission of department
- **Enrollment Limit:** 20
- **Enrollment Preferences:** decided by the department
- **Expected Class Size:** 1
- **Grading:** yes pass/fail option, yes fifth course option
- **Distributions:** (D3)

**Fall 2021**

IND Section: 01 TBA Mihai Stoiciu

**MATH 198 (S) Independent Study: Mathematics**

Directed 100-level independent study in Mathematics.

- **Requirements/Evaluation:** decided by the department
- **Prerequisites:** permission of the department
- **Enrollment Limit:** 20
- **Enrollment Preferences:** decided by the department
- **Expected Class Size:** 1
- **Grading:** yes pass/fail option, yes fifth course option
- **Distributions:** (D3)

**Spring 2022**

IND Section: 01 TBA Mihai Stoiciu

**MATH 200 (F)(S) Discrete Mathematics** (QFR)

This course will help you understand the world through a mathematical lens and will develop your powers of argumentation and critical thinking. We will explore and utilize diverse areas of discrete mathematics including logic, set theory, functions and relations, combinatorics, probability, networks,
and more. We also will discuss methods and styles of mathematical proofs in order to prepare you for more advanced math courses. Finally, while mathematical knowledge is often perceived as being "pure," we will highlight some ways in which it is socially constructed and hence subject to human limitations and biases.

**Class Format:** This course is taught in a flipped classroom format. Students read and watch lecture videos prior to each class session. The instructor uses class time for discussion and collaborative learning activities.

**Requirements/Evaluation:** Students will complete checkpoint quizzes on videos and reading assignments, regularly assigned homework problems, and reflective writing assignments. To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows the policy of "ungrading." Over the course of the semester, students will develop a rubric to assess their own learning and will evaluate themselves according to this rubric.

**Prerequisites:** Calculus at the level of an AP course or Williams College Math 130 or 140. Students who have taken a 300-level or 400-level math course should obtain permission of the instructor before enrolling.

**Enrollment Limit:** 40

**Enrollment Preferences:** Preference given to first and second year students intending to major in mathematics or computer science.

**Expected Class Size:** 40

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Quantitative/Formal Reasoning Notes:** This course involves developing the formal mathematical language of logic and set theory. It also involves using quantitative tools to solve problems relating to combinatorics, probability, and other fields of discrete mathematics.

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**Fall 2021**

LEC Section: 01   TR 8:30 am - 9:45 am   Chad M. Topaz

LEC Section: 02   TR 9:55 am - 11:10 am   Chad M. Topaz

**Spring 2022**

LEC Section: 01   MWF 9:00 am - 9:50 am   Lori A. Pedersen

LEC Section: 02   MWF 10:00 am - 10:50 am   Lori A. Pedersen

**MATH 210 (S) Mathematical Methods for Scientists (QFR)**

**Cross-listings:** PHYS 210  MATH 210

**Secondary Cross-listing**

This course covers a variety of mathematical methods used in the sciences, focusing particularly on the solution of ordinary and partial differential equations. In addition to calling attention to certain special equations that arise frequently in the study of waves and diffusion, we develop general techniques such as looking for series solutions and, in the case of nonlinear equations, using phase portraits and linearizing around fixed points. We study some simple numerical techniques for solving differential equations. A series of optional sessions in Mathematica will be offered for students who are not already familiar with this computational tool.

**Class Format:** three hours per week

**Requirements/Evaluation:** several exams and on weekly problem sets, all of which have a substantial quantitative component

**Prerequisites:** MATH 150 or 151 and familiarity with Newtonian mechanics at the level of PHYS 131

**Enrollment Limit:** 50

**Enrollment Preferences:** sophomores and juniors

**Expected Class Size:** 30

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:

PHYS 210 (D3) MATH 210 (D3)

**Quantitative/Formal Reasoning Notes:** This course will have weekly problem sets using advanced calculus methods and some computer programming at the end of the course.
MATH 250 (F)(S) Linear Algebra (QFR)
Many social, political, economic, biological, and physical phenomena can be described, at least approximately, by linear relations. In the study of systems of linear equations one may ask: When does a solution exist? When is it unique? How does one find it? How can one interpret it geometrically? This course develops the theoretical structure underlying answers to these and other questions and includes the study of matrices, vector spaces, linear independence and bases, linear transformations, determinants and inner products. Course work is balanced between theoretical and computational, with attention to improving mathematical style and sophistication.

Requirements/Evaluation: homework and exams
Prerequisites: MATH 150/151 or MATH 200
Enrollment Limit: 40
Enrollment Preferences: Students who have officially declared a major that requires Math 250.
Expected Class Size: 40
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: In this course, students will engage in both quantitative and formal reasoning.
Attributes: COGS Related Courses
MATH 303 (F) Introduction to Dynamics, p-Adics, and Measure (QFR)
At its most basic level a dynamical system consists of a set of points and a transformation or map acting on the set (i.e., sending points in the set to other points in the set). In this setting we can already ask about the existence, and prevalence, of periodic points (points that come back to themselves). One can also ask about the orbit of a point: the set of points that is obtained as one iteratively applies the transformation the point. An important dynamical notion that comes up here is that of chaos. The course will start by studying basic dynamical systems using notions from calculus. Then we will introduce the p-adic numbers and use them to study dynamical systems. The course will end with an exploration of the notion of measure and its connection with dynamical systems.

Requirements/Evaluation: Homework, class participation, exams.
Prerequisites: Math 250.
Enrollment Limit: 30
Enrollment Preferences: Juniors
Expected Class Size: 20
Grading: no pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: Mathematics

Fall 2021
LEC Section: 01  MWF 10:00 am - 10:50 am  Cesar E. Silva

MATH 306 (S) Fractals and Chaos (QFR)
Early in the course we introduce the notion of dynamical systems. Then we will develop the mathematics behind iterated function systems and study the notions of fractals and chaos. There will be a lot of computer experimentation with various programs and resources which the students are expected to use to learn and discover properties of fractals. The final topics will include dimension complex dynamics and the Mandelbrot set.

Requirements/Evaluation: homework, projects and exams
Prerequisites: MATH 250
Enrollment Limit: 30
Expected Class Size: 18
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Not offered current academic year

MATH 307 (S) Computational Linear Algebra (QFR)
Linear algebra is of central importance in the quantitative sciences, including application areas such as image and signal processing, data mining, computational finance, structural biology, and much more. When the problems must be solved computationally, approximation, round-off errors, convergence, and efficiency matter, and traditional linear algebra techniques may fail to succeed. We will adopt linear algebra techniques on a large scale, implement them computationally, and apply them to core problems in scientific computing. Topics may include: systems of linear and nonlinear equations; approximation and statistical function estimation; optimization; interpolation; data scraping; singular value decomposition; and more. This course could also be considered a course in numerical analysis or computational science.

Class Format: This course is taught in a flipped classroom format. Students read and watch lecture videos prior to each class session. The instructor
uses class time for discussion and collaborative learning activities. This course will be a good fit for students with a strong interest in applied mathematics and a willingness to devote significant effort to learning/doing computer programming.

Requirements/Evaluation: Students will complete checkpoint quizzes, regularly assigned homework problems and projects, and reflective writing assignments. To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows the policy of "ungrading." Over the course of the semester, students will develop a rubric to assess their own learning and will evaluate themselves according to this rubric.

Prerequisites: MATH 250; COMP 134 or equivalent prior experience with computer programming (in any language)

Enrollment Limit: 30

Enrollment Preferences: Preference given to majors and prospective majors.

Expected Class Size: 30

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course involves developing the formal mathematical language of linear algebra. It also involves using quantitative tools to solve problems relating to a wide range of applications in the physical and social sciences.

Spring 2022

LEC Section: 01 TR 8:30 am - 9:45 am Chad M. Topaz

MATH 308 (S) Mathematical and Computational Approaches to Social Justice (DPE) (QFR)

Civil rights activist, educator, and investigative journalist Ida B. Wells said that "the way to right wrongs is to shine the light of truth upon them." In this research-based tutorial, students will bring the vanguard of quantitative approaches to bear on issues of social justice. Each tutorial pair will carry out a substantial project in one of the following areas: criminal justice, education equity, environmental justice, health care equity, and inclusion in arts/media. All students should expect to invest substantial effort in reading social justice literature and in acquiring new skills in data science, mathematics, and computation.

Class Format: This is a research-based tutorial.

Requirements/Evaluation: To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows the policy of "ungrading." Over the course of the semester, students will develop a rubric to assess their own learning and will evaluate themselves according to this rubric.

Prerequisites: Across each tutorial pair: multivariable calculus (e.g., Math 150/151), linear algebra (e.g., Math 250), statistics (e.g., Stat 161/201), computer programming (e.g., Comp 134), some working knowledge of or interest in social justice issues.

Enrollment Limit: 10

Enrollment Preferences: This is a tutorial and hence is capped at 10 students. Students interested in enrolling should contact the instructor as soon as possible. The instructor will ask for a brief statement of interest and selected other information.

Expected Class Size: 10

Grading: yes pass/fail option, no fifth course option

Distributions: (D3) (DPE) (QFR)

Difference, Power, and Equity Notes: Students study issues of equity, diversity, and inclusion in areas such as criminal justice, arts/media, environmental justice, education, and health care, and along identity axes such as gender, race/ethnicity, disability status, and sexual orientation.

Quantitative/Formal Reasoning Notes: Students use multiple mathematical, statistical, and computational frameworks to acquire, model, and analyze real-world data.

Spring 2022

TUT Section: T1 TBA Chad M. Topaz

MATH 309 (S) Differential Equations (QFR)

Ordinary differential equations (ODE) frequently arise as models of phenomena in the natural and social sciences. This course presents core ideas of ODE from an applied standpoint. Topics covered early in the course may include numerical solutions, separation of variables, integrating factors, constant coefficient linear equations, and power series solutions. Later, we will focus on nonlinear ODEs, for which it is usually impossible to find
analytical solutions. Tools from dynamical systems will be introduced to allow us to obtain some information about the behavior of the ODE without explicitly knowing the solution.

**Class Format:** Unless circumstances change, students will have the option of taking the course in person or remotely

**Requirements/Evaluation:** quizzes/exams, problem sets, participation, and possible activities

**Prerequisites:** MATH 150/151 and MATH 250

**Enrollment Limit:** 20

**Enrollment Preferences:** discretion of the instructor

**Expected Class Size:** 20

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Quantitative/Formal Reasoning Notes:** 300-level mathematics course

Spring 2022

LEC Section: 01  MWF 12:00 pm - 12:50 pm  Julie C. Blackwood

**MATH 310 (F) Mathematical Biology** (QFR)

**Cross-listings:** BIOL 210  MATH 310

**Primary Cross-listing**

This course will provide an introduction to the many ways in which mathematics can be used to understand, analyze, and predict biological dynamics. We will learn how to construct mathematical models that capture essential properties of biological processes while maintaining analytic tractability. Analytic techniques, such as stability and bifurcation analysis, will be introduced in the context of both continuous and discrete time models. Additionally, students will couple these analytic tools with numerical simulation to gain a more global picture of the biological dynamics. Possible biological applications include, but are not limited to, single and multi-species population dynamics, neural and biological oscillators, tumor cell growth, and infectious disease dynamics.

**Class Format:** Unless circumstances change, students will have the option of taking the course in person or remotely

**Requirements/Evaluation:** problem sets, quizzes/exams, participation, final project and paper

**Prerequisites:** MATH 250 and MATH 309, or permission of instructor

**Enrollment Limit:** 20

**Enrollment Preferences:** if over-enrolled, will have students submit reasons for taking class; preference to those with interest in both subjects

**Expected Class Size:** 20

**Grading:** no pass/fail option, no fifth course option

**Distributions:** (D3) (QFR)

**This course is cross-listed and the prefixes carry the following divisional credit:**

BIOL 210 (D3) MATH 310 (D3)

**Quantitative/Formal Reasoning Notes:** The course will introduce methods for developing and analyzing mathematical models.

**Attributes:** PHLH Methods in Public Health

Not offered current academic year

**MATH 312 (F) The Mathematics of Pandemics: From the Spread of Infections to Cost-Benefit Analyses of Responses** (QFR)

The goal of the class is to help students learn to ask the right questions, and to gather and analyze the data needed to answer them, to understand the covid pandemic and the worldwide responses. Through local experts and numerous guest speakers playing key roles in these problems, we will discuss numerous aspects, from mathematical models for virus propagation to analyzing the economic, educational, social and emotional consequences of lockdowns and social distancing; from moral and legal dilemmas created by the pandemic and responses to the international political scene and relations between countries. Offered as Math 119 or Math 312 (those taking as Math 312 will have some of the readings replaced with more technical modeling papers and subsequent homework). Pre-requisites: None for Math 119; for Math 312 linear algebra is recommended.

**Requirements/Evaluation:** Class participation, writing, homework problems.
Prerequisites: Linear algebra recommended.

Enrollment Limit: none

Enrollment Preferences: all students will have an equal chance; if possible none will be turned away.

Expected Class Size: 30

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: We will discuss mathematical models and use statistics to analyze data.

Not offered current academic year

MATH 313 (S) Introduction to Number Theory (QFR)

The study of numbers dates back thousands of years, and is fundamental in mathematics. In this course, we will investigate both classical and modern questions about numbers. In particular, we will explore the integers, and examine issues involving primes, divisibility, and congruences. We will also look at the ideas of numbers and primes in more general settings, and consider fascinating questions that are simple to understand, but can be quite difficult to answer. This course will be held virtually using an active learning method, an instructional strategy reversing the traditional learning environment by supplying instructional content outside of class time. This will include reading the textbook and completing problem sets prior to attending class. Class time will be spent clarifying concepts and working in small groups through challenging problems with the support of the professor, teaching assistants, and your peers. Building positive collaborative working relationships and public speaking skills will be added benefits of this class.

Class Format: This course will employ an active learning method rather than the traditional lecture. Please see the course description for details.

Requirements/Evaluation: The course will be graded on a mastery-based system. The final course grade will be a combination of quarterly participation in self-reflections, daily reading assignments, and weekly problem sets.

Prerequisites: MATH 250 or permission of instructor

Enrollment Limit: 20

Enrollment Preferences: All are welcome regardless of major or year. In case of over-enrollment, preference will be given to those needing the course for graduation.

Expected Class Size: 15

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course requires working with various number systems, performing explicit computations, and proving mathematical results using logical reasoning practices.

Not offered current academic year

MATH 314 (S) Cryptography (QFR)

An introduction to the techniques and practices used to keep secrets over non-secure lines of communication, including classical cryptosystems, the data encryption standard, the RSA algorithm, discrete logarithms, hash functions, and digital signatures. In addition to the specific material, there will also be an emphasis on strengthening mathematical problem solving skills, technical reading, and mathematical communication.

Requirements/Evaluation: exams, homework, and quizzes

Prerequisites: MATH 250

Enrollment Limit: 30

Enrollment Preferences: graduating seniors and Math majors

Expected Class Size: 30

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: The course will contain mathematical proofs.

Not offered current academic year
MATH 315 (S) Methods for Solving Diophantine Equations (QFR)

A Diophantine equation is an equation with integer (or rational) coefficients that is to be solved in integers (or rational numbers). A focus of study for hundreds of years, Diophantine analysis remains a vibrant area of research. It has yielded a multitude of beautiful results and has wide ranging applications in other areas of mathematics, in cryptography, and in the natural sciences. In this project-based tutorial, we will focus on studying and implementing various methods for solving previously unsolved infinite families of Diophantine equations. Depending on their interests, students may choose one or several methods to apply to open problems in the field. Please note that this tutorial will be held virtually.

Requirements/Evaluation: The grade for this course will be a combination of weekly problem sets, weekly oral presentations (approx. 15 min. each), quarterly self-reflections, and a final written project manuscript that will be continually edited throughout the semester (minimum of 5 pages).

Prerequisites: MATH 250 or permission of the instructor

Enrollment Limit: 10

Enrollment Preferences: Sophomores, Juniors, and Seniors based on a short questionnaire of interests. In the event of over-enrollment, preference will be given to those that need the course to graduate.

Expected Class Size: 10

Grading: no pass/fail option, no fifth course option

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course requires working with various number systems, performing explicit computations, and proving mathematical results using logical reasoning practices.

Not offered current academic year

MATH 317 (F) Introduction to Operations Research (QFR)

In the first N math classes of your career, you can be misled as to what the world is truly like. How? You're given exact problems and told to find exact solutions. The real world is sadly far more complicated. Frequently we cannot exactly solve problems; moreover, the problems we try to solve are themselves merely approximations to the world! We are forced to develop techniques to approximate not just solutions, but even the statement of the problem. Additionally, we often need the solutions quickly. Operations Research, which was born as a discipline during the tumultuous events of World War II, deals with efficiently finding optimal solutions. In this course we build analytic and programming techniques to efficiently tackle many problems. We will review many algorithms from earlier in your mathematical or CS career, with special attention now given to analyzing their run-time and seeing how they can be improved. The culmination of the course is a development of linear programming and an exploration of what it can do and what are its limitations. For those wishing to take this as a Stats course, the final project must have a substantial stats component approved by the instructor.

Prerequisites: Linear Algebra (MATH 250) and one other 200-level or higher CSCI, MATH or STATS course.

Requirements/Evaluation: homework, exams, projects

Prerequisites: MATH 150, MATH 250 and one other 200-level or higher CSCI, MATH or STATS course

Enrollment Limit: 40

Enrollment Preferences: Computer Science, Mathematics and Statistics majors

Expected Class Size: 25

Grading: yes pass/fail option, yes fifth course option

Unit Notes: http://web.williams.edu/Mathematics/sjmiller/public_html/317/

Distributions: (D3) (QFR)

Not offered current academic year

MATH 319 (S) Integrative Bioinformatics, Genomics, and Proteomics Lab (QFR)

Cross-listings: MATH 319 CHEM 319 BIOL 319 PHYS 319 CSCI 319

Secondary Cross-listing

What can computational biology teach us about cancer? In this lab-intensive experience for the Genomics, Proteomics, and Bioinformatics program, computational analysis and wet-lab investigations will inform each other, as students majoring in biology, chemistry, computer science, mathematics/statistics, and physics contribute their own expertise to explore how ever-growing gene and protein data-sets can provide key insights into human disease. In this course, we will take advantage of one well-studied system, the highly conserved Ras-related family of proteins, which play a central role in numerous fundamental processes within the cell. The course will integrate bioinformatics and molecular biology, using database
searching, alignments and pattern matching, and phylogenetics to reconstruct the evolution of gene families by focusing on the gene duplication events and gene rearrangements that have occurred over the course of eukaryotic speciation. By utilizing high through-put approaches to investigate genes involved in the inflammatory and MAPK signal transduction pathways in human colon cancer cell lines, students will uncover regulatory mechanisms that are aberrantly altered by siRNA knockdown of putative regulatory components. This functional genomic strategy will be coupled with independent projects using phosphorylation-state specific antisera to test our hypotheses. Proteomic analysis will introduce the students to de novo structural prediction and threading algorithms, as well as data-mining approaches and Bayesian modeling of protein network dynamics in single cells. Flow cytometry and mass spectrometry may also be used to study networks of interacting proteins in colon tumor cells.

Class Format: two afternoons of lab, with one hour of lecture, per week. In most weeks, we will meet one day for lecture discussions.

Requirements/Evaluation: lab participation, several short homework assignments, one lab report, a programming project, and a grant proposal

Prerequisites: BIOL 202; students who have not taken BIOL 202 but have taken BIOL 101 and a CSCI course, or CSCI/PHYS 315, may enroll with permission of instructor. No prior computer programming experience is required.

Enrollment Limit: 12

Enrollment Preferences: seniors, then juniors, then sophomores

Expected Class Size: 12

Grading: yes pass/fail option, yes fifth course option

Unit Notes: does not satisfy the distribution requirement for the Biology major

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
MATH 319 (D3) CHEM 319 (D3) BIOL 319 (D3) PHYS 319 (D3) CSCI 319 (D3)

Quantative/Formal Reasoning Notes: Through lab work, homework sets and a major project, students will learn or further develop their skills in programming in Python, and about the basis of Bayesian approaches to phylogenetic tree estimation.

Attributes: BIGP Courses BIMO Interdepartmental Electives

Not offered current academic year

MATH 321 (S) Knot Theory (QFR)

Take a piece of string, tie a knot in it, and glue the ends together. The result is a knotted circle, known as a knot. For the last 100 years, mathematicians have studied knots, asking such questions as, "Given a nasty tangled knot, how do you tell if it can be untangled without cutting it open?" Some of the most interesting advances in knot theory have occurred in the last ten years. This course is an introduction to the theory of knots. Among other topics, we will cover methods of knot tabulation, surfaces applied to knots, polynomials associated to knots, and relationships between knot theory and chemistry and physics. In addition to learning the theory, we will look at open problems in the field.

Requirements/Evaluation: problem sets, midterms, a paper and a final exam

Prerequisites: MATH 250 or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: seniors, junior, sophomores, first year

Expected Class Size: 25

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This is a quantitative course.

Spring 2022
LEC Section: 01 TR 9:55 am - 11:10 am Colin C. Adams

MATH 325 (F) Set Theory (QFR)

Set theory is the traditional foundational language for all of mathematics. We will be discussing the Zermelo-Fraenkel axioms, including the Axiom of Choice and the Continuum Hypothesis, basic independence results and, if time permits, incompleteness theorems. At one time, these issues tore at the foundations of mathematics. They are still vital for understanding the nature of mathematical truth.
MATH 328 (S) Combinatorics (QFR)
Combinatorics is a branch of mathematics that focuses on enumerating, examining, and investigating the existence of discrete mathematical structures with certain properties. This course provides an introduction to the fundamental structures and techniques in combinatorics including enumerative methods, generating functions, partition theory, the principle of inclusion and exclusion, and partially ordered sets.
Class Format: interactive activities and discussion
Requirements/Evaluation: quizzes/exams, homework, activities
Prerequisites: MATH 200 and MATH 250
Enrollment Limit: 30
Enrollment Preferences: discretion of the instructor
Expected Class Size: 25
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Not offered current academic year

MATH 329 (F) Discrete Geometry (QFR)
Discrete geometry is one of the oldest and most consistently vibrant areas of mathematics, stretching from the Platonic Solids of antiquity to the modern day applications of convex optimization and linear programming. In this course we will learn about polygons and their higher-dimensional cousins, polyhedra and polytopes, and the various ways to describe, compute, and classify such objects. We will learn how these objects and ideas can be applied to other areas, from computation and optimization to studying areas of math like algebraic geometry. Throughout this course we will be engaging with mathematical work and literature from as old as 500 BCE and as recent as "posted to the internet yesterday."
Requirements/Evaluation: Problem sets, exams, and a final project
Prerequisites: MATH 200 or Math 250, or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Sophomores, juniors, and seniors
Expected Class Size: 20
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: All of the content in this course is quantitative or formal reasoning.

Fall 2021
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Ralph E. Morrison

MATH 331 (F) The little Questions (QFR)
Using math competitions such as the Putnam Exam as a springboard, in this class we follow the dictum of the Ross Program and "think deeply of simple things". The two main goals of this course are to prepare students for competitive math competitions, and to get a sense of the mathematical landscape encompassing elementary number theory, combinatorics, graph theory, and group theory (among others). While elementary frequently is not synonymous with easy, we will see many beautiful proofs and "a-ha" moments in the course of our investigations. Students will be encouraged to
explore these topics at levels compatible with their backgrounds.

Requirements/Evaluation: homework, classwork, and exams

Prerequisites: MATH 250 or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: members or alternates of the Putnam team, Mathematics, Physics or Computer Science majors

Expected Class Size: 25

Grading: yes pass/fail option, yes fifth course option

Unit Notes: http://web.williams.edu/Mathematics/sjmiller/public_html/331/

Distributions: (D3) (QFR)

Not offered current academic year

MATH 334  (S)  Graph Theory  (QFR)

A graph is a collection of vertices, joined together by edges. In this course, we will study the sorts of structures that can be encoded in graphs, along with the properties of those graphs. We'll learn about such classes of graphs as multi-partite, planar, and perfect graphs, and will see applications to such optimization problems as minimum colorings of graphs, maximum matchings in graphs, and network flows.

Requirements/Evaluation: problem sets and exams

Prerequisites: MATH 200 or MATH 250

Enrollment Limit: 20

Enrollment Preferences: Math majors

Expected Class Size: 20

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course involves the writing of mathematical proofs.

Not offered current academic year

MATH 335  (F)  Decisions, Games, and Evolutionary Dynamics  (QFR)

Given goals, options, and uncertainty, how does one make a rational choice? What happens when we interact with others who are also choosing? How might this play out over time? We will first cover the principles of decision theory including preference, uncertainty, utility, imperfect information, and rational choice. The majority of the course will be spent on the main topics of game theory: sequential games, bimatrix games, parlor games, Nash equilibria, bargaining, repeated games, Bayesian belief, and signaling. Applying these principles to populations that evolve over time through variation, selection, and copying, we will develop basic models of the dynamics of evolution.

Class Format: lecture

Requirements/Evaluation: Weekly homework, midterm exams, and a final.

Prerequisites: Math 150/151 and Math 250. Some background in probability and differential equations is highly recommended.

Enrollment Limit: 35

Enrollment Preferences: Math majors.

Expected Class Size: 35

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: Lots of math.

Fall 2021

LEC Section: 01    MWF 11:00 am - 11:50 am    Stewart D. Johnson

MATH 337  (F)  Electricity and Magnetism for Mathematicians  (QFR)
Maxwell's equations are four simple formulas, linking electricity and magnetism, that are among the most profound equations ever discovered. These equations led to the prediction of radio waves, to the realization that a description of light is also contained in these equations and to the discovery of the special theory of relativity. In fact, almost all current descriptions of the fundamental laws of the universe are deep generalizations of Maxwell's equations. Perhaps even more surprising is that these equations and their generalizations have led to some of the most important mathematical discoveries (where there is no obvious physics) of the last 25 years. For example, much of the math world was shocked at how these physics generalizations became one of the main tools in geometry from the 1980s until today. It seems that the mathematics behind Maxwell is endless. This will be an introduction to Maxwell's equations, from the perspective of a mathematician.

Requirements/Evaluation: performance on homework and exams
Prerequisites: MATH 250; no physics background required
Enrollment Limit: none
Enrollment Preferences: none
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

MATH 338  (F) Intermediate Logic  (QFR)
Cross-listings: MATH 338 PHIL 338
Secondary Cross-listing

In this course, we will begin with an in-depth study of the theory of first-order logic. We will first get clear on the formal semantics of first-order logic and various ways of thinking about formal proof: natural deduction systems, semantic tableaux, axiomatic systems and sequent calculi. Our main goal will be to prove things about this logical system rather than to use this system to think about ordinary language arguments. In this way the goal of the course is significantly different from that of Logic and Language (PHIL 203). Students who have take PHIL 203 will have a good background for this class, but students who are generally comfortable with formal systems need not have taken PHIL 203. We will prove soundness and completeness, compactness, the Lowenheim-Skolem theorems, undecidability and other important results about first-order logic. As we go through these results, we will think about the philosophical implications of first-order logic. From there, we will look at extensions of and/or alternatives to first-order logic. Possible additional topics would include: modal logic, the theory of counterfactuals, alternative representations of conditionals, the use of logic in the foundations of arithmetic and Godel's Incompleteness theorems. Student interest will be taken into consideration in deciding what additional topics to cover.

Requirements/Evaluation: problem sets and exams
Prerequisites: some class in which student has studied formal reasoning
Enrollment Limit: 20
Enrollment Preferences: Philosophy majors; juniors and seniors
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D2) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
MATH 338 (D3) PHIL 338 (D2)

Quantative/Formal Reasoning Notes: This is a class in Formal Logic. PHIL 203 satisfies the QFR requirement. If anything, this class will be significantly more formal.
Attributes: Linguistics

Not offered current academic year

MATH 340 Applications of Mathematics to the Real World  (QFR)

Often for real world applications one does not need to find the optimal solution, which can be extremely difficult, but instead just find something close, or at least better than what is currently being done. We will develop material and techniques from mathematics, statistics and allied fields with an eye to applications. In addition to standard homework assignments and exams there will be a group project where students will work with a local business,
write a report and present the results. Pre-requisites are multivariable calculus and linear algebra, or permission of the instructor. Knowledge of some statistics or programming is beneficial but not required.

Class Format: In addition to standard lectures and assignments, we will be partnering with local businesses to apply mathematics to solve real world problems.

Requirements/Evaluation: Lectures and class participation, homework, exams and encouragement to do a project. We already have several local businesses with projects for students. Working on a project will entail meeting with officials from the company, clearly defining what the problem is, and writing a solution. This will include a presentation, a write-up, and potentially implementable code. Based on previous similar courses, these papers typically run from 10 to 40 pages.

Prerequisites: Mathematics 150 or 151, and Linear Algebra, or permission of the instructor.

Enrollment Limit: 40

Enrollment Preferences: Students who have taken at least one statistics or computer science class

Expected Class Size: 25

Grading:

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is a 300 level mathematics class

Not offered current academic year

MATH 341 (F)(S) Probability (QFR)

Cross-listings: STAT 341 MATH 341

Primary Cross-listing

The historical roots of probability lie in the study of games of chance. Modern probability, however, is a mathematical discipline that has wide applications in a myriad of other mathematical and physical sciences. Drawing on classical gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables (both discrete and continuous), distribution and expectation, independence, laws of large numbers, and the well-known Central Limit Theorem. Many interesting and important applications will also be presented, including some from classical Poisson processes, random walks and Markov Chains.

Requirements/Evaluation: homework, classwork, and exams

Prerequisites: MATH 150 and MATH 250 or permission of the instructor

Enrollment Limit: 30

Enrollment Preferences: Priority will be given to Mathematics majors and to Statistics Majors.

Expected Class Size: 20

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:

STAT 341 (D3) MATH 341 (D3)

Quantitative/Formal Reasoning Notes: This is a 300-level Math/Stat course.

Fall 2021
LEC Section: 01 MWF 9:00 am - 9:50 am Steven J. Miller

Spring 2022
LEC Section: 01 TF 2:35 pm - 3:50 pm Mihai Stoiciu

MATH 350 (F)(S) Real Analysis (QFR)

Real Analysis studies the theory behind calculus. We will first review properties of sets and basic logic. Then we will cover the real number system (What is a real number?), sequences of numbers, basic topology in the set of real numbers, metric spaces, continuity, differentiability, integration, series, and series and sequences of functions.

Requirements/Evaluation: homework, classwork, and exams
MATH 351  (S) Applied Real Analysis  (QFR)
Why is the product of two negative numbers positive? Why do we depict the real numbers as a line? Why is this line continuous, and what does that actually mean? More fundamentally, what is the definition of a real number? Real analysis addresses such questions, delving into the structure of real numbers and functions on them. Along the way we'll discuss sequences and limits, series, completeness, compactness, derivatives and integrals, and metric spaces. This course is excellent preparation for graduate studies in mathematics, statistics, and economics. Math 350 and Math 351 will cover the same material for the first part of the course. Math 350 will then delve deeper into the abstract structures of topological and metric spaces, while Math 351 will closely examine some foundational constructs from differential equations, probability, and optimization.

Class Format: Hybrid format. There may be class meetings; remote students will be fully accommodated.

Requirements/Evaluation: homework, classwork, and exams

MATH 355  (F)(S) Abstract Algebra  (QFR)
Algebra gives us tools to solve equations. The integers, the rationals, and the real numbers have special properties which make algebra work according to the circumstances. In this course, we generalize algebraic processes and the sets upon which they operate in order to better understand, theoretically, when equations can and cannot be solved. We define and study abstract algebraic structures such as groups, rings, and fields, as well as the concepts of factor group, quotient ring, homomorphism, isomorphism, and various types of field extensions. This course introduces students to abstract rigorous mathematics.

Requirements/Evaluation: Problem sets and exams

MATH 250 or permission of instructor
Enrollment Limit: 20
Enrollment Preferences: Seniors
Expected Class Size: 20
Grading: no pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: Math
MATH 361  (F)(S)  Theory of Computation  (QFR)

Secondary Cross-listing
This course introduces a formal framework for investigating both the computability and complexity of problems. We study several models of computation including finite automata, regular languages, context-free grammars, and Turing machines. These models provide a mathematical basis for the study of computability theory—the examination of what problems can be solved and what problems cannot be solved—and the study of complexity theory—the examination of how efficiently problems can be solved. Topics include the halting problem and the P versus NP problem.

Class Format: Lecture content will be delivered through asynchronously viewed video modules. Conference sections meeting twice per week will be used for synchronous discussions. Students should sign up for lecture and one conference section.

Requirements/Evaluation: online multiple choice and short answer questions, weekly problem sets in groups, a research project, and a final examination

Prerequisites: CSCI 256 or both a 300-level MATH course and permission of instructor

Enrollment Limit: 24(12/con)

Enrollment Preferences: current or expected Computer Science majors

Expected Class Size: 24

Grading: no pass/fail option, no fifth course option

Distributions: (D3)  (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
MATH 361 (D3)  CSCI 361 (D3)

Quantative/Formal Reasoning Notes: This course include regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: COGS Interdepartmental Electives

MATH 368  (S)  Positive Characteristic Commutative Algebra  (QFR)

In commutative algebra, one of the most basic invariants of a ring is its characteristic. This is the smallest multiple of 1 that equals 0. Working over a ring of characteristic zero, versus a ring of characteristic $p > 0$, dramatically changes the proof techniques available to us. This realization has had tremendous consequences in commutative algebra. One of the most useful tools in characteristic $p$ is the Frobenius homomorphism. In this course we will study several standard notions in commutative algebra, such as regularity of a ring, Cohen-Macaulayness, and being normal and we will see how
various "splittings" of the Frobenius allow us to easily detect these properties. Many of these methods are not only applicable to commutative algebra, but also to number theory and algebraic geometry.

**Requires/Evaluation:** homework and a final exam  
**Prerequisites:** MATH 355 or permission of instructor  
**Enrollment Limit:** 30  
**Enrollment Preferences:** Math majors primarily, and juniors and seniors secondarily  
**Expected Class Size:** 15  
**Grading:** no pass/fail option, no fifth course option  
**Distributions:** (D3) (QFR)  
**Not offered current academic year**

**MATH 374 (S) Topology** (QFR)  
In Real Analysis you learned about metric spaces -- any set of objects endowed with a way of measuring distance -- and the topology of sets in such spaces (open, closed, bounded, etc). In this course we flip this on its head: we explore how to develop analysis (limits, continuity, etc) in spaces where the topology is known but the metric is not. This will lead us to a bizarre and fascinating version of geometry in which we cannot distinguish between shapes that can be continuously deformed into one another. Not only does this theory turn out to be beautiful in the abstract, it has become a vital part of data analysis and is also connected to many areas of math and physics. This course is excellent preparation for graduate programs in mathematics.

**Class Format:** Taught remotely, but synchronously. While recordings of lectures will be made available, all participants are expected to make their best effort to attend the class over Zoom. In addition to class meetings, there will be tutorial sessions with a TA once per week.

**Requires/Evaluation:** homework, tutorials, and exams  
**Prerequisites:** MATH 350 or 351; not open to students who have taken MATH 323. Familiarity with basic group theory recommended, but not required.  
**Enrollment Limit:** 20  
**Enrollment Preferences:** Juniors and seniors  
**Expected Class Size:** 20  
**Grading:** no pass/fail option, yes fifth course option  
**Distributions:** (D3) (QFR)  
**Quantative/Formal Reasoning Notes:** It's math.  
**Not offered current academic year**

**MATH 383 (F) Complex Analysis** (QFR)  
The calculus of complex-valued functions turns out to have unexpected simplicity and power. As an example of simplicity, every complex-differentiable function is automatically infinitely differentiable. As examples of power, the so-called "residue calculus" permits the computation of "impossible" integrals, and "conformal mapping" reduces physical problems on very general domains to problems on the round disc. The easiest proof of the Fundamental Theorem of Algebra, not to mention the first proof of the Prime Number Theorem, used complex analysis.

**Requires/Evaluation:** homework, classwork, and exams  
**Prerequisites:** MATH 350 or MATH 351 or permission of instructor  
**Enrollment Limit:** 40  
**Enrollment Preferences:** 40  
**Expected Class Size:** 30  
**Grading:** yes pass/fail option, yes fifth course option  
**Unit Notes:** this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major  
**Distributions:** (D3) (QFR)  
**Quantative/Formal Reasoning Notes:** Advanced mathematics course with weekly or daily problem sets.
MATH 390  Undergraduate Research Topics in Algebra (QFR)
The well-known trace map on matrices can be generalized to a map on other algebraic objects. Undergraduates, graduates students and experts in Representation Theory, Commutative Algebra and Algebraic Geometry have been driving recent developments in the theory of trace modules and finding exciting new applications in all of these these fields. This course will serve as an introduction to mathematical research with the aim of producing original research in modern trace theory. Students in this tutorial will read and synthesize research papers, discuss the formation of research questions in pure mathematics, and engage in original mathematical research.

Requirements/Evaluation: oral presentations; writing assignments (summarizing papers, reflections on mathematical research, original research); participation in the course project
Prerequisites: Math 355
Enrollment Limit: 10
Enrollment Preferences: Juniors and Seniors
Expected Class Size: 7
Grading:
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is post-core math class; students will be required to produce mathematical proofs.
Not offered current academic year

MATH 391  (F) Introduction to computer algebra (QFR)
Students will learn new mathematics in the context of computer-based exposition, experimentation, and interaction. They will gain proficiency with Sage, GAP, Macaulay2, or Mathematica, and possibly one of the more-specialized systems SnapPea, kenzo, magma, MATLAB, Perseus, coq, etc. Individuals and teams will build interactive demonstrations of mathematical theorems, which will then be appreciated by the instructor and the rest of the class. No prior programming experience is expected.

Class Format: Class will be held online, but there will be recorded components, asynchronous interactive components, and outside-of-class small-group online meetings.
Requirements/Evaluation: exams, homework, projects
Prerequisites: Math 355 or permission of instructor
Enrollment Limit: 20
Enrollment Preferences: math majors
Expected Class Size: 15
Grading: yes pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: Mathematical programming requires complete synthesis of abstract concepts to produce computer code, which is necessarily formal.
Not offered current academic year

MATH 392  (S) Undergraduate Research Topics in Graph Theory (WS) (QFR)
Graph theory is a vibrant area of research with many applications to the social sciences, psychology, and economics. In this project-based tutorial, students will select among the presented topics and will develop research questions and undertake original research in the field. Student assessment is based on drafts of research project manuscript and presentations.

Requirements/Evaluation: presentations and written project manuscript
Prerequisites: MATH 355 or permission of the instructor
Enrollment Limit: 10
Enrollment Preferences: programming experience, students with interests in the intersection of combinatorics and graph theory
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS) (QFR)

Writing Skills Notes: This course will require multiple revisions of a manuscript related to the research project at hand. The final result will be a 10-20 page research article and the course will be designed as a writing intensive course.

Quantitative/Formal Reasoning Notes: The course deals with mathematical research in graph theory and is a quantitative and formal reasoning course.

Not offered current academic year

MATH 394 (S) Galois Theory (QFR)
Some equations--such as \(x^5 - 1 = 0\)--are easy to solve. Others--such as \(x^5 - x - 1 = 0\)--are very hard, if not impossible (using standard mathematical operations). Galois discovered a deep connection between field theory and group theory that led to a criterion for checking whether or not a given polynomial can be easily solved. His discovery also led to many other breakthroughs, for example proving the impossibility of squaring the circle or trisecting a typical angle using compass and straightedge. From these not-so-humble beginnings, Galois theory has become a fundamental concept in modern mathematics, from topology to number theory. In this course we will develop the theory and explore its applications to other areas of math.

Requirements/Evaluation: written homeworks, oral presentations, and exams
Prerequisites: MATH 355
Enrollment Limit: 50
Enrollment Preferences: discretion of the instructor
Expected Class Size: 10
Grading: no pass/fail option, yes fifth course option

Unit Notes: this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major
Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is a math class

Spring 2022
LEC Section: 01    MWF 9:00 am - 9:50 am    Thomas A. Garrity

MATH 397 (F) Independent Study: Mathematics
Directed 300-level independent study in Mathematics.
Prerequisites: permission of department
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)

Fall 2021
IND Section: 01    TBA    Mihai Stoiciu

MATH 398 (S) Independent Study: Mathematics
Directed 300-level independent study in Mathematics.
Prerequisites: permission of department
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)

Spring 2022
IND Section: 01    TBA    Mihai Stoiciu
MATH 401  (S)  Functional Analysis  (QFR)

Functional analysis can be viewed as linear algebra on infinite-dimensional spaces. It is a central topic in Mathematics, which brings together and extends ideas from analysis, algebra, and geometry. Functional analysis also provides the rigorous mathematical background for several areas of theoretical physics (especially quantum mechanics). We will introduce infinite-dimensional spaces (Banach and Hilbert spaces) and study their properties. These spaces are often spaces of functions (for example, the space of square-integrable functions). We will consider linear operators on Hilbert spaces and investigate their spectral properties. A special attention will be dedicated to various operators arising from mathematical physics, especially the Schrodinger operator.

Class Format: lecture
Requirements/Evaluation: weekly problem sets, two midterm exams, final exam
Prerequisites: MATH 350 or 351 or permission of instructor
Enrollment Limit: 40
Enrollment Preferences: Mathematics and Physics majors; seniors
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)  (QFR)
Quantative/Formal Reasoning Notes: This is an advance course in Mathematical Analysis.

Spring 2022
LEC Section: 01   TR 11:20 am - 12:35 pm   Mihai Stoiciu

MATH 402  (F)  Measure Theory and Hilbert Spaces  (QFR)

How large is the unit square? One might measure the number of individual points in the square (uncountably infinite), the area of the square (1), or the dimension of the square (2). But what about for more complicated sets, e.g., the set of all rational points in the unit square? What's the area of this set? What's the dimension? In this course we'll come up with precise ways to measure size -- length, area, volume, dimension -- that apply to a broad array of sets. Along the way we'll encounter Lebesgue measure and Lebesgue integration, Hausdorff measure and fractals, space-filling curves and the Banach-Tarski paradox. We will also investigate Hilbert spaces, mathematical objects that combine the tidiness of linear algebra with the power of analysis and are fundamental to the study of differential equations, functional analysis, harmonic analysis, and ergodic theory, and also apply to fields like quantum mechanics and machine learning. This material provides good preparation for graduate studies in mathematics, statistics and economics.

Class Format: Discussion-based course held remotely.
Requirements/Evaluation: performance on homework assignments and exams
Prerequisites: MATH 350 or MATH 351 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Seniors
Expected Class Size: 20
Grading: no pass/fail option, yes fifth course option
Distributions: (D3)  (QFR)
Quantative/Formal Reasoning Notes: Math
Not offered current academic year

MATH 403  (S)  Measure and Ergodic Theory  (QFR)

An introduction to measure theory and ergodic theory. Measure theory is a generalization of the notion of length and area, has been used in the study of stochastic (probabilistic) systems. The course covers the construction of Lebesque and Borel measures, measurable functions, and Lebesque integration. Ergodic theory studies the probabilistic behavior of dynamical systems as they evolve through time, and is based on measure theory. The course will cover basic notions, such as ergodic transformations, weak mixing, mixing, and Bernoulli transformations, and transformations admitting and not admitting an invariant measure. There will be an emphasis on specific examples such as group rotations, the binary odometer transformations,
and rank-one constructions. The Ergodic Theorem will also be covered, and will be used to illustrate notions and theorems from measure theory.

Requirements/Evaluation: homework and exams
Prerequisites: MATH 350 or MATH 351 or permission of instructor
Enrollment Limit: 25
Enrollment Preferences: Mathematics majors
Expected Class Size: 15-20
Grading: yes pass/fail option, yes fifth course option
Unit Notes: senior major course
Distributions: (D3) (QFR)

Not offered current academic year

MATH 404  (F)  Random Matrix Theory  (QFR)
Initiated by research in multivariate statistics and nuclear physics, the study of random matrices is nowadays an active and exciting area of
initiated with numerous applications to theoretical physics, number theory, functional analysis, optimal control, and finance. Random Matrix
Theory provides understanding of various properties (most notably, statistics of eigenvalues) of matrices with random coefficients. This course will
provide an introduction to the basic theory of random matrices, starting with a quick review of Linear Algebra and Probability Theory. We will continue
with the study of Wigner matrices and prove the celebrated Wigner's Semicircle Law, which bring together important ideas from analysis and
combinatorics. After this, we will turn our attention to Gaussian ensembles and investigate the Gaussian Orthogonal Ensemble (GOE) and the
Gaussian Unitary Ensemble (GUE). The last lectures of the course will be dedicated to random Schrodinger operators and their spectral properties (in
particular, the phenomenon called Anderson localization). Applications of Random Matrix Theory to theoretical physics, number theory, statistics, and
finance will be discussed throughout the semester.

Requirements/Evaluation: homework assignments and exams
Prerequisites: experience with Real Analysis (MATH 350 or MATH 351) and with Probability (MATH 341 or STAT 201)
Enrollment Limit: 40
Enrollment Preferences: Mathematics and Statistics majors
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course expands ideas in probability and statistics from random variables (1x1 random matrices) to nxn
random matrices. The students will learn to model complex physical phenomena using random matrices and study them using rigorous mathematical
tools and concepts.
Not offered current academic year

MATH 405  (S)  Representation Theory and Special Functions  (QFR)
Representation theory is at the heart of much of modern mathematics. It provides a link between ideas of symmetries, groups and matrices. It has
applications from number theory to Fourier Analysis to elementary particle theory. In part, representation theory is a method for producing interesting
functions. While not having a single definition, special functions are "functions that have names." Over the last few hundred years, scientists have
needed to define and develop certain families of functions, in order to describe different physical phenomena. These families started to be named, and
include Bessel functions, Hermite functions, Laguerre functions and more generally hypergeometric functions. In recent years it has been seen that
these different types of functions are best understood through the lens of symmetry and in particular via representation theory. This course will be an
introduction to representation theory, starting with finite groups, while at the same time being an introduction to special functions. Thus the course will
be a mix of abstract algebra, matrices, calculus and analysis.

Requirements/Evaluation: By exams and homework
Prerequisites: Math 350 or Math 351, and Math 355
Enrollment Limit: 50
Enrollment Preferences: By instructor preference
Expected Class Size: 10
Prime numbers are the building blocks for all numbers and hence for most of mathematics. Though there are an infinite number of them, how they are spread out among the integers is still quite a mystery. Even more mysterious and surprising is that the current tools for investigating prime numbers involve the study of infinite series. Function theory tells us about the primes. We will be studying one of the most amazing functions known: the Riemann Zeta Function. Finding where this function is equal to zero is the Riemann Hypothesis and is one of the great, if not greatest, open problems in mathematics. Somehow where these zeros occur is linked to the distribution of primes. We will be concerned with why anyone would care about this conjecture. More crassly, why should solving the Riemann Hypothesis be worth one million dollars? (Which is what you will get if you solve it, beyond the eternal fame and glory.)

Requirements/Evaluation: exams and weekly homework assignments
Prerequisites: MATH 350 or MATH 351, and MATH 355
Enrollment Limit: 30
Enrollment Preferences: seniors
Expected Class Size: 10
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: It is a math course.

Optimal packing problems arise in many important problems, and have been a source of excellent mathematics for centuries. The Kepler Problem (what is the most efficient way to pack balls in three-space) is a good example. The original formulation has been used in such diverse areas as stacking cannonballs on battleships to grocers preparing fruit displays, and its generalizations allow the creation of powerful error detection and correction codes. While the solution of the Kepler Problem is now known, the higher dimensional version is very much open. There has been remarkable progress in the last few years, with number theory playing a key role in these results. We will develop sufficient background material to understand many of these problems and the current state of the field. Pre-requisites are real analysis.

Requirements/Evaluation: Class participation, homework, exams and participation in writing a textbook on the material. Each student will be responsible for working on a chapter of a book based on this material. In addition to obtaining critical writing feedback from myself and my co-author (who is a world expert in the subject), depending on timing we will also be able to share comments from an editor of a major publishing house or a referee. Chapters can range from short snapshots of a subject, on the order of 5 pages, to longer technical derivations of perhaps 10-30 pages.
Prerequisites: Math 350 or 351
Enrollment Limit: 40
Enrollment Preferences: Senior math majors, students planning on graduate study in a STEM field
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is a 400 level math class

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Prerequisites: Math 350 or 351
Enrollment Limit: 40
Enrollment Preferences: Senior math majors, students planning on graduate study in a STEM field
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is a 400 level math class

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Prerequisites: Math 350 or 351
Enrollment Limit: 40
Enrollment Preferences: Senior math majors, students planning on graduate study in a STEM field
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is a 400 level math class

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Requirements/Evaluation: Class participation, homework, exams and participation in writing a textbook on the material. Each student will be responsible for working on a chapter of a book based on this material. In addition to obtaining critical writing feedback from myself and my co-author (who is a world expert in the subject), depending on timing we will also be able to share comments from an editor of a major publishing house or a referee. Chapters can range from short snapshots of a subject, on the order of 5 pages, to longer technical derivations of perhaps 10-30 pages.
Prerequisites: Math 350 or 351
Enrollment Limit: 40
Enrollment Preferences: Senior math majors, students planning on graduate study in a STEM field
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is a 400 level math class

Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is a math course
Commutative Algebra is an essential area of mathematics that provides indispensable tools to many areas, including Number Theory and Algebraic Geometry. This course will introduce you to the fundamental concepts for the study of commutative rings, with a special focus on the notion of "prime ideals," and how they generalize the well-known notion of primality in the set of integers. Commutative algebra has applications ranging from algebraic geometry to coding theory. For example, one can use commutative algebra to create error correcting codes. It is perhaps most often used, however, to study curves and surfaces in different spaces. To understand these structures, one must study polynomial rings over fields. This course will be an introduction to commutative algebra. Possible topics include polynomial rings, localizations, primary decomposition, completions, and modules.

**Requirements/Evaluation:** homework and exams

**Prerequisites:** MATH 355 or permission of instructor

**Enrollment Limit:** 25

**Enrollment Preferences:** Math majors

**Expected Class Size:** 15

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Quantative/Formal Reasoning Notes:** It is a 400-level math course

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**MATH 419 (S) Algebraic Number Theory** (QFR)

We all know that integers can be factored into prime numbers and that this factorization is essentially unique. In more general settings, it often still makes sense to factor numbers into "primes," but the factorization is not necessarily unique! This surprising fact was the downfall of Lamé's attempted proof of Fermat's Last Theorem in 1847. Although a valid proof was not discovered until over 150 years later, this error gave rise to a new branch of mathematics: algebraic number theory. In this course, we will study factorization and other number-theoretic notions in more abstract algebraic settings, and we will see a beautiful interplay between groups, rings, and fields.

**Requirements/Evaluation:** homework assignments and exams

**Prerequisites:** MATH 355, or permission of instructor

**Enrollment Limit:** 25

**Expected Class Size:** 20

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Not offered current academic year**

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**MATH 420 (S) Analytic Number Theory** (QFR)

How many primes are smaller than $x$? How many divisors does an integer $n$ have? How many different numbers appear in the $N \times N$ multiplication table? Precise formulas for these quantities probably don't exist, but over the past 150 years tremendous progress has been made towards understanding these and similar questions using tools and methods from analysis. The goal of this tutorial is to explain and motivate the ubiquitous appearance of analysis in modern number theory--a surprising fact, given that analysis is concerned with continuous functions, while number theory is concerned with discrete objects (integers, primes, divisors, etc). Topics to be covered will include some subset of the following: asymptotic analysis, partial and Euler-Maclaurin summation, counting divisors and Dirichlet's hyperbola method, the randomness of prime factorization and the Erdos-Kac theorem, the partition function and the saddle point method, the prime number theorem and the Riemann zeta function, primes in arithmetic progressions and Dirichlet L-functions, the Goldbach conjecture and the circle method, and sieve methods and gaps between primes.

**Requirements/Evaluation:** Regularly preparing lectures and writing expository essays in LaTeX. No exams.

**Prerequisites:** MATH 350 or MATH 351 and familiarity with basic modular arithmetic are hard prerequisites. Familiarity with complex analysis and abstract algebra recommended, but not required.

**Enrollment Limit:** 10

**Enrollment Preferences:** Students with complex analysis background will be given priority.

**Expected Class Size:** 10
MATH 421  (S)  Quandles, Knots and Virtual Knots  (QFR)
A quandle is an algebraic object that, like a group, has a "multiplication" of pairs of elements that satisfies certain axioms. But the quandle axioms are very different from the group axioms, and quandles turn out to be incredibly useful when considering the mathematical theory of knots. In this course, we will learn about this relatively new area of research (1982) and learn some knot theory and see how quandles apply to both classical knot theory and the relatively new area of virtual knot theory (1999).

Requirements/Evaluation: problem sets, tests, and a 3-page paper
Prerequisites: MATH 355
Enrollment Limit: 40
Enrollment Preferences: discretion of the instructor
Expected Class Size: 15
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Not offered current academic year

MATH 422  (F)  Algebraic Topology  (QFR)
Is a sphere really different from a torus? Can a sphere be continuously deformed to a point? Algebraic Topology concerns itself with the classification and study of topological spaces via algebraic methods. The key question is this: How do we really know when two spaces are different and in what senses can we claim they are the same? Our answer will use several algebraic tools such as groups and their normal subgroups. In this course we will develop several notions of "equality" starting with the existence of homeomorphisms between spaces. We will then explore several weakenings of this notion, such as homotopy equivalence, having isomorphic homology or fundamental groups, and having homeomorphic universal covers.

Requirements/Evaluation: homework and exams
Prerequisites: MATH 355 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Math majors primarily, the juniors and seniors
Expected Class Size: 15
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Not offered current academic year

MATH 426  (F)  Differential Topology  (QFR)
Differential topology marries the rubber-like deformations of topology with the computational exactness of calculus. This sub eĺd of mathematics asks and answers questions like "Can you take an integral on the surface of doughnut?" and includes far-reaching applications in relativity and robotics. This tutorial will provide an elementary and intuitive introduction to differential topology. We will begin with the definition of a manifold and end with a generalized understanding of Stokes Theorem.

Requirements/Evaluation: weekly homework, weekly presentations, and final paper
Prerequisites: MATH 350 (students who have not taken MATH 250 may enroll only with permission of the instructor)
Enrollment Limit: 10
Enrollment Preferences: seniors, majors
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: There will be weekly math problem sets.

Not offered current academic year

MATH 427 (S) Tiling Theory (QFR)
Since humans first used stones and bricks to tile the floors of their domiciles, tiling has been an area of interest. Practitioners include artists, engineers, designers, architects, crystallographers, scientists and mathematicians. This course will be an investigation into the mathematical theory of tiling. The course will focus on tilings of the plane, including topics such as the symmetry groups of tilings, the topology of tilings, the ergodic theory of tilings, the classification of tilings and the aperiodic Penrose tilings. We will also look at tilings in higher dimensions, including "knotted tilings".

Requirements/Evaluation: problem assignments, exams and a presentation/paper
Prerequisites: MATH 250 Linear Algebra and MATH 355 Abstract Algebra
Enrollment Limit: 30
Enrollment Preferences: senior majors, seniors, juniors, sophomores, first-year students (this is a senior seminar, one of which is required for all senior majors, so they have first preference)
Expected Class Size: 20
Grading: no pass/fail option, yes fifth course option
Materials/Lab Fee: cost of book which will be under $50
Distributions: (D3) (QFR)

Not offered current academic year

MATH 428 (S) Catching Robbers and Spreading Information (QFR)
Cops and robbers is a widely studied game played on graphs that has connections to searching algorithms on networks. The cop number of a graph is the smallest number of cops needed to guarantee that the cops can catch a robber in the graph. Similar combinatorial games such as "zero forcing" can be used to model the spread of information. The idea of "throttling" is to spread the information (or catch the robber) as efficiently as possible. This course will survey some of the main results about cops and robbers and the cop number. We will also explore recent research on throttling for cops and robbers, zero forcing, and other variants.

Class Format: interactive activities and discussion
Requirements/Evaluation: problem sets, investigation journal, final presentation
Prerequisites: MATH 200 and MATH 355
Enrollment Limit: 25
Enrollment Preferences: seniors
Expected Class Size: 20
Grading: yes pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: The course will involve mathematical proofs.

Not offered current academic year

MATH 433 (S) Mathematical Modeling (QFR)
Mathematical modeling means (1) translating a real-life problem into a mathematical object, (2) studying that object using mathematical techniques, and (3) interpreting the results in order to learn something about the real-life problem. Mathematical modeling is used in biology, economics, chemistry, geology, sociology, political science, art, and countless other fields. This is an advanced, seminar-style, course appropriate for students who have strong enthusiasm for applied mathematics, data science, and collaborative teamwork.

Class Format: To afford students flexibility during the COVID pandemic, this course is taught online, largely asynchronously. There is no lecture component. Students will read research literature, work on structured and open-ended projects, and participate in synchronous small-group meetings with the instructor via videoconference. The vast majority of work in this course requires students to collaborate with each other.

Requirements/Evaluation: Students will complete reading assignments, writing assignments, modeling activities, research projects, and will record several presentations to be shared with the rest of the class. To move towards a non-hierarchical, transparent, and egalitarian grading system, the
instructor follows the policy of "ungrading." Over the course of the semester, students will develop a rubric to assess their own learning and will evaluate themselves according to this rubric.

**Prerequisites:** MATH 250; MATH 309 or similar; and some experience with computer programming (equivalent to CSCI 134 or MATH 307).

**Enrollment Limit:** 20

**Enrollment Preferences:** Professor's discretion

**Expected Class Size:** 20

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Quantative/Formal Reasoning Notes:** This course focuses substantially on using mathematical and statistical tools and frameworks to describe, predict, and understand real-world systems.

 نيoto current academic year

MATH 434 (F) Applied Dynamics and Optimal Control (QFR)

We seek to understand how dynamical systems evolve, how that evolution depends on the various parameters of the system, and how we might manipulate those parameters to optimize an outcome. We will explore the language of dynamics by deepening our understanding of differential and difference equations, study parameter dependence and bifurcations, and explore optimal control through Pontryagin's maximum principle and Hamilton-Jacobi-Bellman equations. These tools have broad application in ecology, economics, finance, and engineering, and we will draw on basic models from these fields to motivate our study.

**Requirements/Evaluation:** exams and homework assignments

**Prerequisites:** MATH 209 or PHYS 210, and MATH 350 or 351, or permission of the instructor

**Enrollment Limit:** 20

**Enrollment Preferences:** Preference will be given to senior math majors.

**Expected Class Size:** 20

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Quantative/Formal Reasoning Notes:** This is a 400 level math course.

*Not offered current academic year*

MATH 435 (F) Chip-firing Games on Graphs (QFR)

Starting with a graph (a collection of nodes connected by edges), place an integer number of poker chips on each vertex. Move these chips around according to "chip-firing moves", where a vertex donates a chip along each edge. These simple and intuitive games quickly lead to challenging mathematics with applications ranging from dynamical systems to algebraic geometry. In this course we'll build up a mathematical framework for studying chip-firing games, drawing on linear algebra and group theory. We'll discover algorithms for winning these games, and study their complexity; and we'll prove graph-theoretic versions of famous results like the Riemann-Roch theorem. A key component of this course will be research projects that draw on open questions about chip-firing.

**Requirements/Evaluation:** Weekly homework for the first eight weeks, four quizzes spaced evenly throughout the semester, and a cumulative project worked on throughout the semester (10-20 pages)

**Prerequisites:** Math 250 and Math 355

**Enrollment Limit:** 25

**Enrollment Preferences:** Math majors who need the course to graduate

**Expected Class Size:** 15

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

**Quantative/Formal Reasoning Notes:** All topics are quantitative

Fall 2021
**MATH 441 (F) Information Theory and Applications**

**Cross-listings:** MATH 441 CSCI 441 STAT 441

**Secondary Cross-listing**

What is information? And how do we communicate information effectively? This course will introduce students to the fundamental ideas of Information Theory including entropy, communication channels, mutual information, and Kolmogorov complexity. These ideas have surprising connections to a fields as diverse as physics (statistical mechanics, thermodynamics), mathematics (ergodic theory and number theory), statistics and machine learning (Fisher information, Occam's razor), and electrical engineering (communication theory).

**Requirements/Evaluation:** Weekly homeworks, midterm(s), final exam.

**Prerequisites:** Math/Stat 341; Math 150 or 151; or permission of instructor.

**Enrollment Limit:** 30

**Enrollment Preferences:** Seniors; mathematics and statistics majors.

**Expected Class Size:** 25

**Grading:** yes pass/fail option, yes fifth course option

**Distributions:** (D3)

This course is cross-listed and the prefixes carry the following divisional credit:

MATH 441 (D3) CSCI 441 (D3) STAT 441 (D3)

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**MATH 453 (F) Partial Differential Equations** (QFR)

Partial differential equations (PDE) arise as mathematical models of phenomena in chemistry, ecology, economics, electromagnetics, fluid dynamics, neuroscience, thermodynamics, and more. We introduce PDE models and develop techniques for studying them. Topics include: derivation, classification, and physical interpretation of canonical PDE; solution techniques, including separation of variables, series solutions, integral transforms, and characteristics; and application to problems in the natural and social sciences.

**Requirements/Evaluation:** quizzes/exams, problem sets, projects and activities

**Prerequisites:** MATH 150-151; MATH 209 or MATH/PHYS 210 or MATH 309

**Enrollment Limit:** 30

**Enrollment Preferences:** Professor's discretion

**Expected Class Size:** 25

**Grading:** no pass/fail option, yes fifth course option

**Distributions:** (D3) (QFR)

Not offered current academic year

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**MATH 456 (F) Representation Theory** (QFR)

Representation theory has applications in fields such as physics (via models for elementary particles), engineering (considering symmetries of structures), and even in voting theory (voting for committees in agreeable societies). This course will introduce the concepts and techniques of the representation theory of finite groups, and will focus on the representation theory of the symmetric group. We will undertake this study through a variety of perspectives, including general representation theory, combinatorial algorithms, and symmetric functions.

**Requirements/Evaluation:** evaluation will be based primarily on homework, in class presentations, and exams

**Prerequisites:** MATH 355

**Enrollment Limit:** 40

**Enrollment Preferences:** junior and senior Math majors

**Expected Class Size:** 15
MATH 458 (S) Algebraic Combinatorics (WS) (QFR)

Algebraic combinatorics is a branch of mathematics at the intersection of combinatorics and algebra. On the one hand, we study combinatorial structures using algebraic techniques, while on the other we use combinatorial arguments and methods to solve problems in algebra. In this collaborative project-based course, students will select among the presented topics, develop research questions, and undertake original research in the field. Student assessment is based building positive and supportive collaborative working relationships with their peers, drafts of research project manuscript, and oral presentations.

Requirements/Evaluation: Drafts of manuscript, oral presentations, reflections, peer collaboration skills
Prerequisites: MATH 200 and MATH 355
Enrollment Limit: 25
Enrollment Preferences: Senior mathematics majors, students with programming experience, students with interests in algebra and combinatorics.
Expected Class Size: 20
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS) (QFR)

Writing Skills Notes: This course will require multiple revisions of a manuscript on the mathematical tent and collaborative work. The final result will be a 10-20 page research article and the course will be designed as a writing intensive course.
Quantative/Formal Reasoning Notes: This is a mathematics course in the area of algebraic combinatorics and is a quantitative and formal reasoning course.

Spring 2022
SEM Section: 01 Cancelled

MATH 459 (S) Applied Partial Differential Equations (QFR)

Partial differential equations (PDE) arise as mathematical models of phenomena in chemistry, ecology, economics, electromagnetics, epidemiology, fluid dynamics, neuroscience, and much more. Furthermore, the study of partial differential equations connects with diverse branches of mathematics including analysis, geometry, algebra, and computation. Adopting an applied viewpoint, we develop techniques for studying PDE. We draw from a body of knowledge spanning classic work from the time of Isaac Newton right up to today's cutting edge applied mathematics research. This tutorial is appropriate as a second course in differential equations. In this tutorial, students will: build and utilize PDE-based models; determine the most appropriate tools to apply to a PDE; apply the aforementioned tools; be comfortable with open-ended scientific work; read applied mathematical literature; communicate applied mathematics clearly, precisely, and appropriately; collaborate effectively.

Requirements/Evaluation: participation, problem sets, oral presentations, oral exams, and a final project
Prerequisites: MATH 209 or MATH/PHYS 210 or MATH 309 or permission of instructor; students who have taken MATH 453 may not enroll in MATH 458 without permission of the instructor
Enrollment Limit: 10
Enrollment Preferences: students with an interest in applied mathematics, selected to create a diverse set of tutorial participants
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This tutorial involves regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.
Not offered current academic year
MATH 466 (F) Advanced Applied Analysis (QFR)
This course further develops and explores topics and concepts from real analysis, with special emphasis on introducing students to subject matter and techniques that are useful for graduate study in mathematics or an allied field, as well as applications in industry. Topics include Benford’s law of digit bias, random matrix theory, and Fourier analysis, and as time permits additional areas based on student interest from analytic number theory, generating functions and probabilistic methods. This will be an intense, fast paced class which will give a flavor for graduate school. In addition to standard homework problems, students will assist in writing both reviews for MathSciNet and referee reports for papers for journals, write programs to investigate and conjecture, and read classic and current research papers, and possibly apply these and related methods to real world problems.

Requirements/Evaluation: homework, exams, possible paper/presentation
Prerequisites: MATH 350 or MATH 351
Enrollment Limit: 40
Enrollment Preferences: discretion of the instructor
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Not offered current academic year

MATH 474 (S) Tropical Geometry (QFR)
This course offers an introduction to tropical geometry, a young subject that has already established deep connections between itself and pure and applied mathematics. We will study a rich variety of objects arising from polynomials over the min-plus semiring, where addition is defined as taking a minimum, and multiplication is defined as usual addition. We will learn how these polyhedral objects connect to other areas of mathematics like algebraic geometry, and how they can be applied to solve problems in scheduling theory, phylogenetics, and other diverse fields.

Class Format: Hybrid; if possible we will have classes in person, with remote students attending via Zoom.
Requirements/Evaluation: participation, problem sets, quizzes, exams, and a final project
Prerequisites: MATH 355 or permission of instructor
Enrollment Limit: 25
Enrollment Preferences: Senior math majors
Expected Class Size: 15
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course builds quantitative skills
Not offered current academic year

MATH 482 (F) Homological Algebra (QFR)
Though a relatively young subfield of mathematics, Homological Algebra has earned its place by supplying powerful tools to solve questions in the much older fields of Commutative Algebra, Algebraic Geometry and Representation Theory. This class will introduce theorems and tools of Homological Algebra, grounding its results in applications to polynomial rings and their quotients. We will focus on some early groundbreaking results and learn some of Homological Algebra's most-used constructions. Possible topics include tensor products, chain complexes, homology, Ext, Tor and Hilbert's Syzygy Theorem.

Requirements/Evaluation: homework and exams
Prerequisites: MATH 355
Enrollment Limit: 20
Enrollment Preferences: junior and senior math majors
Expected Class Size: 12
Grading: no pass/fail option, yes fifth course option
Unit Notes: this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major
Distributions: (D3) (QFR)
MATH 487 (S) Computational Algebraic Geometry (QFR)

Algebraic geometry is the study of shapes described by polynomial equations. It has been a major part of mathematics for at least the past two hundred years, and has influenced a tremendous amount of modern mathematics, ranging from number theory to robotics. In this course, we will develop the Ideal-Variety Correspondence that ties geometric shapes to abstract algebra, and will use computational tools to explore this theory in a very explicit way.

Requirements/Evaluation: homework, exams, and final project

Prerequisites: MATH 355

Enrollment Limit: 40

Enrollment Preferences: instructor decision

Expected Class Size: 15

Grading: no pass/fail option, yes fifth course option

Unit Notes: this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major

Distributions: (D3) (QFR)

Not offered current academic year

MATH 493 (F) Senior Honors Thesis: Mathematics

Mathematics senior honors thesis; this is part of a full-year thesis (493-494). Each student carries out an individual research project under the direction of a faculty member that culminates in a thesis. See description under The Degree with Honors in Mathematics.

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

Fall 2021
HON Section: 01 TBA Mihai Stoiciu

MATH 494 (F)(S) Senior Honors Thesis: Mathematics

Mathematics senior honors thesis; this is part of a full-year thesis (493-494). Each student carries out an individual research project under the direction of a faculty member that culminates in a thesis. See description under The Degree with Honors in Mathematics.

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

Fall 2021
HON Section: 01 TBA Mihai Stoiciu

Spring 2022
HON Section: 01 TBA Mihai Stoiciu

MATH 497 (F) Independent Study: Mathematics

Directed 400-level independent study in Mathematics.

Prerequisites: permission of department

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

Fall 2021
IND Section: 01 TBA Mihai Stoiciu
MATH 498 (S) Independent Study: Mathematics
Directed 400-level independent study in Mathematics.

Prerequisites: permission of department

Grading: yes pass/fail option, yes fifth course option

Distributions: (D3)

Spring 2022
IND Section: 01 TBA Mihai Stoiciu

MATH 499 (F)(S) Senior Colloquium
Mathematics senior colloquium. Meets every week for two hours both fall and spring. Senior majors must participate at least one hour a week. This colloquium is in addition to the regular four semester-courses taken by all students.

Class Format: colloquium

Grading: non-graded

Distributions: No divisional credit

Fall 2021
LEC Section: 01 MR 1:10 pm - 2:25 pm Mihai Stoiciu
LEC Section: 02 W 1:10 pm - 3:50 pm Mihai Stoiciu

Spring 2022
LEC Section: 01 MR 1:10 pm - 2:25 pm Mihai Stoiciu
LEC Section: 02 W 1:10 pm - 2:25 pm Mihai Stoiciu

Winter Study ---------------------------------------------------------------

MATH 11 (W) The Deluge--Redesigning Sustainable Towns and Cities
The Intergovernmental Panel on Climate Change has predicted that without controlling greenhouse gas emissions, the average world temperature will increase, and as a result sea levels are going to rise. What does this mean, and how can we control climate change from the perspective of built environment? In this course we will get familiar with and explore concepts such as energy efficiency, smart societies, circulatory economy, sustainability, renewable energies, building certificates, and building systems, as well as their impacts on built environment. We will also learn how building sustainable communities will help societies to fight climate change, to address social justice issues, and to be more climate resilient, among other benefits. We will use Williams College’s campus as our real-life laboratory. This course is a good fit for everyone, including those interested in social justice, engineering, sustainability, regional development, urban studies, architecture, and arts. Students from different backgrounds are encouraged to enroll. No prior experience needed. The course will be tailored towards students’ interests and will include group work, field trips, and readings. Readings: a book of choice, and at least two academic papers. Students are expected to read a book and at least two academic papers.

Work load (20 h/week): - In-class meeting time: Tuesdays and Thursdays afternoon (2 x 3 h/week) - Outside-of-class time: reading, group work and independent assignment (14 h/week) - Field trip (mandatory)

Requirements/Evaluation: participation, final project, small papers, group work

Prerequisites: none

Enrollment Limit: 15

Enrollment Preferences: based on a statement of interest

Grading: pass/fail only

Unit Notes: Ksenia Ruuska is currently a PhD student at the University of Massachusetts Amherst in the department of Environmental Conservation, majoring in Sustainable Building Systems, and since January 2020 has done dissertation work in cooperation work with Umass Facilities to improve energy efficiency in a university-owned residential complex, working to reduce its carbon footprint and energy consumption. She also holds
Bachelor's and Master's degrees in Engineering.

Materials/Lab Fee: $33

Winter 2022
LEC Section: 01

MATH 12 (W) The Mathematics of Lego Bricks
This course is a modification of seven previous winter studies I have done on the Mathematics of LEGO bricks. Similar to those, we will use LEGO bricks as a motivator to talk about some good mathematics (combinatorics, algorithms, efficiency). We will partner with Williamstown Elementary and teach an Adventures in Learning course (where once a week for four weeks we visit the elementary school after the day ends to work with the kids). We will also submit a Lego Ideas Challenge, to try and create a set that Lego will then market and sell. There may be a speed build challenge (college teams vs elementary school teams).
Requirements/Evaluation: final project or presentation
Prerequisites: appreciation of LEGO
Enrollment Limit: 40
Enrollment Preferences: conversation with the instructor
Grading: pass/fail only
Materials/Lab Fee: $30
Attributes: EXPE Experiential Education Courses

Winter 2022
LEC Section: 01    TBA     Steven J. Miller

MATH 13 (W) The Mathematics of SET (and other games)
SET is a popular game where players try to find certain collections of three cards, which share or fail to share properties like color, shape, and number. This seemingly simple game gives rise to an incredible variety of mathematical ideas. These range from counting and probability, to the behavior of lines in strange models of geometry. Throughout this class we’ll study these mathematical ideas, as well as those coming from other mathematically interesting games (and we’ll of course play lots of SET and other games!). Previous experience with SET or with mathematics is not required! We will be meeting for 6 hours per week in class; this time will be split between discussions and lectures covering the mathematics of SET, and Board Game Labs where students explore other games with intricate mathematics behind them. Outside-of-class work will include readings (from the book "The Joy of SET" and short mathematical readings relevant to other board games), learning and practicing other mathematically relevant board games, working on small problem sets, and as a final project either designing a new game based on mathematical ideas, or studying an existing game through a mathematical lens. These final projects will be showcased in a board game night at the end of Winter Study.
Requirements/Evaluation: final project or presentation; problem sets
Prerequisites: none
Enrollment Limit: 16
Enrollment Preferences: preference given to students with less mathematical background
Grading: pass/fail only
Materials/Lab Fee: none
Attributes: EXPE Experiential Education Courses

Winter 2022
LEC Section: 01    TBA     Ralph E. Morrison

MATH 14 (W) Flow Yoga
This class will teach the practice of yoga based on a fusion of Ashtanga, Vinyasa and iyengar methodologies. This course is open to all levels from
those who have never done a pose to those who have practicing yoga for years. The students will learn how to connect movement to breath in a sequence of vigorous yoga poses, or asanas. The flow classes will introduce yoga sequences in an alignment-based curriculum appropriate to each student's experience. In addition to the physical work out of practicing yoga, there will be short discussions on the assigned reading of handouts that explore various topics pertinent to yoga, such as an introduction to yogic philosophy, the essential of the human anatomy, the historical background of yoga, and a basic of knowledge of Sanskrit. The rudiments of meditation will begin and end every session.

**Requirements/Evaluation:** daily practice of yoga, journal, and class presentation

**Prerequisites:** none

**Enrollment Limit:** 25

**Enrollment Preferences:** priority will be given to seniors

**Grading:** pass/fail only

**Unit Notes:** Sylvia has brought her love of movement to the yoga mat. After a career of performing as a professional dancer, then full time mother of 4 and teaching ballet and modern dance, Sylvia dived into the study of yoga 20 years ago. Intensive workshops with David Swenson, Shiva Rea, Patricia Walden, and Tasha Judson introduced her to the rigors of Ashtanga, the dynamic joy of Vinyasa, and the importance of precise alignment in asanas. Sylvia completed her 200 hour Teaching Training last month.

**Materials/Lab Fee:** none

Winter 2022

LEC Section: 01 TBA Sylvia I. Logan

**MATH 16 (W) The Science of Star Trek**

**Cross-listings:** MATH 16 PHYS 16

**Secondary Cross-listing**

Comprising thirteen motion pictures and six major television series, totaling over 500 hours of film, Star Trek has had a profound impact on pop culture and the scientific imagination. In this Winter Study course, we will board Star Trek as vehicle towards a critical discussion of science, technology, and their consequences to society. We will boldly question topics such as the nature of reality, the (uni/multi)verse according to quantum theory and general relativity, the origins of consciousness and the possibility and consequences of extraterrestrial and artificial intelligence. We will view select episodes and films from the franchise, discussing their basis in actual science and using them as a prism to understand issues facing us on Earth.

**Requirements/Evaluation:** short paper and final project or presentation

**Prerequisites:** none

**Enrollment Limit:** 25

**Enrollment Preferences:** selection based on a small assignment and/or conversations with the instructors

**Grading:** pass/fail only

**Materials/Lab Fee:** none

**This course is cross-listed and the prefixes carry the following divisional credit:**

MATH 16 PHYS 16

Winter 2022

LEC Section: 01 TBA Frederick W. Strauch

**MATH 25 (W) Modern Marine Science**

**Cross-listings:** MATH 25 BIOL 26

**Primary Cross-listing**

This travel course will be on site in Woods Hole, MA, home to three world renowned marine science centers: the National Oceanic and Atmospheric Administration (NOAA), the Marine Biological Laboratory (MBL) and the Woods Hole Oceanographic Institution (WHOI). Time will be spent shadowing professionals in their line of work, assisting research when possible (or watching), and also listening to lectures on different topics given by this adjunct professor or other experts.
**Requirements/Evaluation:** short paper and final project or presentation

**Prerequisites:** none (Or perhaps an intro biology course credit?)

**Enrollment Limit:** 8

**Enrollment Preferences:** students interested in a career in marine science will be preferred; then, students in the life sciences or other directly related field (ecological statistics, etc)

**Grading:** pass/fail only

**Unit Notes:** Jennifer Turek has a Master's in Zoology from the University of Otago in Dunedin, New Zealand studying the endangered and endemic Hector's dolphin. Recently, she has continued these marine mammal studies working with NOAA in Woods Hole, MA studying marine mammal acoustics, specifically the highly endangered North Atlantic Right Whale. She also manages the North Atlantic annual stock assessment reports as required by the Marine Mammal Protection Act and other Protected Species Branch efforts.

**Materials/Lab Fee:** $1,500

**This course is cross-listed and the prefixes carry the following divisional credit:**

MATH 25 BIOL 26

**Attributes:** TRVL Winter Study Travel Course

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Winter 2022

TVL Section: 01 TBA Jenna L. Turek

**MATH 30 (W) Senior Project: Mathematics**

To be taken by candidates for honors in Mathematics other than by thesis route.

**Class Format:** honors project

**Grading:** pass/fail only

Winter 2022

HON Section: 01 TBA Mihai Stoiciu

**MATH 31 (W) Senior Thesis: Mathematics**

To be taken by students registered for Mathematics 493-494.

**Class Format:** thesis

**Grading:** pass/fail only

Winter 2022

HON Section: 01 TBA Mihai Stoiciu

**MATH 41 (W) Introduction to Data Science - Intensive**

Data science brings together techniques from computing, mathematics, and statistics to extract knowledge from data in fields of application as diverse as climate science, particle physics, electoral politics, literary analysis, and countless others. This course provides an introduction to data science techniques. First, using the computational package R, students will learn how to acquire, clean, explore, summarize, visualize, and communicate data. Second, in a series of nontechnical guest lectures, professional data scientists will share the types of work they do. Finally, students will carry out a small project, applying their data science skills to problems that interest them. This course requires no background in computer programming, mathematics, or statistics. However, this is an intensive course, and students must have enthusiasm to learn programming and a willingness to practice this skill for several hours per day.

**Class Format:** To afford students flexibility during the COVID pandemic, this course is taught online. Students will watch videos and complete data science modules asynchronously, and will participate in occasional synchronous lectures.

**Requirements/Evaluation:** Students will complete data science modules and a final project. To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows the policy of "ungrading." Over the course of the term, students will develop a rubric to assess their
own learning and will evaluate themselves according to this rubric.

**Prerequisites:** Willingness to learn a new field; willingness to practice computer programming intensively.

**Enrollment Limit:** 20

**Enrollment Preferences:** Contact the Office of the Dean of the College.

**Expected Class Size:** 20

**Grading:** pass/fail only

**Unit Notes:** This course is designed to count for both full semester, Winter Study, and QFR credit. Once a dean approves enrollment, the Registrar's Office will register students in both MATH 101 and MATH 41.

*Not offered current academic year*

**MATH 99 (W) Independent Study: Mathematics**

Open to upperclass students. Students interested in doing an independent project (99) during Winter Study must make prior arrangements with a faculty sponsor. The student and professor then complete the independent study proposal form available online. The deadline is typically in late September. Proposals are reviewed by the pertinent department and the Winter Study Committee. Students will be notified if their proposal is approved prior to the Winter Study registration period.

**Class Format:** independent study

**Grading:** pass/fail only

Winter 2022

IND Section: 01    TBA    Mihai Stoiciu