The Quantitative/Formal Reasoning (QFR) requirement is intended to help students become adept at reasoning mathematically and abstractly. The ability to apply a formal method to reach conclusions, use numbers comfortably, and employ the research tools necessary to analyze data lessens barriers to carrying out professional and economic roles. The hallmarks of a QFR course are the representation of facts in a language of mathematical symbols and the use of formal rules to obtain a determinate answer. Primary evaluation in these courses is based on multistep mathematical, statistical, or logical inference (as opposed to descriptive answers).

Prior to senior year, all students must satisfactorily complete ONE QFR course. Students requiring extra assistance (as assessed during First Days) are normally placed into Mathematics 100/101/102, which is to be taken before fulfilling the QFR requirement.

AMST 363  (F)(S)  Mathematical and Computational Approaches to Social Justice  (DPE) (QFR)
Cross-listings:  STS 363  WGSS 363  AMST 363  MATH 308
Secondary Cross-listing

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 group will carry out a substantial project in an area such as criminal justice, education equity, environmental justice, health care equity, economic justice, or 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.

Class Format:  This is a research-based tutorial.
Requirements/Evaluation:  To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows an "ungrading" methodology.
Prerequisites:  Across each 3 - 5 person tutorial group: 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:  20
Enrollment Preferences:  Students will be admitted in groups of 3 - 5 based on a proposal submitted prior to registration. The instructor is happy to facilitate formation of groups and to give feedback on draft proposals. Contact the instructor early, prior to preregistration.
Expected Class Size:  20
Grading:  yes pass/fail option,  no fifth course option
Distributions:  (D2)  (DPE) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
STS 363 (D2) WGSS 363 (D2) AMST 363 (D2) MATH 308 (D3)
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.

Fall 2022
TUT Section: T1  TBA  Chad M. Topaz
Spring 2023
TUT Section: T1  TBA  Chad M. Topaz

ASIA 241  (S)  Colonialism and Underdevelopment in South Asia  (DPE) (QFR)
Cross-listings:  ECON 240  ASIA 241
Secondary Cross-listing

British colonial rule in South Asia shaped economy and society in fundamental ways. As resistance to colonial rule emerged in the late nineteenth
century, "nationalist" writers developed a critique of its economic impact via taxation, fiscal policy, trade, and many other policies. In their turn, supporters of British rule, "apologists," argued that British rule had laid the foundations of economic growth by securing property rights, enforcing contracts, and developing infrastructure. The debate between "nationalists" and "apologists" has never quite ended, but after the recent growth of the Indian economy it has lost some of its emotional charge. We will use this opportunity to revisit the controversy.

Requirements/Evaluation: essays (one every other week) and responses to partner's essays will be evaluated

Prerequisites: one course in ECON

Enrollment Limit: 10

Enrollment Preferences: Economics major, prior course on South Asia

Expected Class Size: 10

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

Distributions: (D2) (DPE) (QFR)

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

ECON 240 (D2) ASIA 241 (D2)

Difference, Power, and Equity Notes: Issues of difference, power, and equity are at the heart of any analysis of colonialism, hence the DPE designation.

Quantitative/Formal Reasoning Notes: Students will write six essays, in which they will employ economic models and engage with quantitative evidence, so the course satisfies the QFR requirement.

Attributes: GBST South + Southeast Asia Studies Electives POEC Comparative POEC/Public Policy Courses

Spring 2023

TUT Section: T1 TBA Anand V. Swamy

ASTR 111 (F) Introduction to Astrophysics (QFR)

The science of astronomy spans vast scales of space and time, from individual atoms to entire galaxies and from the universe's beginning to the future fate of our Sun. In this course, we will survey some of the main ideas in modern astrophysics, with an emphasis on the physics of stars and galaxies. ASTR 111 is the first course in the Astrophysics and Astronomy major sequences. It is also appropriate for students planning to major in one of the other sciences or mathematics and for others who would like a quantitative introduction that emphasizes the relationship of contemporary physics to astronomy. Topics include gravity and orbits, radiation laws and stellar spectra, physical characteristics of the Sun and other stars, star formation and evolution, black holes, galaxies, the expanding universe, and the Big Bang. Students will also use telescopes to observe stars, nebulae, planets, and galaxies and to make daytime observations of the Sun.

Class Format: The class has 6 afternoon labs. Nighttime observing sessions will occur throughout the semester.

Requirements/Evaluation: weekly problem sets, two hour-long tests, a final exam, lab reports, and an observing portfolio

Prerequisites: a year of high school Physics, concurrent college Physics, or permission of instructor, and MATH 140 or equivalent

Enrollment Limit: 28

Enrollment Preferences: potential Astronomy majors

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: The course requires regular problem sets and quantitative assignments. The course will emphasize how physical equations explain the observed properties of the universe.

Fall 2022

LEC Section: 01 TR 11:20 am - 12:35 pm Marek Demianski, Kevin Flaherty

LAB Section: 02 M 1:00 pm - 4:00 pm Kevin Flaherty

LAB Section: 03 R 1:00 pm - 4:00 pm Kevin Flaherty
ASTR 498 (S) Independent Study: Astronomy or Astrophysics (QFR)
Astronomy/Astrophysics independent study, directed by one of the Astronomy faculty: Pasachoff/Jaskot/Flaherty

Requirements/Evaluation: Regular work with the instructor; submitted presentations and papers as agreed upon

Prerequisites: suitable Astronomy/Astrophysics/Physics/Math-Stats-Geosciences/Chemistry courses

Enrollment Limit: 10

Enrollment Preferences: research topic

Expected Class Size: 5

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: Substantial quantitative and formal reasoning are involved

Spring 2023
IND Section: 01 TBA Daniel P. Aalberts

BIMO 321 (F) Biochemistry I: Structure and Function of Biological Molecules (QFR)

Cross-listings: BIMO 321 BIOL 321 CHEM 321

Primary Cross-listing
This course introduces the foundational concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports

Prerequisites: BIOL 101 and CHEM 251/255 and CHEM 155/256

Enrollment Limit: 16/lab

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 48

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

Unit Notes: does not satisfy the distribution requirement for the Biology major; cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
BIMO 321 (D3) BIOL 321 (D3) CHEM 321 (D3)

Quantative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular problem sets in which quantitative/formal reasoning skills are practiced.

Attributes: BIGP Courses BIMO Required Courses

Fall 2022

LEC Section: 01 MWF 10:00 am - 10:50 am Amy Gehring

LAB Section: 02 M 1:00 pm - 5:00 pm Amy Gehring

LAB Section: 03 T 1:00 pm - 5:00 pm Jenna L. MacIntire

LAB Section: 04 R 1:00 pm - 5:00 pm Jenna L. MacIntire
Cross-listings: BIOL 322  BIMO 322  CHEM 322

Primary Cross-listing

This lecture course provides an in-depth presentation of the complex metabolic reactions that are central to life. Emphasis is placed on the biological flow of energy including alternative modes of energy generation (aerobic, anaerobic, photosynthetic); the regulation and integration of the metabolic pathways including compartmentalization and the transport of metabolites; and biochemical reaction mechanisms including the structures and mechanisms of coenzymes. This comprehensive study also includes the biosynthesis and catabolism of small molecules (carbohydrates, lipids, amino acids, and nucleotides). Laboratory experiments introduce the principles and procedures used to study enzymatic reactions, bioenergetics, and metabolic pathways.

Class Format: Lecture three hours per week and laboratory three hours per week.

Requirements/Evaluation: several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of data

Prerequisites: BIOL 101 and CHEM 251/255 or permission of instructor

Enrollment Limit: 60

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 60

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

Unit Notes: cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3)  (QFR)

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

BIOL 322 (D3)  BIMO 322 (D3)  CHEM 322 (D3)

Quantitative/Formal Reasoning Notes: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Attributes: BIGP Courses  BIMO Required Courses

Spring 2023

LEC Section: 01  TR 11:20 am - 12:35 pm  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Pei-Wen Chen
LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo

BIOL 202  (F)  Genetics  (QFR)

Genetics, classically defined as the study of heredity, is today a multidisciplinary field whose principles provide critical insight and tools to most areas of biology and medicine. This course covers the experimental basis for our current understanding of the inheritance, structures, and functions of genes. It introduces approaches used by contemporary geneticists and molecular biologists to explore questions in areas of biology ranging from evolution to medicine. A primary focus of the course is on students developing familiarity with problem solving, the logic and quantitative reasoning required to understand how genetic mechanisms lead to biological patterns. The laboratory part of the course provides an experimental introduction to modern genetic analysis as well as introductions to interpreting genetic reasoning in the primary research literature. Laboratory experiments include investigating chromosome structure using microscopy, integrating multiple streams of evidence to map a mutation to the genome, determining the structure of a DNA plasmid using molecular tools.

Class Format: Lecture: three hours per week, Lab: three hours per week.

Requirements/Evaluation: bi-weekly problem sets; weekly laboratory exercises and laboratory reports; three exams

Prerequisites: BIOL 101 and 102

Enrollment Limit: 120

Enrollment Preferences: students interested in the Biology major

Expected Class Size: 60

Grading: no pass/fail option, no fifth course option
Unit Notes: does not satisfy the distribution requirement for the Biology major

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course develops quantitative skills through solving problems. Students learn to apply basic calculations and logic to predict the outcomes of biological systems, for example, describing the likelihood that an individual will be affected by an inherited disease. Application of quantitative and logical analysis contributes to a large component of the in-class work and the graded material for the class, in the form of problem sets, exams, and data analysis for lab reports.

Attributes: BIGP Courses  BIMO Required Courses

Fall 2022

LEC Section: 01   MWF 11:00 am - 11:50 am   David W. Loehlin
LAB Section: 02   M 1:00 pm - 4:00 pm   Derek Dean
LAB Section: 03   T 1:00 pm - 4:00 pm   Derek Dean
LAB Section: 04   W 1:00 pm - 4:00 pm   Derek Dean
LAB Section: 05   R 1:00 pm - 4:00 pm   Derek Dean

BIOL 203  (F)  Ecology  (QFR)

Cross-listings: BIOL 203  ENVI 203

Primary Cross-listing

This course combines lectures & discussion with field and indoor laboratory activities to explore factors that determine the distribution and abundance of plants and animals in natural systems. The course begins with an overview of global environmental patterns and then builds from the population to ecosystem level. Throughout the course, we will emphasize the connection between basic ecological principles and current environmental issues. Selected topics include population dynamics (competition, predation, mutualism); community interactions (succession, food chains and diversity) and ecosystem function (biogeochemical cycles, energy flow). Laboratory activities are designed to engage students in the natural history of the region and build skills in data analysis and scientific writing.

Class Format: Six hours per week. Students will view pre-class lecture videos; class meetings will focus on discussion, synthesis, and application of course content.

Requirements/Evaluation: pre-class quizzes, lab reports, two mid-term exams, and a final exam

Prerequisites: BIOL 102, or ENVI 102, or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: students planning to pursue Biology and/or ENVI

Expected Class Size: 30

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

Unit Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
BIOL 203 (D3)  ENVI 203 (D3)

Quantitative/Formal Reasoning Notes: Much of the material in this course centers on the interpretation and application of mathematical models used to describe ecological systems. The laboratory section of this course also contains a large data analysis component (based in R). Students are introduced to t-tests, chi-square analysis, and regression.

Attributes: ENVI Natural World Electives  EVST Environmental Science

Fall 2022

LEC Section: 01   MWF 9:00 am - 9:50 am   Allison L. Gill
LAB Section: 02   T 1:00 pm - 4:00 pm   Allison L. Gill
LAB Section: 03   W 1:00 pm - 4:00 pm   Allison L. Gill
LAB Section: 04   R 1:00 pm - 4:00 pm   Allison L. Gill
This course offers a critical analysis of contemporary concepts in biological evolution. We focus on the relation of evolutionary mechanisms (e.g., selection, drift, and migration) to long term evolutionary patterns (e.g., evolutionary innovations, origin of major groups, and adaptation). Topics include micro-evolutionary models, natural and sexual selection, speciation, the inference of evolutionary history, evolutionary medicine among others.

**Requirements/Evaluation:** independent research project, problem sets, participation in discussions and exams

**Prerequisites:** BIOL 202

**Enrollment Limit:** 22

**Enrollment Preferences:** Seniors and biology majors

**Expected Class Size:** 22

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

**Unit Notes:** satisfies the distribution requirement for the Biology major

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

**Attributes:** BIGP Courses BIMO Interdepartmental Electives COGS Related Courses

### Spring 2023

**LEC Section:** 01  
MWF 11:00 am - 11:50 am  
Luana S. Maroja

**LAB Section:** 02  
W 1:00 pm - 4:00 pm  
Luana S. Maroja

**LAB Section:** 03  
R 1:00 pm - 4:00 pm  
Luana S. Maroja

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

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

**Primary 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:** The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

**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, no fifth course option

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

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

Spring 2023

SEM Section: 01    TR 9:55 am - 11:10 am     Lois M. Banta
LAB Section: 02    TR 1:00 pm - 4:00 pm     Lois M. Banta

BIOL 321  (F)  Biochemistry I: Structure and Function of Biological Molecules  (QFR)

Cross-listings:  BIMO 321  BIOL 321  CHEM 321

Secondary Cross-listing

This course introduces the foundational concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports

Prerequisites: BIOL 101 and CHEM 251/255 and CHEM 155/256

Enrollment Limit: 16/lab

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 48

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

Unit Notes: does not satisfy the distribution requirement for the Biology major; cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3)  (QFR)

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

BIMO 321  (D3) BIOL 321  (D3) CHEM 321  (D3)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular problem sets in which quantitative/formal reasoning skills are practiced.

Attributes: BIGP Courses  BIMO Required Courses

Fall 2022

LEC Section: 01    MWF 10:00 am - 10:50 am     Amy Gehring
LAB Section: 02    M 1:00 pm - 5:00 pm     Amy Gehring
LAB Section: 03    T 1:00 pm - 5:00 pm     Jenna L. MacIntire
LAB Section: 04    R 1:00 pm - 5:00 pm     Jenna L. MacIntire

BIOL 322  (S)  Biochemistry II: Metabolism  (QFR)

Cross-listings:  BIOL 322  BIMO 322  CHEM 322

Secondary Cross-listing

This lecture course provides an in-depth presentation of the complex metabolic reactions that are central to life. Emphasis is placed on the biological flow of energy including alternative modes of energy generation (aerobic, anaerobic, photosynthetic); the regulation and integration of the metabolic pathways including compartmentalization and the transport of metabolites; and biochemical reaction mechanisms including the structures and
mechanisms of coenzymes. This comprehensive study also includes the biosynthesis and catabolism of small molecules (carbohydrates, lipids, amino acids, and nucleotides). Laboratory experiments introduce the principles and procedures used to study enzymatic reactions, bioenergetics, and metabolic pathways.

Class Format: Lecture three hours per week and laboratory three hours per week.

Requirements/Evaluation: several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of data

Prerequisites: BIOL 101 and CHEM 251/255 or permission of instructor

Enrollment Limit: 60

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 60

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

Unit Notes: cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
BIOL 322 (D3) BIMO 322 (D3) CHEM 322 (D3)

Quantative/Formal Reasoning Notes: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Attributes: BIGP Courses BIMO Required Courses

Spring 2023

LEC Section: 01  TR 11:20 am - 12:35 pm  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Pei-Wen Chen
LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo

BIOL 337 (F) Evolutionary Ecology (QFR)
Evolutionary ecology is an interdisciplinary field that integrates concepts in genetics, adaptation, and ecology to understand how evolution operates in the context of ecological communities. This course provides an overview of the discipline including foundational concepts in evolutionary demography, phenotypic plasticity, and population genetics. It also explores how breakthroughs in these topics provide a framework for advances in our understanding of the evolution of reproductive timing and ageing, interspecific interactions (e.g. competition, predation), cooperation, and altruism. The course combines lectures, readings, in-class discussion, and a lab section that includes a mixture of field, computer, and lab projects. Laboratories will give students practical, hands-on experience in how to develop, plan, and carry out evolutionary ecology research from start to finish.

Class Format: lecture, 3 hours per week; laboratory and discussion, 3 hours per week

Requirements/Evaluation: Evaluation will be based on lab assignments, two exams, discussion participation, and a written paper.

Prerequisites: BIOL 102, plus either BIOL 202 or BIOL 203 or equivalent

Enrollment Limit: 24

Enrollment Preferences: preference given to biology majors, seniors, and juniors

Expected Class Size: 24

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

Unit Notes: Satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: Evolutionary ecology uses concepts in genetics and ecology to understand how the frequency of alleles in a population changes over time. These changes are formalized in equations that describe these processes. Students will gain experience in utilizing these equations to describe, analyze, and predict the evolutionary outcome of ecological interactions for both theoretical and experimental purposes. Thus, the students will gain experience in solving systems of equations using algebra and in stat

Fall 2022
CHEM 151 (F) Introductory Chemistry (QFR)
This course provides an introduction to chemistry for those students with little or no high school chemistry. Students will be introduced to concepts fundamental to studying matter at the molecular level. Principal topics include introductions to the nature of atoms and molecules, stoichiometry, solubility rules and equilibria, gas laws, chemical equilibrium, acid-base reactions, periodic relationships, chemical bonding, molecular structure, intermolecular forces, oxidation-reduction reactions, and related applications. Laboratory work comprises a system of qualitative analysis and quantitative techniques. The course provides preparation for further study of organic chemistry, biochemistry, physical and inorganic chemistry and is intended for students who are anticipating professional study in chemistry, in related sciences, or in one of the health professions, as well as for those students who are interested in exploring the fundamental ideas of chemistry as part of their general education. This course may be taken pass/fail; however, students who are considering graduate study in science or in the health professions should elect to take this course for a grade.

Class Format: lecture, three times per week and laboratory, four hours per week
Requirements/Evaluation: electronic and written weekly problem set assignments, laboratory work and analysis, quizzes, two tests, and a final exam
Prerequisites: Students are required to take the online Chemistry Placement Survey prior to registering for the course (chemistry.williams.edu/placement).
Enrollment Limit: 16/lab
Enrollment Preferences: first-year students; students who have studied chemistry for one or more years are directed to CHEM 153 or 155
Expected Class Size: 32
Grading: yes pass/fail option, no fifth course option
Unit Notes: CHEM 151 may be taken concurrently with MATH 102 – see under Mathematics; CHEM 151 or its equivalent is a prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes: BIMO Required Courses

Fall 2022
LEC Section: 01 MWF 8:30 am - 9:45 am Stephanie Christau
LAB Section: 02 M 1:00 pm - 5:00 pm Laura R. Strauch
LAB Section: 03 T 1:00 pm - 5:00 pm Stephanie Christau

CHEM 153 (F) Concepts of Chemistry (QFR)
This course broadens and deepens the foundation in chemistry of students who have had typically one year of chemistry at the high school level. Most students begin study of chemistry at Williams with this course. Familiarity with stoichiometry, basic concepts of equilibria, and the model of an atom is expected. Principal topics for this course include kinetic theory of gases, modern atomic theory, molecular structure and bonding, states of matter, chemical equilibrium (acid-base and solubility), and an introduction to atomic and molecular spectroscopies. Laboratory periods will largely focus on experiment design, data analysis, literature, scientific writing, ethics, and other skills critical to students' development as scientists. The course is of interest to students who anticipate professional study in chemistry, related sciences, or one of the health professions, as well as to those who want to explore the fundamentals of chemistry as part of their general education. This course may be taken pass/fail; however, students who are considering graduate study in science or in the health professions should elect to take this course for a grade.

Class Format: lecture, three times per week and laboratory, four hours per week
Requirements/Evaluation: problem sets and/or quizzes, laboratory work, and exams
Prerequisites: Students are required to take the online Chemistry Placement Survey prior to registering for the course (chemistry.williams.edu/placement).
Enrollment Limit: 45/lecture
Enrollment Preferences: first-year students
Expected Class Size: 90
Grading: yes pass/fail option, no fifth course option
Unit Notes: CHEM 153 or its equivalent is a prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes: BIMO Required Courses

Fall 2022
LEC Section: 01 MWF 9:00 am - 9:50 am Bob Rawle
LEC Section: 02 MWF 11:00 am - 11:50 am Bob Rawle
LAB Section: 03 M 1:00 pm - 5:00 pm Jennifer K. Rosenthal
LAB Section: 04 T 1:00 pm - 5:00 pm Jennifer K. Rosenthal
LAB Section: 05 W 1:00 pm - 5:00 pm Jennifer K. Rosenthal
LAB Section: 06 R 1:00 pm - 5:00 pm Jennifer K. Rosenthal
LAB Section: 07 T 8:00 am - 12:00 pm Laura R. Strauch
LAB Section: 08 W 7:00 pm - 11:00 pm Enrique Peacock-López

CHEM 155  (F) Principles of Modern Chemistry  (QFR)
This course is designed for students with a strong preparation in chemistry (including laboratory experience) in secondary school, such as provided by an Advanced Placement chemistry course (or equivalent) with a corresponding AP Chemistry Exam score of 5 (or a 6 or 7 on the IB Exam, or equivalent). Topics include chemical thermodynamics, kinetics, structure and bonding, coordination chemistry, electrochemistry and spectroscopy and their application to fields such as materials science, catalysis, environmental, biological, and medicinal chemistry. Laboratory periods will focus on hands-on skills, data representation and analysis, scientific writing, exploration of the scientific literature, and other skills critical to students' development as scientists. This course is designed for students who are anticipating further study in chemistry, related sciences, or one of the health professions, as well as for students who want to explore the fundamental ideas of chemistry as part of their general education.
Class Format: lecture, three times per week and laboratory, four hours per week
Requirements/Evaluation: frequent short assignments in preparation for class, quantitative weekly problem sets, laboratory work and reports, an hour test, and a final exam
Prerequisites: Students are required to take the online Chemistry Placement Survey prior to registering for the course (chemistry.williams.edu/placement).
Enrollment Limit: 16/lab
Enrollment Preferences: first-year students and sophomores
Expected Class Size: 32
Grading: no pass/fail option, no fifth course option
Unit Notes: CHEM 155 or its equivalent is a prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes: BIMO Required Courses

Fall 2022
LEC Section: 01 MWF 8:00 am - 8:50 am Lee Y. Park
LAB Section: 02 M 1:00 pm - 5:00 pm Anthony J. Carrasquillo
CHEM 156 (S) Organic Chemistry: Introductory Level (QFR)
This course provides the necessary background in organic chemistry for students who are planning advanced study or a career in chemistry, the biological sciences, or the health professions. It initiates the systematic study of the common classes of organic compounds with emphasis on theories of structure and reactivity. The fundamentals of molecular modeling as applied to organic molecules are presented. Specific topics include basic organic structure and bonding, isomerism, stereochemistry, molecular energetics, the theory and interpretation of infrared and nuclear magnetic spectroscopy, substitution, elimination and addition reactions. The coordinated laboratory work includes purification and separation techniques, structure-reactivity studies, organic synthesis, IR and NMR spectroscopy, and the identification of unknown compounds.

Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: quantitative problem solving, laboratory performance, three midterm exams, and a final exam

Prerequisites: CHEM 151 or 153 or 155 or permission of instructor

Enrollment Limit: 55/lecture

Enrollment Preferences: Seniors, juniors, sophomores, first-year students

Expected Class Size: 100

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem solving in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: BIMO Required Courses

Spring 2023

LEC Section: 01  MWF 8:00 am - 8:50 am   Thomas E. Smith
LEC Section: 02  MWF 9:00 am - 9:50 am   Kerry-Ann Green
LAB Section: 03  M 1:00 pm - 5:00 pm
LAB Section: 04  T 1:00 pm - 5:00 pm
LAB Section: 05  W 1:00 pm - 5:00 pm
LAB Section: 06  R 1:00 pm - 5:00 pm
LAB Section: 07  M 1:00 pm - 5:00 pm
LAB Section: 08  W 1:00 pm - 5:00 pm
LAB Section: 09  T 1:00 pm - 5:00 pm

CHEM 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 throughput 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:** The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

**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, no fifth course option

**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)

**Quantitative/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

Spring 2023

SEM Section: 01  TR 9:55 am - 11:10 am  Lois M. Banta

LAB Section: 02  TR 1:00 pm - 4:00 pm  Lois M. Banta

**CHEM 321 (F) Biochemistry I: Structure and Function of Biological Molecules**  (QFR)

**Cross-listings:** BIMO 321  BIOL 321  CHEM 321

**Secondary Cross-listing**

This course introduces the foundational concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

**Class Format:** lecture, three times per week and laboratory, four hours per week

**Requirements/Evaluation:** quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports

**Prerequisites:** BIOL 101 and CHEM 251/255 and CHEM 155/256

**Enrollment Limit:** 16/lab

**Enrollment Preferences:** junior and senior Biology and Chemistry majors and BIMO concentrators

**Expected Class Size:** 48

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

**Unit Notes:** does not satisfy the distribution requirement for the Biology major; cannot be counted towards the Biology major in addition to BIOL 222

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

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

BIMO 321 (D3)  BIOL 321 (D3)  CHEM 321 (D3)

**Quantitative/Formal Reasoning Notes:** This course fulfills the QFR requirement with regular problem sets in which quantitative/formal reasoning skills are practiced.

**Attributes:** BIGP Courses  BIMO Required Courses

Fall 2022
LEC Section: 01  MWF 10:00 am - 10:50 am  Amy Gehring
LAB Section: 02  M 1:00 pm - 5:00 pm  Amy Gehring
LAB Section: 03  T 1:00 pm - 5:00 pm  Jenna L. MacIntire
LAB Section: 04  R 1:00 pm - 5:00 pm  Jenna L. MacIntire

CHEM 322  (S)  Biochemistry II: Metabolism  (QFR)
Cross-listings:  BIOL 322  BIMO 322  CHEM 322

Secondary Cross-listing
This lecture course provides an in-depth presentation of the complex metabolic reactions that are central to life. Emphasis is placed on the biological flow of energy including alternative modes of energy generation (aerobic, anaerobic, photosynthetic); the regulation and integration of the metabolic pathways including compartmentalization and the transport of metabolites; and biochemical reaction mechanisms including the structures and mechanisms of coenzymes. This comprehensive study also includes the biosynthesis and catabolism of small molecules (carbohydrates, lipids, amino acids, and nucleotides). Laboratory experiments introduce the principles and procedures used to study enzymatic reactions, bioenergetics, and metabolic pathways.

Class Format: Lecture three hours per week and laboratory three hours per week.
Requirements/Evaluation: several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of data
Prerequisites:  BIOL 101 and CHEM 251/255 or permission of instructor
Enrollment Limit:  60
Enrollment Preferences:  junior and senior Biology and Chemistry majors and BIMO concentrators
Expected Class Size:  60
Grading:  no pass/fail option,  no fifth course option
Unit Notes:  cannot be counted towards the Biology major in addition to BIOL 222
Distributions:  (D3)  (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
BIOL 322 (D3) BIMO 322 (D3) CHEM 322 (D3)
Quantative/Formal Reasoning Notes:  The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.
Attributes:  BIGP Courses  BIMO Required Courses

Spring 2023
LEC Section: 01  TR 11:20 am - 12:35 pm  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Pei-Wen Chen
LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo

CHEM 368  (S)  Computational Chemistry and Molecular Spectroscopy  (QFR)
This tutorial provides an introduction to the principles of computational quantum mechanics and their application to problems of chemical interest such as chemical bonding, chemical reactivity, and molecular spectroscopy. Emphasis is placed upon modern electronic structure calculations, their fundamentals, practical considerations, interpretation, and applications to current research questions. Under guidance in sessions and through independent work, students will use computational methods to explore assigned weekly research problems. The research results will be presented to and discussed with the tutorial partner at the end of each week.
Requirements/Evaluation:  tutorial participation, presentations, and submitted papers
Prerequisites:  CHEM 361 or equivalent background in Physics
Enrollment Limit:  10
Enrollment Preferences:  Chemistry majors
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course fulfills the QFC requirement with problem sets for assignments in which quantitative/formal reasoning skills are practiced.

Spring 2023
TUT Section: T1 TBA Enrique Peacock-López

COGS 224 (F) Introduction to Formal Linguistics (QFR)
Cross-listings: COGS 224 PHIL 221
Primary Cross-listing
The sentence "Every cookie is chocolate chip and three of them are oatmeal raisin" is a perfectly grammatical sentence of English, but it's self-contradictory. What does it take to realize this fact? One must grasp the meanings of the various parts of the sentence. In particular, one must grasp that "three of them" picks out a subset of the group picked out by "every cookie", and that there's no such thing as a cookie that is both chocolate chip and oatmeal raisin. There two ways to understand "Many students took every class". According to one, there is a single group of students that had their hands extremely full this semester. According to the other, every class was well-populated, potentially by different groups. The reason for this is that there are two underlying structures that the original sentence can realize. This course serves as an introduction to formal methods in the scientific study of language. Our goal will be to characterize phenomena like those above with logical and mathematical precision. The focus will be on model-theoretic semantics, the sub-field of linguistics that studies meanings. Along the way we will discuss principles of syntax, the sub-field that studies sentence structures, and pragmatics, the sub-field that studies inferences of non-literal content. This is a formal course, but no prior logical or mathematical background will be expected. Starting from scratch, students will learn the building blocks of current-day linguistic research. This introduction will be of use to students interested in language from a variety of perspectives, including philosophy, cognitive science, and computer science.
Requirements/Evaluation: Weekly problem sets, plus a final project (paper/presentation/other type, to be discussed with instructor)
Prerequisites: No prerequisites
Enrollment Limit: 20
Enrollment Preferences: Preference given to seniors and philosophy/cognitive science majors.
Expected Class Size: 20
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:
COGS 224 (D2) PHIL 221 (D2)
Quantitative/Formal Reasoning Notes: This course teaches the fundamentals of the formal analysis of language. Students will learn to provide translation schemes from English to a logical language (typed lambda calculus).
Attributes: COGS Interdepartmental Electives COGS Related Courses Linguistics PHIL Contemp Metaphysics + Epistemology Courses

Fall 2022
SEM Section: 01 TF 1:10 pm - 2:25 pm Christian De Leon

CSCI 103 (S) Electronic Textiles (QFR)
Digital data is being infused throughout the entire physical world, escaping the computer monitor and spreading to other devices and appliances, including the human body. Electronic textiles, or eTextiles, is one of the next steps toward making everything interactive and this course aims to introduce learners to the first steps of developing their own wearable interactive technology devices. After completing a series of introductory eTextiles projects to gain practice in necessary sewing, circuitry, and programming skills, students will propose and design their own eTextiles projects, eventually implementing them with sewable Arduino components, and other found electronic components as needed. The scope of the project will depend on the individual's prior background, but can include everything from a sweatshirt with light-up turn signals for bicycling, to a wall banner that
displays the current air quality of the room, to a stuffed animal that plays a tune when the lights go on, to whatever project you can conceivably accomplish with sewable Arduino inputs, outputs, and development board in a semester context. This class will introduce students to introductory computer programming, circuitry, and sewing with the goal of creating novel wearable artifacts that interact with the world.

**Class Format:** interspersed with hands-on activities in a computer lab

**Requirements/Evaluation:** weekly homework assignments and a final project

**Prerequisites:** none

**Enrollment Limit:** 18

**Enrollment Preferences:** students who have not previously taken a CSCI course

**Expected Class Size:** 18

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

**Unit Notes:** Please see the Computer Science Department website for more information on selecting an introductory computer science class: https://csci.williams.edu/

**Materials/Lab Fee:** a fee of $95 will be added to term bill to cover Lilypad Arduino components (Protosnap Plus Kit, battery holders, sets of LEDs, temperature sensor, vibe board, tri-color LED), alligator test leads, fabric, thread & fabric scissors.

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

**Quantative/Formal Reasoning Notes:** The course will teach students the basics of computer programming through projects in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2023

**LEC Section:** 01   TR 9:55 am - 11:10 am   Iris Howley

**CSCI 104 (F) Understanding Data Through Computation** (QFR)

Many of the world's greatest discoveries and most consequential decisions are enabled or informed by the analysis of data from a myriad of sources. Indeed, the ability to organize, visualize, and draw conclusions from data is now a critical tool in the sciences, business, medicine, politics, other academic disciplines, and society as a whole. This course lays the foundations for reasoning about data by exploring complementary computational, statistical, and visualization concepts. These concepts will be reinforced by lab experiences designed to teach programming and statistics skills while analyzing real-world data sets. This course will also examine the broader context and social issues surrounding data analysis, including privacy and ethics.

**Requirements/Evaluation:** Weekly problem sets involving programming, a project, and examinations.

**Prerequisites:** None; previous programming experience or statistics is not required.

**Enrollment Limit:** 24;12/lab

**Enrollment Preferences:** Not open to those who have completed or are currently enrolled in a Computer Science course numbered 136 or higher or a Statistics course. Preference given to first-year students and sophomores who have not previously taken a computer science course.

**Expected Class Size:** 24

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

**Unit Notes:** Please see the Computer Science Department website for more information on selecting an introductory computer science class: https://csci.williams.edu/

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

**Quantative/Formal Reasoning Notes:** This course includes regular and substantial problem sets, labs, and/or projects in which quantitative/formal reasoning skills are practiced and evaluated.

Fall 2022

**LEC Section:** 01   MWF 10:00 am - 10:50 am   Katie A. Keith

**LEC Section:** 02   MWF 11:00 am - 11:50 am   Stephen N. Freund

**LAB Section:** 03   M 1:00 pm - 2:30 pm   Stephen N. Freund, Katie A. Keith

**LAB Section:** 04   M 2:30 pm - 4:00 pm   Stephen N. Freund, Katie A. Keith
CSCI 134  (F)(S)  Introduction to Computer Science  (QFR)
This course introduces students to the science of computation by exploring the representation and manipulation of data and algorithms. We organize and transform information in order to solve problems using algorithms written in a modern object-oriented language. Topics include organization of data using objects and classes, and the description of processes using conditional control, iteration, methods and classes. We also begin the study of abstraction, self-reference, reuse, and performance analysis. While the choice of programming language and application area will vary in different offerings, the skills students develop will transfer equally well to more advanced study in many areas. In particular, this course is designed to provide the programming skills needed for further study in computer science and is expected to satisfy introductory programming requirements in other departments.

Requirements/Evaluation:  weekly programming projects, weekly written homeworks, and two examinations.
Prerequisites:  none, except for the standard prerequisites for a (QFR) course; previous programming experience is not required
Enrollment Limit:  30;15/lab
Enrollment Preferences:  if the course is over-enrolled, enrollment will be determined by lottery.
Expected Class Size:  30/lec
Grading:  yes pass/fail option,  yes fifth course option
Unit Notes:  Please see the Computer Science Department website for more information on selecting an introductory computer science class:  https://csci.williams.edu/. Students with prior experience with object-oriented programming should discuss appropriate course placement with members of the department.
Distributions:  (D3)  (QFR)
Quantative/Formal Reasoning Notes:  This course includes regular and substantial problem sets, labs, and/or projects in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes:  COGS Interdepartmental Electives

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Iris Howley
LEC Section: 02  MWF 10:00 am - 10:50 am  Jeannie R Albrecht
LEC Section: 03  MWF 11:00 am - 11:50 am  Jeannie R Albrecht
LAB Section: 04  M 1:00 pm - 2:30 pm  Iris Howley
LAB Section: 05  M 1:00 pm - 2:30 pm  Jeannie R Albrecht
LAB Section: 06  M 2:30 pm - 4:00 pm  Jeannie R Albrecht
LAB Section: 07  T 1:00 pm - 2:30 pm  Iris Howley
LAB Section: 08  T 1:00 pm - 2:30 pm  Jeannie R Albrecht
LAB Section: 09  T 2:30 pm - 4:00 pm  Jeannie R Albrecht

Spring 2023
LEC Section: 01  MWF 9:00 am - 9:50 am  Rohit Bhattacharya
LEC Section: 02  MWF 10:00 am - 10:50 am  Rohit Bhattacharya
LEC Section: 03  MWF 11:00 am - 11:50 am  Mark Hopkins
LAB Section: 04  M 1:00 pm - 2:30 pm  Mark Hopkins
LAB Section: 05  M 1:00 pm - 2:30 pm  Rohit Bhattacharya
LAB Section: 06  M 2:30 pm - 4:00 pm  Rohit Bhattacharya
LAB Section: 07  T 1:00 pm - 2:30 pm  Mark Hopkins
LAB Section: 08  T 1:00 pm - 2:30 pm  Rohit Bhattacharya
LAB Section: 09  T 2:30 pm - 4:00 pm  Rohit Bhattacharya
This course builds on the programming skills acquired in Computer Science 134. It couples work on program design, analysis, and verification with an introduction to the study of data structures. Data structures capture common ways in which to store and manipulate data, and they are important in the construction of sophisticated computer programs. Students are introduced to some of the most important and frequently used data structures: lists, stacks, queues, trees, hash tables, graphs, and files. Students will be expected to write several programs, ranging from very short programs to more elaborate systems. Emphasis will be placed on the development of clear, modular programs that are easy to read, debug, verify, analyze, and modify.

Requirements/Evaluation: programming and written assignments, quizzes, examinations
Prerequisites: CSCI 134 or equivalent; fulfilling the Discrete Mathematics Proficiency requirement is recommended, but not required
Enrollment Limit: 30;15/lab
Enrollment Preferences: if the course is over-enrolled, enrollment will be determined by lottery.
Expected Class Size: 30/lec
Grading: yes pass/fail option, no fifth course option
Unit Notes: Please see the Computer Science Department website for more information on selecting an introductory computer science class: https://csci.williams.edu/
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course include regular and substantial problem sets, labs, and/or projects in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes: BIGP Courses

Fall 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Kelly A. Shaw
LEC Section: 02 MWF 9:00 am - 9:50 am Daniel W. Barowy
LAB Section: 03 W 1:00 pm - 2:30 pm Kelly A. Shaw
LAB Section: 04 W 2:30 pm - 4:00 pm Kelly A. Shaw
LAB Section: 05 R 1:00 pm - 2:30 pm Daniel W. Barowy
LAB Section: 06 R 2:30 pm - 4:00 pm Daniel W. Barowy

Spring 2023
LEC Section: 01 MWF 10:00 am - 10:50 am James M. Bern
LEC Section: 02 MWF 11:00 am - 11:50 am Daniel W. Barowy
LAB Section: 03 W 1:00 pm - 2:30 pm James M. Bern
LAB Section: 04 W 2:30 pm - 4:00 pm James M. Bern
LAB Section: 05 R 1:00 pm - 2:30 pm Daniel W. Barowy
LAB Section: 06 R 2:30 pm - 4:00 pm Daniel W. Barowy

CSCI 237 (F)(S) Computer Organization (QFR)
This course studies the basic instruction set architecture and organization of a modern computer. It provides a programmer's view of how computer systems execute programs, store information, and communicate. Over the semester the student learns the fundamentals of translating higher level languages into assembly language, and the interpretation of machine languages by hardware. At the same time, a model of computer hardware organization is developed from the gate level upward.
Requirements/Evaluation: weekly programming assignments and/or problem sets, quizzes, midterm and final exams
Prerequisites: CSCI 136
Enrollment Limit: 24;12/lab
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

CSCI 256  (F)(S)  Algorithm Design and Analysis  (QFR)

This course investigates methods for designing efficient and reliable algorithms. By carefully analyzing the structure of a problem within a mathematical framework, it is often possible to dramatically decrease the computational resources needed to find a solution. In addition, analysis provides a method for verifying the correctness of an algorithm and accurately estimating its running time and space requirements. We will study several algorithm design strategies that build on data structures and programming techniques introduced in Computer Science 136. These include greedy, divide-and-conquer, dynamic programming, and network flow algorithms. Additional topics of study include algorithms on graphs and strategies for handling potentially intractable problems.

Requirements/Evaluation: Problem sets, midterm and final examinations

Prerequisites: CSCI 136 and fulfillment of the Discrete Mathematics Proficiency requirement

Enrollment Limit: 24

Enrollment Preferences: Preference will be given to students who need the class in order to complete the major. Ties will be broken by seniority (seniors first, then juniors, etc.).

Expected Class Size: 24

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course will have weekly problem sets in which students will formally prove statements about the behavior and performance of algorithms. In short, the course is about applying abstract and mathematical reasoning to the study of algorithms and computation.

CSCI 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 throughput 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:** The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

**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, no fifth course option

**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)

**Quantitative/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

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**CSCI 334 (F)(S) Principles of Programming Languages (QFR)**
This course examines the concepts and structures governing the design and implementation of programming languages. It presents an introduction to the concepts behind compilers and run-time representations of programming languages; features of programming languages supporting abstraction and polymorphism; and the procedural, functional, object-oriented, and concurrent programming paradigms. Programs will be required in languages illustrating each of these paradigms.

**Requirements/Evaluation:** weekly problem sets and programming assignments, a midterm examination, and a final examination

**Prerequisites:** CSCI 136

**Enrollment Limit:** 30

**Enrollment Preferences:** current or expected Computer Science majors

**Expected Class Size:** 30

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

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

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

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**Fall 2022**
LEC Section: 01 TR 9:55 am - 11:10 am Daniel W. Barowy

**Spring 2023**
LEC Section: 01 TR 9:55 am - 11:10 am Stephen N. Freund
CSCI 339 (S) Distributed Systems (QFR)

This course studies the key design principles of distributed systems, which are collections of independent networked computers that function as single coherent systems. Covered topics include communication protocols, processes and threads, naming, synchronization, consistency and replication, fault tolerance, and security. Students also examine some specific real-world distributed systems case studies, including Google and Amazon. Class discussion is based on readings from the textbook and research papers. The goals of this course are to understand how large-scale computational systems are built, and to provide students with the tools necessary to evaluate new technologies after the course ends.

Requirements/Evaluation: weekly homework assignments, midterm, 3 major programming projects, and a final project
Prerequisites: CSCI 237
Enrollment Limit: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2023
LEC Section: 01 MR 1:10 pm - 2:25 pm Jeannie R Albrecht

CSCI 361 (F) Theory of Computation (QFR)

Cross-listings: MATH 361 CSCI 361

Primary 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: 48(12/con)
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 48
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

Fall 2022
LEC Section: 01 ASYN Aaron M. Williams
CON Section: 02 MWF 11:00 am - 12:15 pm Aaron M. Williams
CON Section: 03 MR 1:10 pm - 2:25 pm Aaron M. Williams
CSCI 371 (F)(S) Computer Graphics (QFR)
This course covers the fundamental mathematics and techniques behind computer graphics, and will teach students how to represent and draw 2D and 3D geometry for real-time and photorealistic applications. Students will write challenging implementations from the ground up in C/C++, OpenGL, and GLSL. Topics include transformations, rasterization, ray tracing, immediate mode GUI, forward and inverse kinematics, and physically-based animation. Examples are drawn from video games, movies, and robotics.
Requirements/Evaluation: evaluation based on assignments, projects, and exams.
Prerequisites: CSCI 136 and CSCI 237 or permission of instructor
Enrollment Limit: 24;12/lab
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Fall 2022
LEC Section: 01  MR 2:35 pm - 3:50 pm  James M. Bern
LAB Section: 02  T 1:00 pm - 2:30 pm  James M. Bern
LAB Section: 03  T 2:30 pm - 4:00 pm  James M. Bern

Spring 2023
LEC Section: 01  MR 2:35 pm - 3:50 pm  James M. Bern
LAB Section: 02  T 1:00 pm - 2:30 pm  James M. Bern
LAB Section: 03  T 2:30 pm - 4:00 pm  James M. Bern

CSCI 373 (F)(S) Artificial Intelligence (QFR)
Artificial Intelligence (AI) has become part of everyday life, but what is it, and how does it work? This course introduces theories and computational techniques that serve as a foundation for the study of artificial intelligence. Potential topics include the following: Problem solving by search, Logic, Planning, Constraint satisfaction problems, Reasoning under uncertainty, Probabilistic graphical models, and Automated Learning.
Requirements/Evaluation: Evaluation based on assignments, projects, and exams.
Prerequisites: CSCI 136 and (CSCI 256 or permission of instructor)
Enrollment Limit: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes: COGS Interdepartmental Electives

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Mark Hopkins

Spring 2023
CSCI 374 (F) Machine Learning (QFR)

Machine learning is a field that derives from artificial intelligence and statistics, and is concerned with the design and analysis of computer algorithms that "learn" automatically through the use of data. Computer algorithms are capable of discerning subtle patterns and structure in the data that would be practically impossible for a human to find. As a result, real-world decisions, such as treatment options and loan approvals, are being increasingly automated based on predictions or factual knowledge derived from such algorithms. This course explores topics in supervised learning (e.g., random forests and neural networks), unsupervised learning (e.g., k-means clustering and expectation maximization), and possibly reinforcement learning (e.g., Q-learning and temporal difference learning.) It will also introduce methods for the evaluation of learning algorithms (with an emphasis on analysis of generalizability and robustness of the algorithms to distribution/environmental shift), as well as topics in computational learning theory and ethics.

Requirements/Evaluation: Presentations, problem sets, programming exercises, empirical analyses of algorithms, critical analysis of current literature; the final two weeks are focused on a project of the student's design.

Prerequisites: CSCI 136 and CSCI 256 or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: Current or expected Computer Science majors.

Expected Class Size: 24

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course heavily relies on discrete mathematics, calculus, and elementary statistics. Students will be proving theorems, among many other mathematically oriented assignments. Additionally, they will be programming, which involves analytical and logical thinking.

Attributes: COGS Interdepartmental Electives

Fall 2022

LEC Section: 01 MR 2:35 pm - 3:50 pm Rohit Bhattacharya

CSCI 375 (S) Natural Language Processing (QFR)

Natural language processing (NLP) is a set of methods for making human language accessible to computers. NLP underlies many technologies we use on a daily basis including automatic machine translation, search engines, email spam detection, and automated personalized assistants. These methods draw from a combination of algorithms, linguistics and statistics. This course will provide a foundation in building NLP models to classify, generate, and learn from text data.

Requirements/Evaluation: Evaluation based on assignments, projects, and exams.

Prerequisites: CSCI 136, and either CSCI 256 or STAT 201/202.

Enrollment Limit: 24

Enrollment Preferences: current or expected Computer Science majors.

Expected Class Size: 24

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2023

LEC Section: 01 MWF 10:00 am - 10:50 am Katie A. Keith
LEC Section: 02 MWF 11:00 am - 11:50 am Katie A. Keith
ECON 110 (F)(S) Principles of Microeconomics  (QFR)

This course is an introduction to the study of the forces of supply and demand that determine prices and the allocation of resources in markets for goods and services, markets for labor, and markets for natural resources. The focus is on how and why markets work, why they may fail to work, and the policy implications of both their successes and failures. The course focuses on developing the basic tools of microeconomic analysis and then applying those tools to topics of popular or policy interest such as minimum wage legislation, pollution control, competition policy, international trade policy, discrimination, tax policy, and the role of government in a market economy.

Requirements/Evaluation: problem sets, quizzes, short essays, two midterms, final exam

Prerequisites: none

Enrollment Limit: 40

Enrollment Preferences: This course is required of Economics and Political Economy majors and highly recommended for those non-majors interested in Environmental Studies and Women's, Gender and Sexuality Studies.

Expected Class Size: 40

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

Unit Notes: The department recommends students follow this course with ECON 120 or with a lower-level elective that has ECON 110 as its prerequisite; students may alternatively proceed directly to ECON 251 after taking this introductory course.

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: Course involves mathematical modeling of real-world phenomena, analyzing quantitative results, and describing those results in words.

Attributes: POEC Required Courses

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ECON 120 (F)(S) Principles of Macroeconomics  (QFR)

This course provides an introduction to the study of the aggregate national economy. It develops the basic theories of macroeconomics and applies them to topics of current interest. Issues to be explored include: the causes of inflation, unemployment, recessions, and depressions; the role of government fiscal and monetary policy in stabilizing the economy; the determinants of long-run economic growth; the long- and short-run effects of taxes, budget deficits, and other government policies on the national economy; the role of financial frictions in amplifying recessions; and the workings of exchange rates and international finance.

Requirements/Evaluation: Depending on instructor, may include: problem sets, short essays, quizzes, reading assignments, either one or two midterms, and a final exam.

Prerequisites: ECON 110

Enrollment Limit: 40

Enrollment Preferences: First-year students and sophomores.

Expected Class Size: 40

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

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: Course involves mathematical modeling of real-world phenomena, analyzing quantitative results, and
ECON 213 (F) Introduction to Environmental and Natural Resource Economics  (QFR)

Cross-listings:  ECON 213  ENVI 213

Primary Cross-listing

We'll use economics to learn why we harm the environment and overuse natural resources, and what we can do about it. We'll talk about whether and how we can put a dollar value on nature and ecosystem services. We'll study cost-benefit analysis, pollution in general, climate change, environmental justice, natural resources (like fisheries, forests, and fossil fuels), and energy. We will take an economic approach to global sustainability, and study the relationship between the environment and economic growth and trade. Consideration of justice and equity will be woven through the whole semester.

Requirements/Evaluation: problem sets, short essays, final paper; intermediate assignments may include poster, presentation, brief writing assignment

Prerequisites:  ECON 110 or equivalent

Enrollment Limit:  30

Enrollment Preferences:  first-year and sophomore students

Expected Class Size:  30

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

Unit Notes: this course will count toward both the Environmental Studies major and concentration

Distributions:  (D2)  (QFR)

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

ECON 213 (D2) ENVI 213 (D2)

Quantitative/Formal Reasoning Notes: We will use formal theory expressed in math and graphs, perform calculations, and consume statistical data.

Attributes:  ENVI Environmental Policy  EVST Social Science/Policy  MAST Interdepartmental Electives  POEC Comparative POEC/Public Policy Courses

ECON 232 (F) Financial Markets, Institutions and Policies  (QFR)

The focus of the course will be on how firms, financial markets, and central banks interact in the economy. Key questions addressed in the course include: How do firms allocate their resources to enhance their value? How are firms evaluated by the financial markets? How are asset prices determined, and how are these prices related to interest rates? Are financial markets efficient, and what are the implications of their efficiency or lack thereof? How does the financial system help with the management of risks faced by society? We will also study the role of the central bank (the Federal Reserve in the US), monetary policy, and government regulation and their impacts on financial decision making. Key questions include: How do central banks set monetary policy and how do those policies affect the economy and the financial decision-making process? How does monetary
policy change when interest rates are (virtually) zero?

Class Format: There will be a mix of lecture and discussion.

Requirements/Evaluation: 5-7 Problem Sets, Quantitative Exercises, Group Paper, and Final Exam

Prerequisites: ECON 110 and ECON 120

Enrollment Limit: 25

Enrollment Preferences: Sophomore and Junior Economics majors

Expected Class Size: 25

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

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: We will use mathematical models, graphs, and data analysis to understand financial decisions at the firm and economy-wide levels.

Attributes: POEC Comparative POEC/Public Policy Courses

Fall 2022

LEC Section: 01 TR 9:55 am - 11:10 am Neal J. Rappaport

ECON 240 (S) Colonialism and Underdevelopment in South Asia (DPE) (QFR)

Cross-listings: ECON 240 ASIA 241

Primary Cross-listing

British colonial rule in South Asia shaped economy and society in fundamental ways. As resistance to colonial rule emerged in the late nineteenth century, "nationalist" writers developed a critique of its economic impact via taxation, fiscal policy, trade, and many other policies. In their turn, supporters of British rule, "apologists," argued that British rule had laid the foundations of economic growth by securing property rights, enforcing contracts, and developing infrastructure. The debate between "nationalists" and "apologists" has never quite ended, but after the recent growth of the Indian economy it has lost some of its emotional charge. We will use this opportunity to revisit the controversy.

Requirements/Evaluation: essays (one every other week) and responses to partner's essays will be evaluated

Prerequisites: one course in ECON

Enrollment Limit: 10

Enrollment Preferences: Economics major, prior course on South Asia

Expected Class Size: 10

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

Distributions: (D2) (DPE) (QFR)

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

ECON 240 (D2) ASIA 241 (D2)

Difference, Power, and Equity Notes: Issues of difference, power, and equity are at the heart of any analysis of colonialism, hence the DPE designation.

Quantative/Formal Reasoning Notes: Students will write six essays, in which they will employ economic models and engage with quantitative evidence, so the course satisfies the QFR requirement.

Attributes: GBST South + Southeast Asia Studies Electives POEC Comparative POEC/Public Policy Courses

Spring 2023

TUT Section: T1 TBA Anand V. Swamy

ECON 251 (F)(S) Price and Allocation Theory (QFR)

A study of the determination of relative prices and their importance in shaping the allocation of resources and the distribution of income. Subjects include: behavior of households in a variety of settings, such as buying goods and services, saving, and labor supply; behavior of firms in various kinds of markets; results of competitive and noncompetitive markets in goods, labor, land, and capital; market failure; government policies as sources of and
responses to market failure; welfare criteria; limitations of mainstream analysis.

**Requirements/Evaluation:** Requirements vary by professor, but typically include frequent problem sets and multiple exams, including a final exam. They may also include one or more quizzes, short essays, collaborative projects, or presentations.

**Prerequisites:** ECON 110 and MATH 130 or its equivalent

**Enrollment Limit:** 30

**Enrollment Preferences:** Current or prospective Economics majors.

**Expected Class Size:** 30

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

**Distributions:** (D2) (QFR)

**Quantitative/Formal Reasoning Notes:** Course involves developing and analyzing mathematical models of real-world phenomena, grounded in tools like calculus and game theory. Students are assumed to be comfortable with topics from introductory calculus, including differentiation and integration.

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**Fall 2022**

LEC Section: 01  MW 11:00 am - 12:15 pm  Pamela Jakiela
LEC Section: 02  MR 1:10 pm - 2:25 pm  Stephen C. Sheppard
LEC Section: 03  MR 2:35 pm - 3:50 pm  Stephen C. Sheppard

**Spring 2023**

LEC Section: 01  MWF 8:30 am - 9:45 am  Sarah A. Jacobson
LEC Section: 02  MWF 11:00 am - 12:15 pm  Ashok S. Rai

**ECON 252 (F)(S) Macroeconomics** (QFR)

A study of aggregate economic activity: output, employment, inflation, and interest rates. The class will develop a theoretical framework for analyzing economic growth and business cycles. The theory will be used to evaluate policies designed to promote growth and stability, and to understand economic developments in the U.S. and abroad. Instructors may use elementary calculus in assigned readings, exams and lectures.

**Requirements/Evaluation:** Requirements vary by professor, but typically include frequent problem sets and/or written assignments, midterm(s), and a final exam.

**Prerequisites:** ECON 110 and 120 and MATH 130 or its equivalent

**Enrollment Limit:** 30

**Enrollment Preferences:** Current or prospective Economics majors.

**Expected Class Size:** 30

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

**Distributions:** (D2) (QFR)

**Quantitative/Formal Reasoning Notes:** Course involves mathematical modeling of real-world phenomena, analyzing quantitative results, and describing those results in words.

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**Fall 2022**

LEC Section: 01  TF 2:35 pm - 3:50 pm  Peter L. Pedroni
LEC Section: 02  TR 11:20 am - 12:35 pm  Andrew T. Hessler

**Spring 2023**

LEC Section: 01  MR 1:10 pm - 2:25 pm  Kenneth N. Kuttner
LEC Section: 02  TF 1:10 pm - 2:25 pm  Andrew T. Hessler
LEC Section: 03  TF 2:35 pm - 3:50 pm  Andrew T. Hessler

**ECON 255 (F)(S) Econometrics** (QFR)

An introduction to the theory and practice of applied quantitative economic analysis. This course familiarizes students with the strengths and
weaknesses of the basic empirical methods used by economists to evaluate economic theory against economic data. Emphasizes both the statistical foundations of regression techniques and the practical application of those techniques in empirical research, with a focus on understanding when a causal interpretation is warranted. Computer exercises will provide experience in using the empirical methods, but no previous computer experience is expected. Highly recommended for students considering graduate training in economics or public policy.

Requirements/Evaluation: Requirements vary by professor, but typically include frequent problem sets, multiple exams, a group project, and possible additional assignments or quizzes.

Prerequisites: MATH 130, plus STAT 161, 201 or 202 (or equivalent, including a score of 5 on the AP Statistics Exam), plus one course in ECON; STAT 101 will also serve as a prerequisite, but only if taken prior to the fall of 2018

Enrollment Limit: 30

Enrollment Preferences: Current or prospective Economics and Political Economy majors.

Expected Class Size: 30

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

Unit Notes: Students may substitute the combination of STAT 201 and 346 for ECON 255

Distributions: (D2)  (QFR)

Quantative/Formal Reasoning Notes: Course teaches research tools necessary to analyze data.

Attributes: PHLH Statistics Courses  POEC Required Courses

Fall 2022

LEC Section: 01  MR 1:10 pm - 2:25 pm  Matthew Gibson
LEC Section: 02  MR 2:35 pm - 3:50 pm  Matthew Gibson
LEC Section: 03  TR 8:30 am - 9:45 am  Owen Ozier

Spring 2023

LEC Section: 01  TR 8:30 am - 9:45 am  David J. Zimmerman
LEC Section: 02  TR 9:55 am - 11:10 am  David J. Zimmerman
LEC Section: 03  MWF 8:30 am - 9:45 am  David J. Zimmerman

ECON 345  (S)  Growth Diagnostics  (QFR)

Cross-listings: ECON 545  ECON 345

Primary Cross-listing

Evidence from across the developing world suggests that the "binding constraints" to economic growth can be remarkably heterogeneous--i.e., the growth potential of stagnating or underperforming economies may be unlocked in a large variety of ways. For instance, pre-reform China had been constrained by poor supply incentives in agriculture, whereas Brazil has been held back by an inadequate supply of credit, South Africa by poor employment incentives in manufacturing, El Salvador by insufficient production incentives in tradables, Zimbabwe by bad governance, and so forth.

How can developing-country policymakers determine country-specific constraints like these, thus enabling them to pragmatically pursue a selected set of growth-promoting policies rather than attempting to implement a "laundry list" of reforms that are naively based on "best practice" rules-of-thumb? This course will serve as a primer on "growth diagnostics," an empirically-driven analytical framework for identifying the most binding constraints to economic growth in a given country at a point in time, thereby allowing policymakers to develop well-targeted reforms for relaxing these constraints while being cognizant of the nation's prevailing economic, political, and social context. The course will first build on the basic theories and empirics of economic growth to elucidate the diagnostic framework and will then employ a wide range of country-specific case studies to demonstrate how the framework can be operationalized for policy making. Throughout the semester, students will be required to work in groups, each representing a given developing or emerging-market economy, in order to build a growth diagnostic for their group's assigned country by the end of the course.

Requirements/Evaluation: extensive class participation, two short (5-page) papers, two 15-page team papers comprising a country growth diagnostic, and a team presentation on the diagnostic

Prerequisites: for undergraduates ECON 251, ECON 252, and either ECON 255 or STAT 346

Enrollment Limit: 19

Enrollment Preferences: CDE fellows and senior Economics majors

Expected Class Size: 19
**Grading:** no pass/fail option, yes fifth course option

**Distributions:** (D2) (QFR)

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

ECON 545 (D2) ECON 345 (D2)

**Quantitative/Formal Reasoning Notes:** The course material will be drawn heavily on mathematical and statistical models of economic growth and macroeconomic development, and students will be required to routinely develop mathematical models and/or conduct econometric analysis in their assignments.

Spring 2023

SEM Section: 01 TR 9:55 am - 11:10 am Quamrul H. Ashraf

**ECON 371 (F) Time Series Econometrics and Empirical Methods for Macro (QFR)**

Econometric methods in many fields including macro and monetary economics, finance and international growth and development, as well as numerous fields beyond economics, have evolved a distinct set of techniques which are designed to meet the practical challenges posed by the typical empirical questions and available time series data of these fields. The course will begin with an introductory review of concepts of estimation and inference for large data samples in the context of the challenges of multivariate endogenous systems, and will then focus on associated methods for analysis of short dynamics such as vector autoregressive techniques and methods for analysis of long run dynamics such as cointegration techniques. Students will be introduced to concepts and techniques analytically, but also by intuition, learning by doing, and by computer simulation and illustration. The course is particularly well suited for economics majors wishing to explore advanced empirical methods, or for statistics, mathematics or computer science majors wishing to learn more about the ways in which the subject of their majors interacts with the fields of economics. The method of evaluation will include a term paper. ECON 252 and either STATS 346 or ECON 255 are formal prerequisites, although for students with exceptionally strong math/stats backgrounds these can be waived subject to instructor permission. Credit may not be earned for both ECON 371 and ECON 356.

**Requirements/Evaluation:** term paper and regular homework assignments

**Prerequisites:** ECON 252 and either ECON 255 or STATS 346

**Enrollment Limit:** 19

**Enrollment Preferences:** students wishing to write an honors thesis, and students with strong MATH/STAT/CSCI backgrounds

**Expected Class Size:** 19

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

**Distributions:** (D2) (QFR)

**Quantitative/Formal Reasoning Notes:** Uses quantitative/formal reasoning intensively in the form of mathematical and statistical arguments, as well as computer programming.

Fall 2022

SEM Section: 01 TF 1:10 pm - 2:25 pm Peter L. Pedroni

**ECON 378 (F) Long-Run Comparative Development (QFR)**

The world today is marred by vast disparities in the standard of living, with about a 30-fold difference in real GDP per capita between the poorest and most affluent of nations. What are the causes of such differences in prosperity across countries? Are the origins of global inequality to be found in underlying differences among societies over the past few decades, the past few centuries, or the past few millennia? If contemporary differences in living standards have such "deep" historical roots, what scope exists for policies to reduce global inequality today? Can we expect inequality to be reduced through some natural process of macroeconomic development, or is it likely to persist unless acted upon by policy? This course will present a unified theory of economic growth for thinking about these and related questions. Examples of issues to be covered include: the Neoclassical growth model and its inefficacy for answering questions about development over long time horizons; Malthusian stagnation across societies during the pre-industrial stage of economic development; the importance of the so-called demographic transition and of human capital formation in the course of industrialization; the persistent influence of colonialism, slavery, and ethnic fragmentation in shaping the quality of contemporary politico-economic institutions; and the enduring effects of geography on comparative development, through its impact on the emergence of agriculture in early human societies and its influence in shaping the composition of traits in populations across the globe.
**ECON 384 (S) Corporate Finance (QFR)**

This course analyzes the major financial decisions facing firms. While the course takes the perspective of a manager making decisions about both what investments to undertake and how to finance these projects, it will emphasize the underlying economic models that are relevant for these decisions. Topics include capital budgeting, links between real and financial investments, capital structure choices, dividend policy, and firm valuation. Additional topics may include issues in corporate risk management, corporate governance and corporate restructuring, such as mergers and acquisitions.

**Class Format:** Lecture / discussion

**Requirements/Evaluation:** class participation, problem sets, short quizzes, short projects such as case write ups, a midterm exam, a final exam and a research paper (possibly written with a partner)

**Prerequisites:** ECON 251, 252, and some familiarity with statistics (e.g., ECON 255)

**Enrollment Limit:** 28

**Enrollment Preferences:** Economics majors; seniority

**Expected Class Size:** 28

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

**Distributions:** (D2) (QFR)

**Quantitative/Formal Reasoning Notes:** The course uses quantitative models to evaluate decisions.

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**ECON 387 (S) Economics of Climate Change (QFR)**

Cross-listings: ECON 522  ENVI 387  ECON 387

**Primary Cross-listing**

This course introduces the economic view of climate change, including both theory and empirical evidence. Given the substantial changes implied by the current stock of greenhouse gases (GHGs) in the atmosphere, we will begin by looking at impacts on agriculture, health, income, and migration. We will consider the distribution of climate damages across poor and wealthy people, both within and across countries. Next we will study adaptation, including capital investments and behavioral changes. We will examine the sources of climate change, especially electricity generation and transportation, and think about optimal policies. Throughout the course we will discuss the limits of the economic approach, pointing out normative questions on which economic theory provides little guidance.
Government policy is important for economic development. To finance their policies, governments must build the fiscal capacity to implement a tax system. In turn, fiscal capacity—the ability for the government to raise revenue—depends on economic development. This endogeneity between fiscal capacity and economic development creates challenges for tax policy in developing countries. Given these challenges, what types of taxes should countries use to raise revenues? How can governments build the fiscal capacity to generate revenue to finance critical services? This class explores tax policy from a global and comparative perspective. Because most students will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are pertinent to developing countries. However, many tax policy lessons are universal so we will also learn about tax policies in developed countries, especially issues relevant for transnational transactions. Topics addressed include: how economic principles can be applied to the efficiency and equity consequences of tax policies; how personal income taxes, corporate income taxes, and value-added taxes are designed and administered and how they influence the economy; ideas for fundamental tax reforms; the debate over progressive taxes versus "flat" taxes; how taxes affect incentives to save and invest; how market failures and administrative problems may influence the optimality of tax policy; the implications of global capital flows and corporate tax avoidance for tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on foreign direct investment, labor supply, and tax evasion; tax policy towards natural resources such as minerals and oil; case studies of efforts to reform tax administration and reduce tax evasion and corruption; taxes on land and property; taxes on imports and exports; presumptive taxation; and the informal economy and its implications for tax policy.

**Requirements/Evaluation:** midterm exam, several problem sets, two 10-page essays

**Prerequisites:** one public economics course or microeconomics course (ECON 504 or ECON 110), and one empirical methods course (POEC 253 or ECON 255, 502, or 503); students who have previously taken ECON 351 will not be enrolled

**Enrollment Limit:** 19

**Enrollment Preferences:** CDE students, but undergraduates with the prerequisites are welcome

**Expected Class Size:** 15-19

**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:**
ECON 514 (D2) ECON 389 (D2)

**Quantitative/Formal Reasoning Notes:** The course builds on other QFR Reasoning econ classes.

**Attributes:** POEC Comparative POEC/Public Policy Courses POEC International Political Economy Courses

Spring 2023
ECON 471 (S) Topics in Advanced Econometrics (QFR)
The course uses both a practical and conceptual/theory based approach, with emphasis on methods of structural identification of dynamics in VARs and long run cointegration and nonlinear function estimation and analysis, both in conventional time series and especially panel time series which contain spatial dimensions. The course will also investigate methods of computer simulation related to these techniques. The course is well suited for students considering empirically oriented honors theses in fields that employ these techniques, such as macro, finance, growth, trade and development, as well as fields outside of economics that use time series data. It is also well suited for students majoring in economics, statistics, computer sciences or mathematics who wish to expand their econometrics training and understanding to a more advanced level.

Requirements/Evaluation: periodic homework assignments, term paper
Prerequisites: ECON 371
Enrollment Limit: 19
Enrollment Preferences: students with strong quantitative backgrounds, and to students intending to write an honors thesis
Expected Class Size: 19
Grading: no pass/fail option, yes fifth course option
Distributions: (D2) (QFR)
Quantitative/Formal Reasoning Notes: Course will make use of mathematics, statistics and computer analysis for the conceptualization and implementation of the econometric topics that are taught.

Spring 2023
SEM Section: 01 M 7:00 pm - 9:40 pm Peter L. Pedroni

ECON 477 (F) Economics of Environmental Behavior (QFR)

Cross-listings: ECON 477 ENVI 376
Primary Cross-listing
A community maintains a fishery; a firm decides whether to get a green certification; you choose to fly home or stay here for spring break: behaviors of people and firms determine our impact on the environment. We'll use economics to model environmental behavior and to consider how policies can help or hurt the environment. Topics we'll study include: voluntary conservation, social norms and nudges, firm responses to mandatory and voluntary rules, and boycotts and divestment.

Class Format: Class sessions will largely consist of presentations and discussions of academic research papers, as well as lab sessions to work on empirical exercises; we may break the class into groups for some discussions

Requirements/Evaluation: regular reading responses, empirical exercises, class participation, 2 oral presentations, and a final original research paper using an experiment, existing data, or theory
Prerequisites: ECON 251 and (ECON 255 or STAT 346)
Enrollment Limit: 19
Enrollment Preferences: senior Economics majors
Expected Class Size: 19
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:
ECON 477 (D2) ENVI 376 (D2)
Quantitative/Formal Reasoning Notes: The research students will consume and produce in the class will be based on math-based theory and/or econometric-based empirical analysis.
Attributes: ENVI Humanities, Arts + Social Science Electives MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

Fall 2022
**ECON 514 (S) Tax Policy in Global Perspective** (QFR)

**Cross-listings:** ECON 514  ECON 389

**Primary Cross-listing**

Government policy is important for economic development. To finance their policies, governments must build the fiscal capacity to implement a tax system. In turn, fiscal capacity—the ability for the government to raise revenue—depends on economic development. This endogeneity between fiscal capacity and economic development creates challenges for tax policy in developing countries. Given these challenges, what types of taxes should countries use to raise revenues? How can governments build the fiscal capacity to generate revenue to finance critical services? This class explores tax policy from a global and comparative perspective. Because most students will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are pertinent to developing countries. However, many tax policy lessons are universal so we will also learn about tax policies in developed countries, especially issues relevant for transnational transactions. Topics addressed include: how economic principles can be applied to the efficiency and equity consequences of tax policies; how personal income taxes, corporate income taxes, and value-added taxes are designed and administered and how they influence the economy; ideas for fundamental tax reforms; the debate over progressive taxes versus "flat" taxes; how taxes affect incentives to save and invest; how market failures and administrative problems may influence the optimality of tax policy; the implications of global capital flows and corporate tax avoidance for tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on foreign direct investment, labor supply, and tax evasion; tax policy towards natural resources such as minerals and oil; case studies of efforts to reform tax administration and reduce tax evasion and corruption; taxes on land and property; taxes on imports and exports; presumptive taxation; and the informal economy and its implications for tax policy.

**Requirements/Evaluation:** midterm exam, several problem sets, two 10-page essays

**Prerequisites:** one public economics course or microeconomics course (ECON 504 or ECON 110), and one empirical methods course (POEC 253 or ECON 255, 502, or 503); students who have previously taken ECON 351 will not be enrolled

**Enrollment Limit:** 19

**Enrollment Preferences:** CDE students, but undergraduates with the prerequisites are welcome

**Expected Class Size:** 15-19

**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:

ECON 514 (D2) ECON 389 (D2)

**Quantative/Formal Reasoning Notes:** The course builds on other QFR Reasoning econ classes.

**Attributes:** POEC Comparative POEC/Public Policy Courses  POEC International Political Economy Courses

Spring 2023

SEM Section: 01  MR 2:35 pm - 3:50 pm  Jon M. Bakija

**ECON 522 (S) Economics of Climate Change** (QFR)

**Cross-listings:** ECON 522  ENVI 387  ECON 387

**Secondary Cross-listing**

This course introduces the economic view of climate change, including both theory and empirical evidence. Given the substantial changes implied by the current stock of greenhouse gases (GHGs) in the atmosphere, we will begin by looking at impacts on agriculture, health, income, and migration. We will consider the distribution of climate damages across poor and wealthy people, both within and across countries. Next we will study adaptation, including capital investments and behavioral changes. We will examine the sources of climate change, especially electricity generation and transportation, and think about optimal policies. Throughout the course we will discuss the limits of the economic approach, pointing out normative questions on which economic theory provides little guidance.

**Requirements/Evaluation:** problem sets, midterm, group presentation, final exam

**Prerequisites:** ECON 251, familiarity with statistics

**Enrollment Limit:** 25
Enrollment Preferences: Junior/Senior Economics majors and CDE fellows

Expected Class Size: 25

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

Distributions: (D2) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
ECON 522 (D2) ENVI 387 (D2) ECON 387 (D2)

Quantitative/Formal Reasoning Notes: The course involves simple calculus-based theory and applied statistics.

Attributes: ENVI Environmental Policy MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

Spring 2023
LEC Section: 01 MR 1:10 pm - 2:25 pm Matthew Gibson

ECON 545 (S) Growth Diagnostics (QFR)

Cross-listings: ECON 545 ECON 345

Secondary Cross-listing

Evidence from across the developing world suggests that the "binding constraints" to economic growth can be remarkably heterogeneous—i.e., the growth potential of stagnating or underperforming economies may be unlocked in a large variety of ways. For instance, pre-reform China had been constrained by poor supply incentives in agriculture, whereas Brazil has been held back by an inadequate supply of credit, South Africa by poor employment incentives in manufacturing, El Salvador by insufficient production incentives in tradables, Zimbabwe by bad governance, and so forth. How can developing-country policymakers determine country-specific constraints like these, thus enabling them to pragmatically pursue a selected set of growth-promoting policies rather than attempting to implement a "laundry list" of reforms that are naively based on "best practice" rules-of-thumb?

This course will serve as a primer on "growth diagnostics," an empirically-driven analytical framework for identifying the most binding constraints to economic growth in a given country at a point in time, thereby allowing policymakers to develop well-targeted reforms for relaxing these constraints while being cognizant of the nation's prevailing economic, political, and social context. The course will first build on the basic theories and empirics of economic growth to elucidate the diagnostic framework and will then employ a wide range of country-specific case studies to demonstrate how the framework can be operationalized for policy making. Throughout the semester, students will be required to work in groups, each representing a given developing or emerging-market economy, in order to build a growth diagnostic for their group's assigned country by the end of the course.

Requirements/Evaluation: extensive class participation, two short (5-page) papers, two 15-page team papers comprising a country growth diagnostic, and a team presentation on the diagnostic

Prerequisites: for undergraduates ECON 251, ECON 252, and either ECON 255 or STAT 346

Enrollment Limit: 19

Enrollment Preferences: CDE fellows and senior Economics majors

Expected Class Size: 19

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

Distributions: (D2) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
ECON 545 (D2) ECON 345 (D2)

Quantitative/Formal Reasoning Notes: The course material will be draw heavily on mathematical and statistical models of economic growth and macroeconomic development, and students will be required to routinely develop mathematical models and/or conduct econometric analysis in their assignments.

Spring 2023
SEM Section: 01 TR 9:55 am - 11:10 am Quamrul H. Ashraf

ENVI 203 (F) Ecology (QFR)

Cross-listings: BIOL 203 ENVI 203
Secondary Cross-listing

This course combines lectures & discussion with field and indoor laboratory activities to explore factors that determine the distribution and abundance of plants and animals in natural systems. The course begins with an overview of global environmental patterns and then builds from the population to ecosystem level. Throughout the course, we will emphasize the connection between basic ecological principles and current environmental issues. Selected topics include population dynamics (competition, predation, mutualism); community interactions (succession, food chains and diversity) and ecosystem function (biogeochemical cycles, energy flow). Laboratory activities are designed to engage students in the natural history of the region and build skills in data analysis and scientific writing.

Class Format: Six hours per week. Students will view pre-class lecture videos; class meetings will focus on discussion, synthesis, and application of course content.

Requirements/Evaluation: pre-class quizzes, lab reports, two mid-term exams, and a final exam

Prerequisites: BIOL 102, or ENVI 102, or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: students planning to pursue Biology and/or ENVI

Expected Class Size: 30

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

Unit Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

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

BIOL 203 (D3) ENVI 203 (D3)

Quantitative/Formal Reasoning Notes: Much of the material in this course centers on the interpretation and application of mathematical models used to describe ecological systems. The laboratory section of this course also contains a large data analysis component (based in R). Students are introduced to t-tests, chi-square analysis, and regression.

Attributes: ENVI Natural World Electives EVST Environmental Science

Fall 2022

LEC Section: 01  MWF 9:00 am - 9:50 am  Allison L. Gill
LAB Section: 02  T 1:00 pm - 4:00 pm  Allison L. Gill
LAB Section: 03  W 1:00 pm - 4:00 pm  Allison L. Gill
LAB Section: 04  R 1:00 pm - 4:00 pm  Allison L. Gill

ENVI 213  (F)  Introduction to Environmental and Natural Resource Economics  (QFR)

Cross-listings: ECON 213  ENVI 213

Secondary Cross-listing

We'll use economics to learn why we harm the environment and overuse natural resources, and what we can do about it. We'll talk about whether and how we can put a dollar value on nature and ecosystem services. We'll study cost benefit analysis, pollution in general, climate change, environmental justice, natural resources (like fisheries, forests, and fossil fuels), and energy. We will take an economic approach to global sustainability, and study the relationship between the environment and economic growth and trade. Consideration of justice and equity will be woven through the whole semester.

Requirements/Evaluation: problem sets, short essays, final paper; intermediate assignments may include poster, presentation, brief writing assignment

Prerequisites: ECON 110 or equivalent

Enrollment Limit: 30

Enrollment Preferences: first-year and sophomore students

Expected Class Size: 30

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

Unit Notes: this course will count toward both the Environmental Studies major and concentration
ENVI 215 (S) Climate Changes (QFR)

Cross-listings: ENVI 215 GEOS 215

Secondary Cross-listing

Paleoclimatology is the reconstruction of past climate variability and the forces that drove the climate changes. The Earth's climate system is experiencing unprecedented and catastrophic change because of anthropogenic emission of greenhouse gases and land use change. Paleoclimatology allows humans to put modern climate changes into the context of the history of this planet, and shows how and why it is unprecedented and catastrophic. Each climate event we study from Earth's past teaches us lessons on why the climate system responds to anthropogenic perturbations, what climate changes we're committed to in the future, how long-lasting they will be, and what climate consequences we can avoid if we take action and reduce greenhouse gas emissions sooner. In this course, we will discuss the major mechanisms that cause natural climate variability, how climate of the past is reconstructed, and how climate models are used to test mechanisms that drive climate variation. With these tools, you will analyze and interpret data and model simulations from climate events from Earth's history, and apply these findings to anthropogenic climate changes happening now and that are projected to happen in the future. Laboratories and homework will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change. This course is in the Oceans and Climate group for the Geosciences major.

Class Format: This class has three scheduled lectures per week, and one lab meeting per week which will consist of field excursions, lab exercises, problem solving and discussion

Requirements/Evaluation: lab exercises and homework (25%), three quizzes (50%), and a final project (25%)

Prerequisites: 100-level course in GEOS, CHEM, or PHYS or ENVI 102 or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: Geosciences majors and Environmental Studies majors and concentrators and Maritime Studies concentrators

Expected Class Size: 16

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:

ENVI 215 (D3) GEOS 215 (D3)

Quantitative/Formal Reasoning Notes: Labs and homework include quantitative problem solving, visualization and analysis of quantitative data, and scientific computing with Matlab. No previous programming experience is assumed.

Attributes: ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans MAST Interdepartmental Electives
A community maintains a fishery; a firm decides whether to get a green certification; you choose to fly home or stay here for spring break: behaviors of people and firms determine our impact on the environment. We'll use economics to model environmental behavior and to consider how policies can help or hurt the environment. Topics we'll study include: voluntary conservation, social norms and nudges, firm responses to mandatory and voluntary rules, and boycotts and divestment.

**Class Format:** Class sessions will largely consist of presentations and discussions of academic research papers, as well as lab sessions to work on empirical exercises; we may break the class into groups for some discussions.

**Requirements/Evaluation:** regular reading responses, empirical exercises, class participation, 2 oral presentations, and a final original research paper using an experiment, existing data, or theory.

**Prerequisites:** ECON 251 and (ECON 255 or STAT 346)

**Enrollment Limit:** 19

**Enrollment Preferences:** senior Economics majors

**Expected Class Size:** 19

**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:

ECON 477 (D2) ENVI 376 (D2)

**Quantitative/Formal Reasoning Notes:** The research students will consume and produce in the class will be based on math-based theory and/or econometric-based empirical analysis.

**Attributes:** ENVI Humanities, Arts + Social Science Electives MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

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**ENVI 387 (S) Economics of Climate Change** (QFR)

**Cross-listings:** ECON 522 ENVI 387 ECON 387

**Secondary Cross-listing**

This course introduces the economic view of climate change, including both theory and empirical evidence. Given the substantial changes implied by the current stock of greenhouse gases (GHGs) in the atmosphere, we will begin by looking at impacts on agriculture, health, income, and migration. We will consider the distribution of climate damages across poor and wealthy people, both within and across countries. Next we will study adaptation, including capital investments and behavioral changes. We will examine the sources of climate change, especially electricity generation and transportation, and think about optimal policies. Throughout the course we will discuss the limits of the economic approach, pointing out normative questions on which economic theory provides little guidance.

**Requirements/Evaluation:** problem sets, midterm, group presentation, final exam

**Prerequisites:** ECON 251, familiarity with statistics

**Enrollment Limit:** 25

**Enrollment Preferences:** Junior/Senior Economics majors and CDE fellows

**Expected Class Size:** 25

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

**Distributions:** (D2) (QFR)

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

ECON 522 (D2) ENVI 387 (D2) ECON 387 (D2)

**Quantitative/Formal Reasoning Notes:** The course involves simple calculus-based theory and applied statistics.

**Attributes:** ENVI Environmental Policy MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses
Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces—wind, waves, storms, and people—that shape the coastal zone, as well as the geologic formations—sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs—that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change. Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

Class Format: lecture two times a week with a lab one time per week

Requirements/Evaluation: lab reports, quizzes, and an independent research project

Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.

Enrollment Limit: 12

Enrollment Preferences: senior Geosciences majors, then juniors

Expected Class Size: 10

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

Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.

Distributions: (D3) (QFR)

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

MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)

Quantitative/Formal Reasoning Notes: This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.

Attributes: ENVI Natural World Electives GEOS Group B Electives - Sediments + Life

Fall 2022

LEC Section: 01 MWF 8:30 am - 9:45 am Alex A. Apotsos

GEOS 215 (S) Climate Changes (QFR)

Cross-listings: ENVI 215 GEOS 215

Primary Cross-listing

Paleoclimatology is the reconstruction of past climate variability and the forces that drove the climate changes. The Earth's climate system is experiencing unprecedented and catastrophic change because of anthropogenic emission of greenhouse gases and land use change. Paleoclimatology allows humans to put modern climate changes into the context of the history of this planet, and shows how and why it is
unprecedented and catastrophic. Each climate event we study from Earth’s past teaches us lessons on why the climate system responds to anthropogenic perturbations, what climate changes we’re committed to in the future, how long-lasting they will be, and what climate consequences we can avoid if we take action and reduce greenhouse gas emissions sooner. In this course, we will discuss the major mechanisms that cause natural climate variability, how climate of the past is reconstructed, and how climate models are used to test mechanisms that drive climate variation. With these tools, you will analyze and interpret data and model simulations from climate events from Earth’s history, and apply these findings to anthropogenic climate changes happening now and that are projected to happen in the future. Laboratories and homework will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change. This course is in the Oceans and Climate group for the Geosciences major.

**Class Format:** This class has three scheduled lectures per week, and one lab meeting per week which will consist of field excursions, lab exercises, problem solving and discussion

**Requirements/Evaluation:** lab exercises and homework (25%), three quizzes (50%), and a final project (25%)

**Prerequisites:** 100-level course in GEOS, CHEM, or PHYS or ENVI 102 or permission of instructor

**Enrollment Limit:** 24

**Enrollment Preferences:** Geosciences majors and Environmental Studies majors and concentrators and Maritime Studies concentrators

**Expected Class Size:** 16

**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:**

ENVI 215 (D3) GEOS 215 (D3)

**Quantitative/Formal Reasoning Notes:** Labs and homework include quantitative problem solving, visualization and analysis of quantitative data, and scientific computing with Matlab. No previous programming experience is assumed.

**Attributes:** ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans MAST Interdepartmental Electives

Spring 2023

LEC Section: 01 MWF 9:00 am - 9:50 am Mea S. Cook

LAB Section: 02 W 1:00 pm - 4:00 pm Mea S. Cook

LAB Section: 03 T 1:00 pm - 4:00 pm Mea S. Cook

**GEOS 404 (F) Coastal Processes and Geomorphology** (QFR)

**Cross-listings:** MAST 404 ENVI 404 GEOS 404

**Primary Cross-listing**

Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces--wind, waves, storms, and people--that shape the coastal zone, as well as the geologic formations--sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs--that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change.

Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

**Class Format:** lecture two times a week with a lab one time per week
Requirements/Evaluation: lab reports, quizzes, and an independent research project

Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.

Enrollment Limit: 12

Enrollment Preferences: senior Geosciences majors, then juniors

Expected Class Size: 10

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

Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.

Distributions: (D3) (QFR)

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

- MAST 404 (D3)
- ENVI 404 (D3)
- GEOS 404 (D3)

Quantitative/Formal Reasoning Notes: This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.

Attributes: ENVI Natural World Electives GEOS Group B Electives - Sediments + Life

Fall 2022

LEC Section: 01 MWF 8:30 am - 9:45 am Alex A. Apotsos

GEOS 414 (S) Reading Deep Time (QFR)

Ancient sedimentary rocks and the fossils they contain are time machines - direct windows into the deep history of life on Earth and the environments that life inhabited. In this course you will learn to "read" these deep time records by collecting, interpreting, and analyzing paleontological, stratigraphic, and sedimentological data. The course will be organized around a week-long spring break trip to explore the rocks of the House Range of Utah. The Cambrian and Ordovician strata of the House Range offers an outstanding record of one of the most important periods in Earth history, tracking the rise of animal ecosystems and major increases in fossil diversity. The first 6 weeks of class will be spent learning the fundamentals of quantitative methods in paleontology and stratigraphy (often referred to as historical geology). Labs will focus on skill building including learning basic coding in R (no experience needed or expected), and learning how to interpret paleontological, sedimentological, and stratigraphic data. We will also read widely on the field locality and on the Cambrian and Ordovician Periods. During the field trip, we will explore the House Range. Students will learn skills including interpreting geological maps, measuring stratigraphic sections, finding and identifying fossils, and correlating rock units across basins. We will collect samples and data on the field trip and bring them back to Williams. The second 6 weeks of the course will be spent processing and analyzing the samples and data collected during the field trip, culminating in final projects to be done in small groups. Students will help determine what data we will collect in the field and what projects emerge. Examples might be interpreting carbon isotopic analyses to reconstruct ancient oceanographic conditions, biostratigraphic correlation using fossils to reconstruct basin dynamics, determining paleoenvironment based on analyses of thin sections, or digging into trilobite fossil preservation and evolutionary trends. Students will draw on previous experiences and course content in the Geosciences and bring small group research projects to completion by the end of the semester, which will be presented in poster form. This course fulfills the Geosciences Group B Elective: Sediments and Life.

Class Format: weekly lectures, paper discussions, and hands-on labs. Required week-long spring break field course.

Requirements/Evaluation: Short papers and lab assignments, spring break field course participation (REQUIRED), and a final group project presented in poster form.

Prerequisites: GEOS majors who have taken at least one of the following courses: GEOS 212, GEOS 203, GEOS 201, GEOS 301, GEOS 302, GEOS 312T, or permission of instructor.

Enrollment Limit: 12

Enrollment Preferences: Senior, and then Junior, Geosciences majors

Expected Class Size: 12

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

Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major

Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course will rely on the programming language R. Students will learn how to code in R, and will use R to analyze large data sets of geological data. The majority of labs, as well as the final project, will rely on R, statistical analyses, and wrangling data.

Attributes: GEOS Group B Electives - Sediments + Life

Spring 2023
SEM Section: 01  MW 11:00 am - 12:15 pm  Phoebe A. Cohen
LAB Section: 02  M 1:00 pm - 4:00 pm  Phoebe A. Cohen

MAST 404 (F) Coastal Processes and Geomorphology  (QFR)
Cross-listings: MAST 404  ENVI 404  GEOS 404
Secondary Cross-listing
Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces—wind, waves, storms, and people—that shape the coastal zone, as well as the geologic formations—sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs—that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change.

Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

Class Format: lecture two times a week with a lab one time per week
Requirements/Evaluation: lab reports, quizzes, and an independent research project
Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.
Enrollment Limit: 12
Enrollment Preferences: senior Geosciences majors, then juniors
Expected Class Size: 10
Grading: yes pass/fail option, yes fifth course option
Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.
Distributions: (D3)  (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)

Quantitative/Formal Reasoning Notes: This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.
Attributes: ENVI Natural World Electives  GEOS Group B Electives - Sediments + Life

Fall 2022
LEC Section: 01  MWF 8:30 am - 9:45 am  Alex A. Apotsos
MATH 130  (F)(S)  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: 50
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 2022
LEC Section: 01  MWF 11:00 am - 11:50 am  Lori A. Pedersen
LEC Section: 02  MWF 12:00 pm - 12:50 pm  Lori A. Pedersen

Spring 2023
LEC Section: 01  MWF 10:00 am - 10:50 am  Lori A. Pedersen

MATH 140  (F)(S)  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)
Quantative/Formal Reasoning Notes: This is a math class

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Bhagya Athukorallage
LEC Section: 02  MWF 10:00 am - 10:50 am  Bhagya Athukorallage

Spring 2023
LEC Section: 01  MWF 11:00 am - 11:50 am  Lori A. Pedersen

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)

Quantative/Formal Reasoning Notes: mathematics

Fall 2022
LEC Section: 01  MWF 10:00 am - 10:50 am  Colin C. Adams
LEC Section: 02  MWF 11:00 am - 11:50 am  Colin C. Adams
LEC Section: 03  MWF 12:00 pm - 12:50 pm  Colin C. Adams

Spring 2023
LEC Section: 01  MWF 9:00 am - 9:50 am  Steven J. Miller

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.

Requirements/Evaluation: problem sets and exams

Prerequisites: AP BC 3 or higher or integral calculus with infinite series

Enrollment Limit: 50

Enrollment Preferences: First-years, sophomores, and juniors

Expected Class Size: 40

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

Unit Notes: MATH 151 satisfies any MATH 150 prerequisite; credit will not be given for both MATH 150 and MATH 151

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course builds quantitative skills

Fall 2022
LEC Section: 01  MWF 8:00 am - 8:50 am  Susan R. Loepp
LEC Section: 02  MWF 9:00 am - 9:50 am  Susan R. Loepp
LEC Section: 03  MWF 10:00 am - 10:50 am  Susan R. Loepp

MATH 200 (F)(S) Discrete Mathematics (QFR)
In contrast to calculus, which is the study of continuous processes, this course examines the structure and properties of finite sets. Topics to be covered include mathematical logic, elementary number theory, mathematical induction, set theory, functions, relations, elementary combinatorics and probability, and graphs. Emphasis will be given on the methods and styles of mathematical proofs, in order to prepare the students for more advanced math courses.

**Requirements/Evaluation:** Fall: Homework, proof portfolio, group work, presentations, quizzes/exams, reflections. Spring: The grade will be based on homework and 4 exams.

**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)

**Quantative/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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**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. An optional session 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 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)

**Quantative/Formal Reasoning Notes:** This course will have weekly problem sets using advanced calculus methods

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Spring 2023

LEC Section: 01    TR 9:55 am - 11:10 am     Daniel P. Aalberts
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:  60
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

Fall 2022
LEC Section: 01    TR 8:30 am - 9:45 am     Thomas A. Garrity
LEC Section: 02    TR 9:55 am - 11:10 am     Thomas A. Garrity

Spring 2023
LEC Section: 01    MWF 10:00 am - 10:50 am     Jenna Zomback
LEC Section: 02    MWF 11:00 am - 11:50 am     Jenna Zomback

MATH 307  (F)(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:  24
Enrollment Preferences:  Preference given to majors and prospective majors.
Expected Class Size:  24
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.

Fall 2022
MATH 308  (F)(S) Mathematical and Computational Approaches to Social Justice  (DPE) (QFR)

Cross-listings: STS 363  WGSS 363  AMST 363  MATH 308

Primary Cross-listing

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 group will carry out a substantial project in an area such as criminal justice, education equity, environmental justice, health care equity, economic justice, or 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.

Class Format: This is a research-based tutorial.

Requirements/Evaluation: To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows an "ungrading" methodology.

Prerequisites: Across each 3 - 5 person tutorial group: 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: 20

Enrollment Preferences: Students will be admitted in groups of 3 - 5 based on a proposal submitted prior to registration. The instructor is happy to facilitate formation of groups and to give feedback on draft proposals. Contact the instructor early, prior to preregistration.

Expected Class Size: 20

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

Distributions: (D3)  (DPE)  (QFR)

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

STS 363 (D2)  WGSS 363 (D2)  AMST 363 (D2)  MATH 308 (D3)

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.

Fall 2022
TUT Section: T1  TBA  Chad M. Topaz

Spring 2023
TUT Section: T1  TBA  Chad M. Topaz

MATH 309  (F)(S) Differential Equations  (QFR)

Ordinary differential equations (ODEs) frequently arise as models of phenomena in the natural and social sciences. This course presents core ideas of ODEs from an applied standpoint. Topics covered early in the course may include numerical solutions, separation of variables, integrating factors, and constant coefficient linear equations. 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 information about the behavior of the ODEs without explicitly knowing the solution.

Requirements/Evaluation: quizzes/exams, problem sets, participation

Prerequisites: MATH 150/151 and MATH 250

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)
MATH 311  (F)  Advanced topics in applied mathematics  (QFR)
Applied mathematics is an expansive field that uses mathematical methods to explore problems that arise in biology, physics, engineering, and many other disciplines. In this course, we will explore a diversity of methods that may include stochastic processes, optimization, signal processing, and numerical analysis. We will also explore how these methods can be utilized to understand questions in other disciplines.

Requirements/Evaluation:  This course will have some combination of problem sets, presentations, exams, and a final project
Prerequisites:  Differential equations (Math 309) or permission of the instructor

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.

Requirements/Evaluation:  Problem sets and exams
Prerequisites:  MATH 250 or permission of instructor

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, or permission of the instructor.

**Requirements/Evaluation:** homework, exams, projects

**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)

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

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**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:** The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

**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, no fifth course option

**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)

**Quantitative/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
MATH 329  (S) Discrete Geometry  (QFR)
Discrete geometry is one of the oldest and most consistently vibrant areas of mathematics, stretching from the Platonic Solids of the ancient Greeks to the modern day applications of convex optimization and linear programming. In this tutorial 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: Evaluation will be based primarily on participation, problem sets, oral presentations, a written midterm exam, an oral final exam, and a final project
Prerequisites: MATH 200 or Math 250, or permission of instructor
Enrollment Limit: 10
Enrollment Preferences: First-years and sophomores
Expected Class Size: 10
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.

Spring 2023
TUT Section: T1  TBA  Ralph E. Morrison

MATH 334  (F) 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, exams, and a short final project
Prerequisites: MATH 200 or MATH 250
Enrollment Limit: 30
Enrollment Preferences: Math majors
Expected Class Size: 25
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This course involves the writing of mathematical proofs.

Fall 2022
LEC Section: 01  MWF 11:00 am - 11:50 am  Ralph E. Morrison

MATH 338  (S) Intermediate Logic  (QFR)
Cross-listings: PHIL 338  MATH 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: (D3) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
PHIL 338 (D2) MATH 338 (D3)
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: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2023
SEM Section: 01 Cancelled

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

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

Spring 2023
LEC Section: 01 TF 2:35 pm - 3:50 pm Mihai Stoiciu
MATH 342  (F) Logic  (QFR)
This course will introduce the main ideas and basic results of mathematical logic, and explain their applications to other areas of mathematics and computer science. We will begin with a study of first-order logic, covering structures and definability, theories, models and categoricity, as well as formal proofs. We will prove Gödel's completeness and compactness theorems and the Lowenheim-Skolem theorems. The course will briefly dive into computability theory, enough to prove Gödel's Incompleteness theorems and basic undecidability results.

Requirements/Evaluation: Evaluation based on homework, exams, and class participation.
Prerequisites: Math 250 - Linear Algebra
Enrollment Limit: 20
Enrollment Preferences: Junior and Senior Math Majors
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: Mathematics course in logic and applications.

Fall 2022
LEC Section: 01    MWF 9:00 am - 9:50 am     Jenna  Zomback

MATH 344  (S) The Mathematics of Sports  (QFR)
The purpose of this class is to use sports as a springboard to study applications of mathematics, especially in gathering data to build and test models and develop predictive statistics. Examples will be drawn from baseball, basketball, cross country, football, hockey, soccer, track, as well as class choices. Pre-requisites are linear algebra (Math 250) and either a 200 level statistics class or a 100 level programming class, or permission of the instructor.

Requirements/Evaluation: Homework, exams, projects
Prerequisites: Math 250: Linear Algebra
Enrollment Limit: 40
Enrollment Preferences: None. If the course is over-enrolled preference will be given to math and stats majors, and then if needed by performance on a small assignment.
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is a 300 level mathematics course.

Spring 2023
LEC Section: 01    MWF 10:00 am - 10:50 am     Steven J. Miller

MATH 345  (S) Introduction to Numerical Analysis  (QFR)
Numerical analysis is the study of algorithms that use numerical approximation to solve problems which arise in scientific applications. This course provides an introduction to the theory, development, and analysis of algorithms for obtaining numerical solutions. Topics discussed in the course include: Error Analysis and Convergence Rates of Algorithms; Root Finding for Nonlinear Equations; Approximating Functions using Lagrange Interpolation and Cubic Spline Approximation; Numerical Differentiation and Integration; Numerical Solution of Ordinary Differential Equations; Iterative Methods for Solving Linear Systems

Requirements/Evaluation: Evaluation will be based on homework, projects, and exams.
Prerequisites: Math 250
Enrollment Limit: 30
Enrollment Preferences: Mathematics and Statistics majors.
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is an advanced mathematics class that will cover the fundamental ideas of Numerical Analysis. The students will study in depths various algorithms that provide numerical solutions to various questions in science.

Spring 2023
LEC Section: 01 TR 8:30 am - 9:45 am Bhagya Athukorallage

MATH 350 (F)(S) 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 do we mean when we say that? Perhaps most fundamentally, what is a real number? Real analysis addresses such questions, delving into the structure of real numbers and functions of them. Along the way we'll discuss sequences and limits, series, completeness, compactness, derivatives and integrals, and metric spaces. Results covered will include the Cantor-Schroeder-Bernstein theorem, the monotone convergence theorem, the Bolzano-Weierstrass theorem, the Cauchy criterion, Dirichlet's and Riemann's rearrangement theorem, the Heine-Borel theorem, the intermediate value theorem, and many others. This course is excellent preparation for graduate studies in mathematics, statistics, and economics.

Requirements/Evaluation: Problem sets, exams, and an expository essay.

Prerequisites: MATH 250 or permission of instructor.

Enrollment Limit: 40

Enrollment Preferences: Juniors and Seniors.

Expected Class Size: 25

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: It's math.

Fall 2022
LEC Section: 01 MR 2:35 pm - 3:50 pm Leo Goldmakher

Spring 2023
LEC Section: 01 MR 2:35 pm - 3:50 pm Leo Goldmakher

MATH 351 (S) Applied Real Analysis (QFR)

Real analysis or the theory of calculus (derivatives, integrals, continuity, convergence) starts with a deeper understanding of real numbers and limits. Applications in the calculus of variations or “infinite-dimensional calculus” include geodesics, harmonic functions, minimal surfaces, Hamilton's action and Lagrange's equations, optimal economic strategies, nonEuclidean geometry, and general relativity.

Requirements/Evaluation: homework, classwork, and exams

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

Enrollment Limit: 30

Enrollment Preferences: Seniors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: Math

Spring 2023
LEC Section: 01 MR 2:35 pm - 3:50 pm Mihai Stoiciu

LEC Section: 02 TR 11:20 am - 12:35 pm Mihai Stoiciu
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
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Students who have officially declared a major that requires Math 355.
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: 300-level math course

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Ralph E. Morrison

Spring 2023
LEC Section: 01  MWF 11:00 am - 11:50 am  Thomas A. Garrity
LEC Section: 02  MWF 12:00 pm - 12:50 pm  Thomas A. Garrity

MATH 361  (F)  Theory of Computation  (QFR)

Cross-listings: MATH 361  CSCI 361

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: 48(12/con)
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 48
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

Fall 2022
LEC Section: 01  ASYN  Aaron M. Williams
MATH 374  (F) 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 plays an important role in math, physics, and data analysis. This course is excellent preparation for graduate programs in mathematics.

Requirements/Evaluation: Problem sets, exams, an expository essay.
Prerequisites: MATH 350 or 351; not open to students who have taken MATH 323. If you didn't cover metric spaces in real analysis, that's OK!
Enrollment Limit: 30
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.

Fall 2022
LEC Section: 01  TR 9:55 am - 11:10 am  Leo Goldmakher

MATH 393  (S) Research Topics in Combinatorics  (WS) (QFR)

Combinatorics provides techniques and tools to enumerate, examine, and investigate the existence of discrete mathematical structures with certain properties. There are numerous areas of applications including algebra, discrete geometry, and number theory. In this project-based research course students will work in small groups to learn combinatorial techniques and tools in order to develop research questions and begin tackling unsolved problems in combinatorics.

Requirements/Evaluation: Students will be evaluated through written drafts of a manuscript and its revisions and multiple in-class presentation.
Prerequisites: Math 355
Enrollment Limit: 19
Enrollment Preferences: Post-core mathematics majors
Expected Class Size: 19
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS) (QFR)

Writing Skills Notes: The main goal of this course is to undertake original research in combinatorics, as such student assessment is based on developing positive collaboration skills, and improving technical written and oral skills in mathematics through manuscript draft submissions and in-class presentations. Students will provide multiple drafts of their manuscript and in right of this the course will be writing intensive.
Quantative/Formal Reasoning Notes: The main goal of this course is to undertake original research in the math field of mathematics. See above for more details.

Spring 2023
SEM Section: 01  Cancelled

MATH 409  (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, exams, presentations.
Prerequisites: Real Analysis (either Math 350 or 351) and Abstract Algebra (Math 355), or permission of the instructor.
Enrollment Limit: 30
Enrollment Preferences: Math/stat senior 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 class.

Fall 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Steven J. Miller

**MATH 412 (S) Mathematical Biology** (QFR)

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 may include, but are not limited to, single and multi-species population dynamics, neural and biological oscillators, tumor cell growth, and infectious disease dynamics.

Requirements/Evaluation: problem sets, quizzes/exams, participation, final project and paper
Prerequisites: MATH 250 and MATH 309, or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: preference for senior math/stats major and also based on an interest statement
Expected Class Size: 30
Grading: yes pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: The course will introduce methods for developing and analyzing mathematical models.
Attributes: PHLH Methods in Public Health

Spring 2023
LEC Section: 01 TR 11:20 am - 12:35 pm Julie C. Blackwood

**MATH 413 (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: Evaluation will be based on weekly problem sets, three exams, and final project. Any students who have taken Math 411 should consult with the instructor before enrolling in this course.
Prerequisites: Math 355
Enrollment Limit: 30
Enrollment Preferences: Preference given to senior math majors
MATH 427  (S)  Tiling Theory  (QFR)
Since people 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, types of tilings, random tilings, the classification of tilings and aperiodic tilings. We will also look at tilings of the sphere, tilings of the hyperbolic plane, and tilings in 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: 25
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)  (QFR)
Quantative/Formal Reasoning Notes: Mathematics course

Spring 2023
LEC Section: 01    TR 9:55 am - 11:10 am     Ralph E. Morrison

MATH 442  (F)  Introduction to Descriptive Set Theory  (QFR)
Descriptive set theory (DST) combines techniques from analysis, topology, set theory, combinatorics, and other areas of mathematics to study definable (typically Borel) subsets of Polish spaces. The first part of this course will cover the topics necessary to understand the main objects of study in DST: we will develop comfort with point-set topology (enough to juggle with Polish spaces and Borel sets), and set theory (just well-orderings and cardinality). The second part of the course will feature selected topics in descriptive set theory: for example, trees, the perfect set property, Baire category, and infinite games.

Requirements/Evaluation: Evaluation based on homework, exams, and classroom participation.
Prerequisites: Math 250 - Linear Algebra, Math 350/351 Real Analysis/Applied Real Analysis
Enrollment Limit: 14
Enrollment Preferences: Senior Math Majors, then non-Senior Math Majors
Expected Class Size: 14
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)  (QFR)
Quantative/Formal Reasoning Notes: Mathematics course in descriptive set theory.

Fall 2022
LEC Section: 01    MWF 11:00 am - 11:50 am     Jenna  Zomback

MATH 453  (S)  Partial Differential Equations  (QFR)
In this course, we further explore the world of differential equations. Mainly, we cover topics in partial differential equations. Partial Differential Equations (PDEs) are fundamental to the modeling of many natural phenomena, arising in many fields, including fluid mechanics, heat and mass transfer, electromagnetic theory, finance, elasticity, and more. The goals of this course are to discuss the following topics: classification of PDEs in terms of order, linearity and homogeneity; physical interpretation of canonical PDEs; solution techniques, including separation of variables, series solutions, integral transforms, and the method of characteristics.

Requirements/Evaluation: Evaluation will be based on homework, projects, and exams.

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

Enrollment Limit: 20

Enrollment Preferences: Mathematics and Physics majors.

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This is an advanced mathematics class dedicated to the study of partial differential equations (PDEs). These equations are the most important mathematical tools for the study of complex physical phenomena such as waves and fluids (including both air and water), heat transfer, electromagnetism, and finance.

Spring 2023
LEC Section: 01 TR 11:20 am - 12:35 pm Bhagya Athukorallage

MATH 481 (S) 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, etc.—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 excellent preparation for graduate studies in mathematics, statistics and economics.

Requirements/Evaluation: Problem sets, exams, an expository essay

Prerequisites: At least one previous course that has Math 350 or 351 as a prerequisite (eg Math 374, 383, 401, 404, 408, 420, 426, 485), or permission of instructor.

Enrollment Limit: 20

Enrollment Preferences: Juniors and seniors.

Expected Class Size: 10

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: It's math.

Spring 2023
LEC Section: 01 TF 2:35 pm - 3:50 pm Leo Goldmakher

PHIL 221 (F) Introduction to Formal Linguistics (QFR)

Cross-listings: COGS 224 PHIL 221

Secondary Cross-listing

The sentence "Every cookie is chocolate chip and three of them are oatmeal raisin" is a perfectly grammatical sentence of English, but it's self-contradictory. What does it take to realize this fact? One must grasp the meanings of the various parts of the sentence. In particular, one must
grasp that "three of them" picks out a subset of the group picked out by "every cookie", and that there's no such thing as a cookie that is both chocolate chip and oatmeal raisin. There two ways to understand "Many students took every class". According to one, there is a single group of students that had their hands extremely full this semester. According to the other, every class was well-populated, potentially by different groups. The reason for this is that there are two underlying structures that the original sentence can realize. This course serves as an introduction to formal methods in the scientific study of language. Our goal will be to characterize phenomena like those above with logical and mathematical precision. The focus will be on model-theoretic semantics, the sub-field of linguistics that studies meanings. Along the way we will discuss principles of syntax, the sub-field that studies sentence structures, and pragmatics, the sub-field that studies inferences of non-literal content. This is a formal course, but no prior logical or mathematical background will be expected. Starting from scratch, students will learn the building blocks of current-day linguistic research. This introduction will be of use to students interested in language from a variety of perspectives, including philosophy, cognitive science, and computer science.

Requirements/Evaluation: Weekly problem sets, plus a final project (paper/presentation/other type, to be discussed with instructor)
Prerequisites: No prerequisites
Enrollment Limit: 20
Enrollment Preferences: Preference given to seniors and philosophy/cognitive science majors.
Expected Class Size: 20
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:
COGS 224 (D2) PHIL 221 (D2)

Quantative/Formal Reasoning Notes: This course teaches the fundamentals of the formal analysis of language. Students will learn to provide translation schemes from English to a logical language (typed lambda calculus).
Attributes: COGS Interdepartmental Electives COGS Related Courses Linguistics PHIL Contemp Metaphysics + Epistemology Courses

Fall 2022
SEM Section: 01 TF 1:10 pm - 2:25 pm Christian De Leon

PHIL 338 (S) Intermediate Logic (QFR)
Cross-listings: PHIL 338 MATH 338
Primary 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:
PHIL 338 (D2) MATH 338 (D3)

Quantitative/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: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2023

SEM Section: 01 Cancelled

PHYS 109 (S) Sound, Light, and Perception (QFR)

Light and sound allow us to perceive the world around us, from appreciating music and art to learning the details of atomic structure. Because of their importance in human experience, light and sound have long been the subject of scientific inquiry. How are sound and light related? How do physiology and neural processing allow us to hear and see the world around us? What are the origins of color and musical pitch? This course introduces the science and technology of light and sound to students not majoring in physics. We will start with the origins of sound and light as wave phenomena, and go on to topics including color, the optics of vision, the meaning of musical pitch and tone, and the physical basis of hearing. We will also discuss some recent technological applications of light, such as lasers and optical communications. The class will meet for two 75-minute periods each week for a variable mixture of lecture, discussion, and hands-on, interactive experiments.

Class Format: each student will attend one lecture plus one conference section weekly

Requirements/Evaluation: class participation, problem sets, in-class exams, oral presentations, and a final exam, all with a quantitative component

Prerequisites: none

Enrollment Limit: 20

Enrollment Preferences: non-science majors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This class will have weekly problem sets requiring substantial quantitative reasoning

Spring 2023

LEC Section: 01 Cancelled

PHYS 131 (F) Introduction to Mechanics (QFR)

We focus first on the Newtonian mechanics of point particles: the relationship between velocity, acceleration, and position; the puzzle of circular motion; forces, Newton's laws, and gravitation; energy and momentum; and the physics of vibrations. Then we turn to the basic properties of waves, such as interference and refraction, as exemplified by sound and light waves. We also study the optics of lenses, mirrors and the human eye. This course is not intended for students who have successfully completed an AP physics course in high school.

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

Prerequisites: MATH 130; students who scored 4 or 5 on an AP physics exam, or 6 or 7 on the IB Physics HL exam may not take this course and are encouraged to take PHYS 141 instead

Enrollment Limit: 30

Enrollment Preferences: seniority

Expected Class Size: 60

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

Unit Notes: PHYS 131 can lead to either PHYS 132 (for students wanting a one-year survey of physics) or PHYS 142 (for students considering a Physics or Astrophysics major)

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This class will have weekly problem sets requiring substantial quantitative reasoning
PHYS 132 (S) Electromagnetism and the Physics of Matter (QFR)
This course is intended as the second half of a one-year survey of physics with some emphasis on applications to medicine. In the first part of the semester we will focus on electromagnetic phenomena. We will introduce the concept of electric and magnetic fields and study in detail the way in which electrical circuits and circuit elements work. The deep connection between electric and magnetic phenomena is highlighted with a discussion of Faraday's Law of Induction. Following our introduction to electromagnetism we will discuss some of the most central topics in twentieth-century physics, including Einstein's theory of special relativity and some aspects of quantum theory. We will end with a treatment of nuclear physics, radioactivity, and uses of radiation.

Class Format: lecture three hours per week, laboratory three hours approximately every other week, and conference section 1 hour approximately every other week

Requirements/Evaluation: weekly problem sets, labs, quizzes and exams

Prerequisites: PHYS 131 or 141 or permission of instructor, and MATH 130 (formerly 103)

Enrollment Limit: 22 per lab

Enrollment Preferences: sophomores

Expected Class Size: 60

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: Significant homework, exams, quizzes requiring mathematical and physical reasoning.

Spring 2023

PHYS 141 (F) Mechanics and Waves (QFR)
This is the typical first course for a prospective physics major. It covers most of the same topics as PHYS 131, but with a higher level of mathematical sophistication. It is intended for students with solid backgrounds in the sciences, either from high school or college, who are comfortable with basic calculus.

Class Format: lecture, three hours per week; laboratory, three hours approximately every other week; conference section, one hour approximately every other week

Requirements/Evaluation: weekly problem sets, labs, three or more short quizzes/tests, and a final exam, all of which have a substantial quantitative component

Prerequisites: high school physics and MATH 130 or equivalent placement, or permission of the instructor

Enrollment Limit: 30

Enrollment Preferences: first-year students and science majors

Expected Class Size: 30

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

Unit Notes: PHYS 141 can lead to either PHYS 132 (for students wanting a one-year survey of physics) or PHYS 142 (for students considering a Physics or Astrophysics major)

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course consists of lectures, problem-solving conferences, lab exercises, problem sets and exams, all of
which have a substantial quantitative component.

Fall 2022
LEC Section: 01  MWF 11:00 am - 11:50 am  Katharine E. Jensen
LAB Section: 02  M 1:00 pm - 4:00 pm  Katharine E. Jensen
LAB Section: 03  T 1:00 pm - 4:00 pm  Katharine E. Jensen

PHYS 142  (S) Foundations of Modern Physics  (QFR)
Newtonian Mechanics, spectacular as it is in describing planetary motion and a wide range of other phenomena, only hints at the richness of behaviors seen in the universe. Special relativity, which extends physics into the realm of high speeds and high energies, requires us to rethink our basic notions of space and time. Quantum mechanics successfully describes atoms, molecules, and solids while at the same time calling into question our expectation of what can be predicted by a physical theory. Statistical physics reveals new behaviors that emerge when many particles are present in a system.
This course will survey ideas from each of these three arenas, and can serve either as a terminal course for those seeking to complete a year of physics or as the basis for future advanced study of these topics.
Class Format: lecture, three hours weekly; laboratory, 2-3 hours most weeks, alternating between 'hands-on' sessions and problem-solving/discussion sessions
Requirements/Evaluation: weekly homework, labs, two hour tests, and a final exam, all of which have a substantial quantitative component
Prerequisites: PHYS 141 and MATH 130, or equivalent; PHYS 131 may substitute for PHYS 141 with the permission of instructor; students may not take both PHYS 142 and PHYS 151
Enrollment Limit: 14/L
Enrollment Preferences: first-year students
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3)  (QFR)
Quantitative/Formal Reasoning Notes: Heavily problem-solving focused, involving algebraic manipulations, single-variable calculus, generating and reading graphs, etc.

Spring 2023
LEC Section: 01  MWF 11:00 am - 11:50 am  Protik K. Majumder
LAB Section: 02  M 1:00 pm - 4:00 pm  Jennifer G. Winters
LAB Section: 03  T 1:00 pm - 4:00 pm  Jennifer G. Winters

PHYS 151  (F) Seminar in Modern Physics  (QFR)
Newtonian Mechanics, spectacular as it is in describing planetary motion and a wide range of other phenomena, only hints at the richness of behaviors seen in the universe. Special relativity has extended physics into the realm of high speeds and high energies and requires us to rethink our basic notions of space and time. Quantum mechanics successfully describes atoms, molecules, and solids while at the same time calling into question our notions of what can be predicted by a physical theory. Statistical physics reveals new behaviors that emerge when many particles are present in a system. This course covers the same core material as PHYS 142 but in a small seminar format for students with strong prior preparation in physics.
Class Format: three 50-minute lecture/discussions per week, one 3-hour lab per week
Requirements/Evaluation: class participation, weekly lab assignments, weekly problem sets, exams
Prerequisites: placement by the department (see "advanced placement" section in the description about the department). Students may take either PHYS 142 or PHYS 151 but not both
Enrollment Limit: 18
Enrollment Preferences: first-years
Expected Class Size: 18
Grading: yes pass/fail option, yes fifth course option
Unit Notes: this is a small seminar designed for first-year students who have placed out of PHYS 141

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: all assignments in the course have a substantial quantitative component

Fall 2022
LEC Section: 01    WF 11:00 am - 11:50 am    Jennifer G. Winters
LAB Section: 02    W 1:00 pm - 4:00 pm     Jennifer G. Winters
CON Section: 03    M 11:00 am - 11:50 am    Jennifer G. Winters

PHYS 201  (F) Electricity and Magnetism  (QFR)
The classical theory of electricity and magnetism is very rich yet it can be written in a remarkably succinct form using Maxwell's equations. This course is an introduction to electricity and magnetism and their mathematical description, connecting electric and magnetic phenomena via the special theory of relativity. Topics include electrostatics, magnetic fields, electromagnetic induction, DC and AC circuits, and the electromagnetic properties of matter. The laboratory component of the course is an introduction to electronics where students will develop skills in building and debugging electrical circuits.

Class Format: lecture, three hours per week; laboratory, three hours per week
Requirements/Evaluation: problem sets, labs/conference section assignments, two take-home midterms, and a final exam, all of which have a substantial quantitative component
Prerequisites: PHYS 142 OR 151; MATH 150 or 151; with a preference for MATH 151
Enrollment Limit: 10 per lab
Enrollment Preferences: prospective physics majors, then by seniority
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course involves significant problem-solving and mathematical analysis of phenomena using calculus, numerical methods, and other quantitative tools.

Fall 2022
LEC Section: 01    MWF 10:00 am - 10:50 am    Catherine Kealhofer
LAB Section: 02    T 1:00 pm - 4:00 pm     Catherine Kealhofer
LAB Section: 03    W 1:00 pm - 4:00 pm     Catherine Kealhofer

PHYS 202  (S) Vibrations, Waves and Optics  (QFR)
Waves and oscillations characterize many different physical systems, including vibrating strings, springs, water waves, sound waves, electromagnetic waves, and gravitational waves. Quantum mechanics even describes particles with wave functions. Despite these diverse settings waves exhibit several common characteristics, so that the understanding of a few simple systems can provide insight into a wide array of phenomena. In this course we begin with the study of oscillations of simple systems with only a few degrees of freedom. We then move on to study transverse and longitudinal waves in continuous media in order to gain a general description of wave behavior. The rest of the course focuses on electromagnetic waves and in particular on optical examples of wave phenomena. In addition to well known optical effects such as interference and diffraction, we will study a number of modern applications of optics such as short pulse lasers and optical communications. Throughout the course mathematical methods useful for higher-level physics will be introduced.

Class Format: lecture, three hours per week; laboratory, three hours per week
Requirements/Evaluation: problem sets, labs, midterm examinations, and a final exam, all of which have a substantial quantitative component
Prerequisites: PHYS 201; co-requisite: PHYS/MATH 210 or MATH 209 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: sophomores
### PHYS 210  (S) Mathematical Methods for Scientists  (QFR)

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

**Primary 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. An optional session 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 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

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### PHYS 301  (F) Quantum Physics  (QFR)

This course serves as a one-semester introduction to the formalism, and phenomenology of quantum mechanics. After a brief discussion of historical origins of the quantum theory, we introduce the Schrodinger wave equation, the concept of matter waves, and wave-packets. With this introduction as background, we will continue our discussion with a variety of one-dimensional problems such as the particle-in-a-box and the harmonic oscillator. We then extend this work to systems in two and three dimensions, including a detailed discussion of the structure of the hydrogen atom. Along the way we will develop connections between mathematical formalism and physical predictions of the theory. Finally, we conclude the course with a discussion of angular momentum and spins, with applications to atomic physics, entanglement, and quantum information.

**Class Format:** lecture, three hours per week; laboratory, three hours per week

**Requirements/Evaluation:** weekly problem sets, laboratory reports / write-ups, a midterm exam, and final exam, all of which have a substantial quantitative component

**Prerequisites:** PHYS 202 and PHYS/MATH 210 or MATH 309

**Enrollment Limit:** 20
Enrollment Preferences: physics majors

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: Phys 301 relies heavily upon mathematics and quantitative reasoning in all elements, including problem sets, examinations, and laboratories.

Fall 2022

LEC Section: 01  MWF 9:00 am - 9:50 am  Protik K. Majumder
LAB Section: 02  T 1:00 pm - 4:00 pm  John H. Lacy
LAB Section: 03  W 1:00 pm - 4:00 pm  John H. Lacy
LAB Section: 04  M 1:00 pm - 4:00 pm  John H. Lacy

PHYS 302  (S)  Statistical Mechanics & Thermodynamics  (QFR)

Macroscopic objects are made up of huge numbers of fundamental particles interacting in simple ways—obeying the Schrödinger equation, Newton's and Coulomb's Laws—and these objects can be described by macroscopic properties like temperature, pressure, magnetization, heat capacity, conductivity, etc. In this course we will develop the tools of statistical physics, which will allow us to predict the cooperative phenomena that emerge in large ensembles of interacting particles. We will apply those tools to a wide variety of physical questions, including the behavior of gases, polymers, heat engines, biological and astrophysical systems, magnets, and electrons in solids.

Class Format: lecture/discussion three hours per week and weekly laboratory work

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

Prerequisites: required: PHYS 201, PHYS/MATH 210 or MATH 309; recommended: PHYS 202, PHYS 301

Enrollment Limit: 10 per lab

Enrollment Preferences: physics majors

Expected Class Size: 10 per lab

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: weekly problem sets, exams, and labs, all of which have a substantial quantitative component

Spring 2023

LEC Section: 01  MWF 10:00 am - 10:50 am  Katharine E. Jensen
LAB Section: 02  T 1:00 pm - 4:00 pm  Katharine E. Jensen
LAB Section: 03  W 1:00 pm - 4:00 pm  Katharine E. Jensen

PHYS 315  (S)  Computational Biology  (QFR)

This course will provide an overview of Computational Biology, the application of computational, mathematical, statistical, and physical problem-solving techniques to interpret the rapidly expanding amount of biological data. Topics covered will include database searching, DNA sequence alignment, clustering, RNA structure prediction, protein structural alignment, methods of analyzing gene expression, networks, and genome assembly using techniques such as string matching, dynamic programming, hidden Markov models, and statistics.

Requirements/Evaluation: weekly Python programming assignments, code reviews, problem sets, plus a few quizzes and a final project

Prerequisites: programming experience (e.g., CSCI 136), mathematics (PHYS/MATH 210 or MATH 150), and physical science (PHYS 142 or 151, or CHEM 151 or 153 or 155), or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: courage

Expected Class Size: 8

Grading: no pass/fail option, no fifth course option
PHYS 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: The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

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, no fifth course option

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

PHYS 402 (S) Applications of Quantum Mechanics (QFR)

This course will explore a number of important topics in the application of quantum mechanics to physical systems, including perturbation theory, the variational principle and the semiclassical interaction of atoms and radiation. The course will finish up with three weeks on quantum optics including an experimental project on non-classical interference phenomena. Applications and examples will be taken mostly from atomic physics with some discussion of solid state systems.
**Requirements/Evaluation:** weekly problem sets, tutorial participation, presentations, and a final exam, all of which have a substantial quantitative component

**Prerequisites:** PHYS 301

**Enrollment Limit:** 10 per sec

**Enrollment Preferences:** Physics and Astrophysics Majors

**Expected Class Size:** 16

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

**Distributions:** (QFR)

**Quantitative/Formal Reasoning Notes:** This course has weekly problem sets, all of which have a substantial quantitative component.

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Spring 2023

TUT Section: T1  F 1:10 pm - 2:25 pm  David R. Tucker-Smith

**PHYS 411 (F) Classical Mechanics** (QFR)

This course will explore advanced topics in classical mechanics. Central ideas include the calculus of variations, the Lagrangian and Hamiltonian formulations of mechanics, phase space, central-force motion, non-inertial reference frames (including implications for physics on a rotating Earth), rigid-body rotations, and non-linear dynamics & chaos, with additional topics from continuum and fluid mechanics as time permits. Numerical and perturbative techniques will be developed and used extensively. We will also examine the ways in which classical mechanics informs other fields of physics. In addition to weekly tutorial meetings the class will meet weekly as a whole to introduce and discuss new material.

**Requirements/Evaluation:** weekly problem sets, tutorial participation, presentations, a final project, and a final exam, all of which have a substantial quantitative component

**Prerequisites:** PHYS 202 and PHYS/MATH 210 or MATH 309

**Enrollment Limit:** 10/section

**Enrollment Preferences:** majors

**Expected Class Size:** 20

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

**Distributions:** (Q3) (QFR)

**Quantitative/Formal Reasoning Notes:** weekly problem sets requiring substantial quantitative reasoning using analytical and numerical methods.

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Fall 2022

TUT Section: T1  F 1:10 pm - 2:25 pm  Charlie Doret, Daniel P. Aalberts

**POEC 253 (F) Empirical Methods in Political Economy** (QFR)

This course introduces students to common empirical tools used in policy analysis and implementation. The broad aim is to train students to be discriminating consumers of public policy-relevant research. The emphasis in the course is on intuitive understanding of the central concepts. Through hands-on work with data and critical assessment of existing empirical social scientific research, students will develop the ability to choose and employ the appropriate tool for a particular research problem, and to understand the limitations of the techniques. Topics to be covered include basic principles of probability; random variables and distributions; statistical estimation, inference and hypothesis testing; and modeling using multiple regression, with a particular focus on understanding whether and how relationships between variables can be determined to be causal—an essential requirement for effective policy formation. Throughout the course, the focus will be on public policy applications relevant to the fields of political science, sociology, and public health, as well as to economics.

**Requirements/Evaluation:** Problem sets, group project, midterm exam, final exam

**Prerequisites:** MATH 130 or its equivalent; one course in ECON; not open to students who have taken ECON 255

**Enrollment Limit:** 20

**Enrollment Preferences:** Political Economy majors, Environmental Policy majors and sophomores

**Expected Class Size:** 15
Grading: yes pass/fail option, yes fifth course option

Unit Notes: does not satisfy the econometrics requirement for the Economics major; POEC 253 cannot be substituted for ECON 255, or count as an elective towards the Economics major

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: The course teaches econometrics, i.e. statistics as economists use it, with applications in economics, political science, and other fields.

Attributes: PHLH Statistics Courses POEC Required Courses

Fall 2022
LEC Section: 01  TF 2:35 pm - 3:50 pm  Anand V. Swamy

PSYC 201 (F)(S) Experimentation and Statistics (QFR)
An introduction to the basic principles of research in psychology. We focus on how to design and execute experiments, analyze and interpret results, and write research reports. Students conduct a series of research studies in different areas of psychology that illustrate basic designs and methods of analysis. You must register for lab and lecture with the same instructor.

Requirements/Evaluation: research reports, exams, and problem sets

Prerequisites: PSYC 101; not open to first-year students except with permission of instructor

Enrollment Limit: 16

Enrollment Preferences: Psychology majors

Expected Class Size: 16

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course has problem sets focused on experimental design and quantitative data analysis. Students will help design and conduct experiments, analyze the data, and report their findings.

Attributes: COGS Related Courses PHLH Statistics Courses

Fall 2022
LEC Section: A1  TR 11:20 am - 12:35 pm  Amie A. Hane
LAB Section: A2  R 1:00 pm - 4:00 pm  Amie A. Hane
LEC Section: B3  MR 1:10 pm - 2:25 pm  Catherine B. Stroud
LAB Section: B4  W 1:00 pm - 4:00 pm  Catherine B. Stroud

Spring 2023
LEC Section: A1  TR 9:55 am - 11:10 am  Victor A. Cazares
LAB Section: A2  W 1:00 pm - 4:00 pm  Victor A. Cazares
LEC Section: B3  MWF 11:00 am - 12:15 pm  Jeremy D. Cone
LAB Section: B4  T 1:00 pm - 4:00 pm  Jeremy D. Cone
LEC Section: C5  TR 11:20 am - 12:35 pm  Kris N. Kirby
LAB Section: C6  W 1:00 pm - 4:00 pm  Kris N. Kirby

STAT 101 (F)(S) Elementary Statistics and Data Analysis (QFR)
It is impossible to be an informed citizen in today's world without an understanding of data. Whether it is opinion polls, unemployment rates, salary differences between men and women, the efficacy of vaccines, etc, we need to be able to interpret and gain information from statistics. This course will introduce the common methods used to analyze and present data with an emphasis on interpretation and informed decision making.

Requirements/Evaluation: weekly homework, quizzes, exams, and a project

Prerequisites: MATH 102 (or demonstrated proficiency on a diagnostic test)
Enrollment Limit: 50
Enrollment Preferences: juniors and seniors
Expected Class Size: 35
Grading: yes pass/fail option, yes fifth course option
Unit Notes: students with MATH130 but no statistics should enroll in STAT161; students with MATH150 but no statistics should enroll in STAT201. Students with AP Stat 4/5 or STAT 101/161 should enroll in STAT 202.
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: It is a quantitative course.
Attributes: COGS Related Courses PHLH Statistics Courses

Fall 2022
LEC Section: 01 TF 1:10 pm - 2:25 pm Elizabeth M. Upton
LEC Section: 01 TF 1:10 pm - 2:25 pm Elizabeth M. Upton

Spring 2023
LEC Section: 01 TF 1:10 pm - 2:25 pm Elizabeth M. Upton

STAT 161 (F)(S) Introductory Statistics for Social Science (QFR)
This course will cover the basics of modern statistical analysis with a view toward applications in the social sciences. Topics include exploratory data analysis, linear regression, basic statistical inference, and elements of probability theory. The course focuses on the application of statistical tools to solve problems, to make decisions, and the use of statistical thinking to understand the world.
Requirements/Evaluation: Weekly homework, quizzes, two midterms and a final exam (midterms include take-home components), and a data analysis project. Students will need to become familiar with the statistical software STATA.
Prerequisites: MATH 130 (or equivalent); not open to students who have completed STAT 101 or equivalent
Enrollment Limit: 40
Enrollment Preferences: Economics majors, sophomores
Expected Class Size: 40
Grading: yes pass/fail option, no fifth course option
Unit Notes: Students with calculus background should consider STAT 201. Students without any calculus background should consider STAT 101. Students with AP Stat 4 or 5 should consider Stat 202. Please refer to the placement chart on the Math&Stat department website for more information.
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: Reasoning with data
Attributes: PHLH Statistics Courses

Fall 2022
LEC Section: 01 MWF 9:00 am - 9:50 am Anna M. Plantinga
LEC Section: 02 MWF 10:00 am - 10:50 am Anna M. Plantinga
LEC Section: 01 MWF 10:00 am - 10:50 am Richard D. De Veaux

Spring 2023
LEC Section: 01 MWF 10:00 am - 10:50 am Richard D. De Veaux

STAT 201 (F)(S) Statistics and Data Analysis (QFR)
Statistics can be viewed as the art and science of turning data into information. Real world decision-making, whether in business or science is often based on data and the perceived information it contains. Sherlock Holmes, when prematurely asked the merits of a case by Dr. Watson, snapped back, "Data, data, data! I can't make bricks without clay." In this course, we will study the basic methods by which statisticians attempt to extract information from data. These will include many of the standard tools of statistical inference such as hypothesis testing, confidence intervals, and linear regression as well as exploratory and graphical data analysis techniques. This is an accelerated introductory statistics course that involves computational programming and incorporates modern statistical techniques.
Requirements/Evaluation: weekly homework and projects, midterm exams, and a final exam.
Prerequisites: MATH 150 or equivalent; not open to students who have completed STAT 101 or STAT 161 or equivalent

Enrollment Limit: 30

Enrollment Preferences: Prospective Statistics majors, students for whom the course is a major prerequisite, and seniors

Expected Class Size: 30

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

Unit Notes: Students with AP Stat 4/5 or STAT 101/161 should enroll in STAT 202. Students with no calc or stats background should enroll in STAT 101. Students with MATH 140 but no statistics should enroll in STAT 161.

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: Students will learn to interpret, choose, carry out, and communicate analyses of data.

Attributes: COGS Related Courses PHLH Statistics Courses

Fall 2022
LEC Section: 01 MWF 12:00 pm - 12:50 pm Stewart D. Johnson
LEC Section: 02 MWF 11:00 am - 11:50 am Stewart D. Johnson

Spring 2023
LEC Section: 01 MWF 9:00 am - 9:50 am Anna M. Plantinga

STAT 202 (F)(S) Introduction to Statistical Modeling (QFR)

Data come from a variety of sources: sometimes from planned experiments or designed surveys, sometimes by less organized means. In this course we'll explore the kinds of models and predictions that we can make from both kinds of data, as well as design aspects of collecting data. We'll focus on model building, especially multiple regression, and talk about its potential to answer questions about the world -- and about its limitations. We'll emphasize applications over theory and analyze real data sets throughout the course.

Requirements/Evaluation: Homework problems; quizzes; exams; a final project (on a topic that interests you!). Participation matters! Engagement with your peers is an important part of learning, of being a statistician in the Real World...and of your evaluation in this course. While your assignments will be submitted (and graded) individually, you'll be responsible for giving and receiving peer feedback, contributing to class discussions, and working together with classmates on practice problems.

Prerequisites: MATH 140 and STAT 101/161/201/AP Statistics 4/5, or permission of instructor.

Enrollment Limit: 40

Enrollment Preferences: Prospective Statistics majors and more senior students

Expected Class Size: 25

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

Unit Notes: Students with a 4 on the AP Stats exam should contact the department for proper placement. Students with STAT 201 are strongly encouraged to take STAT 346 or other 300-level statistics electives.

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course uses mathematical tools and computing programs to create models, make predictions, assess uncertainty, and describe data. We'll also emphasize choosing appropriate mathematical tools and interpreting their results in a real-world context.

Attributes: PHLH Statistics Courses

Fall 2022
LEC Section: 01 TF 1:10 pm - 2:25 pm Xizhen Cai
LEC Section: 02 MWF 12:00 pm - 12:50 pm Richard D. De Veaux

Spring 2023
LEC Section: 01 MWF 12:00 pm - 12:50 pm Xizhen Cai
LEC Section: 02 TR 9:55 am - 11:10 am Daniel B. Turek

STAT 341 (F)(S) Probability (QFR)
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 2022
LEC Section: 01 TF 2:35 pm - 3:50 pm Mihai Stoiciu

Spring 2023
LEC Section: 01 TF 2:35 pm - 3:50 pm Mihai Stoiciu

STAT 344 (F) Statistical Design of Experiments (QFR)
When you hear the word experiment you might be picturing white lab coats and pipettes, but businesses, especially e-commerce, are constantly experimenting as well. How do you get the most out of both scientific and business investigations? By doing the right experiment in the first place. We'll explore the techniques used to plan experiments that are both efficient and statistically sound. We'll learn how to analyze the data that come from these experiments and the conclusions we can draw from that analysis. We'll look at both classical tools like fractional factorial designs as well as optimal design, and see how these two frameworks differ in their philosophy and in what they can do. Throughout the course, we'll make extensive use of both R and JMP software to work with real-world data.

Requirements/Evaluation: Homework problems--both individual and in groups, midterm, final, and projects (on topics that interest you!).
Prerequisites: STAT 161 or 201 or 202, or equivalent, and Math 140 or equivalent, or permission of instructor
Enrollment Limit: 20
Enrollment Preferences: Statistics majors, seniors, juniors, sophomores, first years
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course uses mathematical tools and computing programs to design experiments, analyze their results, and assess their effectiveness. We'll also emphasize choosing appropriate mathematical tools and interpreting their results in a real-world context.

Fall 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Richard D. De Veaux

STAT 346 (F)(S) Regression Theory and Applications (QFR)
This course focuses on the building of empirical models through data in order to predict, explain, and interpret scientific phenomena. Regression
modeling is the most widely used method for analyzing and predicting a response data and for understand the relationship with explanatory variables. This course provides both theoretical and practical training in statistical modeling with particular emphasis on simple linear and multiple regression, using R to develop and diagnose models. The course covers the theory of multiple regression and diagnostics from a linear algebra perspective with emphasis on the practical application of the methods to real data sets. The data sets will be taken from a wide variety of disciplines.

Requirements/Evaluation: Weekly homework, theory and data analysis exams, final course project.
Prerequisites: MATH 250, and at least one of STAT 201 or 202. Or permission of the instructor.

Enrollment Limit: 30
Enrollment Preferences: Statistics Majors
Expected Class Size: 20
Grading: yes pass/fail option, no fifth course option
Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course prepares students in the use of quantitative methods for the modeling, prediction and understanding of scientific phenomena.

Fall 2022
LEC Section: 01 TR 9:55 am - 11:10 am Xizhen Cai

Spring 2023
LEC Section: 01 TR 9:55 am - 11:10 am Elizabeth M. Upton

STAT 356 (F) Time Series Analysis (QFR)
Time series -- data collected over time -- crop up in applications from economics to engineering to transit. But because the observations are generally not independent, we need special methods to investigate them. This course will include exploratory methods and modeling for time series, including descriptive methods and checking for significance, and a foray into the frequency domain. We will emphasize applications to a variety of real data, explored using R.

Requirements/Evaluation: Evaluation is primarily based on quizzes and projects (on topics that interest you!). You'll be given the opportunity to assess your own work and resubmit/reattempt assignments as you gain mastery of a topic. Participation matters! Engagement with your peers is an important part of learning, of being a statistician in the Real World...and of your evaluation in this course. While most assignments will be submitted (and graded) individually, you'll be responsible for giving and receiving peer feedback, contributing to live and online discussions, and working together with classmates on practice problems.
Prerequisites: STAT 346 (may be taken concurrently) or permission of instructor

Enrollment Limit: 15
Enrollment Preferences: Statistics majors, seniors
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course uses mathematical tools and computing programs to create models, make predictions, assess uncertainty, and describe data. We'll also emphasize choosing appropriate mathematical tools and interpreting their results in a real-world context.

Fall 2022
LEC Section: 01 Cancelled

STAT 360 (S) Statistical Inference (QFR)
How do we estimate unknown parameters and express the uncertainty we have in our estimate? Is there an estimator that works best? Many topics from introductory statistics such as random variables, the central limit theorem, point and interval estimation and hypotheses testing will be revisited and put on a more rigorous mathematical footing. The focus is on maximum likelihood estimators and their properties. Bayesian and computer intensive resampling techniques (e.g., the bootstrap) will also be considered.

Requirements/Evaluation: Homework, Quizzes, Exams
Prerequisites: MATH 250, STAT 201 or 202, STAT 341

Enrollment Limit: 15

Enrollment Preferences: Statistics majors

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: A rigorous mathematical course laying the foundation for reasoning with data

Spring 2023

LEC Section: 01 TR 11:20 am - 12:35 pm Daniel B. Turek

STAT 365 (F) Bayesian Statistics (QFR)

The Bayesian approach to statistical inference represents a reversal of traditional (or frequentist) inference, in which data are viewed as being fixed and model parameters as unknown quantities. Interest and application of Bayesian methods have exploded in recent decades, being facilitated by recent advances in computational power. We begin with an introduction to Bayes' Theorem, the theoretical underpinning of Bayesian statistics which dates back to the 1700's, and the concepts of prior and posterior distributions, conjugacy, and closed-form Bayesian inference. Building on this, we introduce modern computational approaches to Bayesian inference, including Markov chain Monte Carlo (MCMC), Metropolis-Hastings sampling, and the theory underlying these simple and powerful methods. Students will become comfortable with modern software tools for MCMC using a variety of applied hierarchical modeling examples, and will use R for all statistical computing.

Requirements/Evaluation: homework and exams

Prerequisites: STAT 201 and MATH 150 and 250, or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: juniors and seniors, Statistics majors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course utilizes mathematics and computer-based tools for the Bayesian approach for analyzing data and making statistical inferences.

Fall 2022

LEC Section: 01 Cancelled

STAT 372 (S) Longitudinal Data Analysis (QFR)

This course explores modern statistical methods for drawing scientific inferences from longitudinal data, i.e., data collected repeatedly on experimental units over time. The independence assumption made for most classical statistical methods does not hold with this data structure because we have multiple measurements on each individual. Topics will include linear and generalized linear models for correlated data, including marginal and random effect models, as well as computational issues and methods for fitting these models. As time permits, we will also investigate joint modeling of longitudinal and time-to-event data. We will consider many applications in the social and biological sciences.

Requirements/Evaluation: Weekly homework, midterm exams, a final exam, and a data analysis project

Prerequisites: STAT 346 (and an appropriate introductory statistics course, typically STAT 201 or 202)

Enrollment Limit: 20

Enrollment Preferences: junior and senior Statistics majors

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: The course will cover a variety of statistical analysis methods for longitudinal data.
In both science and industry today, the ability to collect and store data can outpace our ability to analyze it. Traditional techniques in statistics are often unable to cope with the size and complexity of today's data bases and data warehouses. New methodologies in Statistics have recently been developed, designed to address these inadequacies, emphasizing visualization, exploration and empirical model building at the expense of traditional hypothesis testing. In this course we will examine these new techniques and apply them to a variety of real data sets.

**Class Format:** Students cannot take both STAT 315 and STAT 442. Only one of the two can be taken for credit.

**Requirements/Evaluation:** weekly homework, exams and an end-of-term project

**Prerequisites:** MATH/STAT 341 and STAT 346, or permission of instructor

**Enrollment Limit:** 20

**Enrollment Preferences:** Statistics majors, juniors and seniors. Students cannot take both STAT 315 and STAT 442. Only one of the two can be taken for credit.

**Expected Class Size:** 15

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

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

**Quantative/Formal Reasoning Notes:** This is an advanced statistics class involving theory and application of statistical methods to data.

This course will explore generalized linear models (GLMs)--the extension of linear models, discussed in Stat346, to response variables that have specific non-normal distributions, such as counts and proportions. We will consider the general structure and theory of GLMs and see their use in a range of applications. As time permits, we will also examine extensions of these models for clustered data such as mixed effects models and generalized estimating equations.

**Requirements/Evaluation:** Weekly homework consisting of theoretical exercises and data analyses carried out in R. Short frequent quizzes and one midterm (with an in-class and take-home component). Final project and final exam.

**Prerequisites:** STAT 346, or permission of instructor

**Enrollment Limit:** 20

**Enrollment Preferences:** Seniors and Statistics majors

**Expected Class Size:** 10

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

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

**Quantative/Formal Reasoning Notes:** This is an intensive statistics course, involving theoretical and mathematical reasoning as well as the application of mathematical ideas to data using software.
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 group will carry out a substantial project in an area such as criminal justice, education equity, environmental justice, health care equity, economic justice, or 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.

Class Format: This is a research-based tutorial.

Requirements/Evaluation: To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows an "ungrading" methodology.

Prerequisites: Across each 3 - 5 person tutorial group: 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: 20

Enrollment Preferences: Students will be admitted in groups of 3 - 5 based on a proposal submitted prior to registration. The instructor is happy to facilitate formation of groups and to give feedback on draft proposals. Contact the instructor early, prior to preregistration.

Expected Class Size: 20

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

Distributions: (D2) (DPE) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
STS 363 (D2) WGSS 363 (D2) AMST 363 (D2) MATH 308 (D3)

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.

Fall 2022
TUT Section: T1  TBA  Chad M. Topaz

Spring 2023
TUT Section: T1  TBA  Chad M. Topaz

Fall 2022
TUT Section: T1  TBA  Chad M. Topaz

Quantitative and Formal Reasoning

AMST 363  (F)(S)  Mathematical and Computational Approaches to Social Justice  (DPE) (QFR)

Cross-listings: STS 363  WGSS 363  AMST 363  MATH 308

Secondary Cross-listing

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 group will carry out a substantial project in an area such as criminal justice, education equity, environmental justice, health care equity, economic justice, or 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.

Class Format: This is a research-based tutorial.

Requirements/Evaluation: To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows an "ungrading" methodology.

Prerequisites: Across each 3 - 5 person tutorial group: 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: 20

Enrollment Preferences: Students will be admitted in groups of 3 - 5 based on a proposal submitted prior to registration. The instructor is happy to facilitate formation of groups and to give feedback on draft proposals. Contact the instructor early, prior to preregistration.

Expected Class Size: 20
**Grading:** yes pass/fail option, no fifth course option

**Distributions:** (D2) (DPE) (QFR)

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

STS 363 (D2) WCSS 363 (D2) AMST 363 (D2) MATH 308 (D3)

**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.

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**Fall 2022**

TUT Section: T1    TBA    Chad M. Topaz

**Spring 2023**

TUT Section: T1    TBA    Chad M. Topaz

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**ASIA 241 (S) Colonialism and Underdevelopment in South Asia** (DPE) (QFR)

**Cross-listings:** ECON 240 ASIA 241

**Secondary Cross-listing**

British colonial rule in South Asia shaped economy and society in fundamental ways. As resistance to colonial rule emerged in the late nineteenth century, "nationalist" writers developed a critique of its economic impact via taxation, fiscal policy, trade, and many other policies. In their turn, supporters of British rule, "apologists," argued that British rule had laid the foundations of economic growth by securing property rights, enforcing contracts, and developing infrastructure. The debate between "nationalists" and "apologists" has never quite ended, but after the recent growth of the Indian economy it has lost some of its emotional charge. We will use this opportunity to revisit the controversy.

**Requirements/Evaluation:** essays (one every other week) and responses to partner's essays will be evaluated

**Prerequisites:** one course in ECON

**Enrollment Limit:** 10

**Enrollment Preferences:** Economics major, prior course on South Asia

**Expected Class Size:** 10

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

**Distributions:** (D2) (DPE) (QFR)

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

ECON 240 (D2) ASIA 241 (D2)

**Difference, Power, and Equity Notes:** Issues of difference, power, and equity are at the heart of any analysis of colonialism, hence the DPE designation.

**Quantitative/Formal Reasoning Notes:** Students will write six essays, in which they will employ economic models and engage with quantitative evidence, so the course satisfies the QFR requirement.

**Attributes:** GBST South + Southeast Asia Studies Electives  POEC Comparative POEC/Public Policy Courses

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**Spring 2023**

TUT Section: T1    TBA    Anand V. Swamy

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**ASTR 111 (F) Introduction to Astrophysics** (QFR)

The science of astronomy spans vast scales of space and time, from individual atoms to entire galaxies and from the universe's beginning to the future fate of our Sun. In this course, we will survey some of the main ideas in modern astrophysics, with an emphasis on the physics of stars and galaxies.

ASTR 111 is the first course in the Astrophysics and Astronomy major sequences. It is also appropriate for students planning to major in one of the other sciences or mathematics and for others who would like a quantitative introduction that emphasizes the relationship of contemporary physics to astronomy. Topics include gravity and orbits, radiation laws and stellar spectra, physical characteristics of the Sun and other stars, star formation and
evolution, black holes, galaxies, the expanding universe, and the Big Bang. Students will also use telescopes to observe stars, nebulae, planets, and
galaxies and to make daytime observations of the Sun.

**Class Format:** The class has 6 afternoon labs. Nighttime observing sessions will occur throughout the semester.

**Requirements/Evaluation:** weekly problem sets, two hour-long tests, a final exam, lab reports, and an observing portfolio

**Prerequisites:** a year of high school Physics, concurrent college Physics, or permission of instructor, and MATH 140 or equivalent

**Enrollment Limit:** 28

**Enrollment Preferences:** potential Astronomy majors

**Expected Class Size:** 15

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

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

**Quantitative/Formal Reasoning Notes:** The course requires regular problem sets and quantitative assignments. The course will emphasize how
physical equations explain the observed properties of the universe.

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**Fall 2022**

LAB Section: 03  R 1:00 pm - 4:00 pm  Kevin Flaherty

LAB Section: 02  M 1:00 pm - 4:00 pm  Kevin Flaherty

LEC Section: 01  TR 11:20 am - 12:35 pm  Marek Demianski, Kevin Flaherty

**ASTR 498 (S) Independent Study: Astronomy or Astrophysics (QFR)**

Astronomy/Astrophysics independent study, directed by one of the Astronomy faculty: Pasachoff/Jaskot/Flaherty

**Requirements/Evaluation:** Regular work with the instructor; submitted presentations and papers as agreed upon

**Prerequisites:** suitable Astronomy/Astrophysics/Physics/Math-Stats-Geosciences/Chemistry courses

**Enrollment Limit:** 10

**Enrollment Preferences:** research topic

**Expected Class Size:** 5

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

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

**Quantitative/Formal Reasoning Notes:** Substantial quantitative and formal reasoning are involved

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**Spring 2023**

IND Section: 01  TBA  Daniel P. Aalberts

**BIMO 321 (F) Biochemistry I: Structure and Function of Biological Molecules (QFR)**

**Cross-listings:** BIMO 321 BIOL 321 CHEM 321

**Primary Cross-listing**

This course introduces the foundational concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

**Class Format:** lecture, three times per week and laboratory, four hours per week

**Requirements/Evaluation:** quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports

**Prerequisites:** BIOL 101 and CHEM 251/255 and CHEM 155/256
Enrollment Limit: 16/lab
Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators
Expected Class Size: 48
Grading: no pass/fail option, no fifth course option
Unit Notes: does not satisfy the distribution requirement for the Biology major; cannot be counted towards the Biology major in addition to BIOL 222
Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
BIMO 321 (D3) BIOL 321 (D3) CHEM 321 (D3)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular problem sets in which quantitative/formal reasoning skills are practiced.
Attributes: BIGP Courses BIMO Required Courses

Fall 2022
LAB Section: 04  R 1:00 pm - 5:00 pm  Jenna L. MacIntire
LAB Section: 03  T 1:00 pm - 5:00 pm  Jenna L. MacIntire
LEC Section: 01  MWF 10:00 am - 10:50 am  Amy Gehring
LAB Section: 02  M 1:00 pm - 5:00 pm  Amy Gehring

BIMO 322 (S) Biochemistry II: Metabolism (QFR)

Cross-listings: BIOL 322  BIMO 322  CHEM 322

Primary Cross-listing

This lecture course provides an in-depth presentation of the complex metabolic reactions that are central to life. Emphasis is placed on the biological flow of energy including alternative modes of energy generation (aerobic, anaerobic, photosynthetic); the regulation and integration of the metabolic pathways including compartmentalization and the transport of metabolites; and biochemical reaction mechanisms including the structures and mechanisms of coenzymes. This comprehensive study also includes the biosynthesis and catabolism of small molecules (carbohydrates, lipids, amino acids, and nucleotides). Laboratory experiments introduce the principles and procedures used to study enzymatic reactions, bioenergetics, and metabolic pathways.

Class Format: Lecture three hours per week and laboratory three hours per week.

Requirements/Evaluation: several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of data

Prerequisites: BIOL 101 and CHEM 251/255 or permission of instructor

Enrollment Limit: 60
Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators
Expected Class Size: 60
Grading: no pass/fail option, no fifth course option
Unit Notes: cannot be counted towards the Biology major in addition to BIOL 222
Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
BIOL 322 (D3) BIMO 322 (D3) CHEM 322 (D3)

Quantitative/Formal Reasoning Notes: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.
Attributes: BIGP Courses BIMO Required Courses

Spring 2023
LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo
LEC Section: 01  TR 11:20 am - 12:35 pm  Pei-Wen Chen
BIOL 202  (F)  Genetics  (QFR)
Genetics, classically defined as the study of heredity, is today a multidisciplinary field whose principles provide critical insight and tools to most areas of biology and medicine. This course covers the experimental basis for our current understanding of the inheritance, structures, and functions of genes. It introduces approaches used by contemporary geneticists and molecular biologists to explore questions in areas of biology ranging from evolution to medicine. A primary focus of the course is on students developing familiarity with problem solving, the logic and quantitative reasoning required to understand how genetic mechanisms lead to biological patterns. The laboratory part of the course provides an experimental introduction to modern genetic analysis as well as introductions to interpreting genetic reasoning in the primary research literature. Laboratory experiments include investigating chromosome structure using microscopy, integrating multiple streams of evidence to map a mutation to the genome, determining the structure of a DNA plasmid using molecular tools.

Class Format: Lecture: three hours per week, Lab: three hours per week.
Requirements/Evaluation: bi-weekly problem sets; weekly laboratory exercises and laboratory reports; three exams
Prerequisites: BIOL 101 and 102
Enrollment Limit: 120
Enrollment Preferences: students interested in the Biology major
Expected Class Size: 60
Grading: no pass/fail option, no fifth course option
Unit Notes: does not satisfy the distribution requirement for the Biology major
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course develops quantitative skills through solving problems. Students learn to apply basic calculations and logic to predict the outcomes of biological systems, for example, describing the likelihood that an individual will be affected by an inherited disease. Application of quantitative and logical analysis contributes to a large component of the in-class work and the graded material for the class, in the form of problem sets, exams, and data analysis for lab reports.
Attributes: BIGP Courses  BIMO Required Courses

Fall 2022
LAB Section: 03  T 1:00 pm - 4:00 pm  Derek  Dean
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo

BIOL 203  (F)  Ecology  (QFR)
Cross-listings: BIOL 203  ENVI 203

Primary Cross-listing
This course combines lectures & discussion with field and indoor laboratory activities to explore factors that determine the distribution and abundance of plants and animals in natural systems. The course begins with an overview of global environmental patterns and then builds from the population to ecosystem level. Throughout the course, we will emphasize the connection between basic ecological principles and current environmental issues. Selected topics include population dynamics (competition, predation, mutualism); community interactions (succession, food chains and diversity) and ecosystem function (biogeochemical cycles, energy flow). Laboratory activities are designed to engage students in the natural history of the region and build skills in data analysis and scientific writing.

Class Format: Six hours per week. Students will view pre-class lecture videos; class meetings will focus on discussion, synthesis, and application of course content.
Requirements/Evaluation: pre-class quizzes, lab reports, two mid-term exams, and a final exam
Prerequisites: BIOL 102, or ENVI 102, or permission of instructor
Enrollment Limit: 30

Enrollment Preferences: students planning to pursue Biology and/or ENVI

Expected Class Size: 30

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

Unit Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

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

BIOL 203 (D3) ENVI 203 (D3)

Quantitative/Formal Reasoning Notes: Much of the material in this course centers on the interpretation and application of mathematical models used to describe ecological systems. The laboratory section of this course also contains a large data analysis component (based in R). Students are introduced to t-tests, chi-square analysis, and regression.

Attributes: ENVI Natural World Electives EVST Environmental Science

Fall 2022

LAB Section: 04 R 1:00 pm - 4:00 pm Allison L. Gill
LAB Section: 03 W 1:00 pm - 4:00 pm Allison L. Gill
LEC Section: 01 MWF 9:00 am - 9:50 am Allison L. Gill
LAB Section: 02 T 1:00 pm - 4:00 pm Allison L. Gill

BIOL 305 (S) Evolution (QFR)
This course offers a critical analysis of contemporary concepts in biological evolution. We focus on the relation of evolutionary mechanisms (e.g., selection, drift, and migration) to long term evolutionary patterns (e.g., evolutionary innovations, origin of major groups, and adaptation). Topics include micro-evolutionary models, natural and sexual selection, speciation, the inference of evolutionary history, evolutionary medicine among others.

Requirements/Evaluation: independent research project, problem sets, participation in discussions and exams

Prerequisites: BIOL 202

Enrollment Limit: 22

Enrollment Preferences: Seniors and biology majors

Expected Class Size: 22

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

Unit Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: We will use mathematical models to study population genetics.

Attributes: BIGP Courses BIMO Interdepartmental Electives COGS Related Courses

Spring 2023

LAB Section: 02 W 1:00 pm - 4:00 pm Luana S. Maroja
LEC Section: 01 MWF 11:00 am - 11:50 am Luana S. Maroja
LAB Section: 03 R 1:00 pm - 4:00 pm Luana S. Maroja

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

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

Primary 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 throughput 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: The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

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, no fifth course option

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

Spring 2023

SEM Section: 01 TR 9:55 am - 11:10 am Lois M. Banta
LAB Section: 02 TR 1:00 pm - 4:00 pm Lois M. Banta

BIOL 321 (F) Biochemistry I: Structure and Function of Biological Molecules (QFR)

Cross-listings: BIMO 321 BIOL 321 CHEM 321

Secondary Cross-listing

This course introduces the foundational concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports

Prerequisites: BIOL 101 and CHEM 251/255 and CHEM 155/256

Enrollment Limit: 16/lab

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 48

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

Unit Notes: does not satisfy the distribution requirement for the Biology major; cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:

BIMO 321 (D3) BIOL 321 (D3) CHEM 321 (D3)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular problem sets in which quantitative/formal reasoning skills are practiced.

Attributes: BIGP Courses BIMO Required Courses

Fall 2022

LEC Section: 01 MWF 10:00 am - 10:50 am Amy Gehring
LAB Section: 03 T 1:00 pm - 5:00 pm Jenna L. MacIntire
LAB Section: 02 M 1:00 pm - 5:00 pm Amy Gehring
LAB Section: 04 R 1:00 pm - 5:00 pm Jenna L. MacIntire

BIOL 322 (S) Biochemistry II: Metabolism (QFR)

Cross-listings: BIOL 322 BIMO 322 CHEM 322

Secondary Cross-listing

This lecture course provides an in-depth presentation of the complex metabolic reactions that are central to life. Emphasis is placed on the biological flow of energy including alternative modes of energy generation (aerobic, anaerobic, photosynthetic); the regulation and integration of the metabolic pathways including compartmentalization and the transport of metabolites; and biochemical reaction mechanisms including the structures and mechanisms of coenzymes. This comprehensive study also includes the biosynthesis and catabolism of small molecules (carbohydrates, lipids, amino acids, and nucleotides). Laboratory experiments introduce the principles and procedures used to study enzymatic reactions, bioenergetics, and metabolic pathways.

Class Format: Lecture three hours per week and laboratory three hours per week.

Requirements/Evaluation: several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of data

Prerequisites: BIOL 101 and CHEM 251/255 or permission of instructor

Enrollment Limit: 60

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 60

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

Unit Notes: cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3) (QFR)

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

BIOL 322 (D3) BIMO 322 (D3) CHEM 322 (D3)

Quantitative/Formal Reasoning Notes: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Attributes: BIGP Courses BIMO Required Courses

Spring 2023

LAB Section: 04 R 1:00 pm - 4:00 pm Janis E. Bravo
LEC Section: 01 TR 11:20 am - 12:35 pm Pei-Wen Chen
LAB Section: 03 W 1:00 pm - 4:00 pm Pei-Wen Chen
LAB Section: 02 T 1:00 pm - 4:00 pm Janis E. Bravo

BIOL 337 (F) Evolutionary Ecology (QFR)

Evolutionary ecology is an interdisciplinary field that integrates concepts in genetics, adaptation, and ecology to understand how evolution operates in the context of ecological communities. This course provides an overview of the discipline including foundational concepts in evolutionary demography,
phenotypic plasticity, and population genetics. It also explores how breakthroughs in these topics provide a framework for advances in our understanding of the evolution of reproductive timing and ageing, interspecific interactions (e.g., competition, predation), cooperation, and altruism. The course combines lectures, readings, in-class discussion, and a lab section that includes a mixture of field, computer, and lab projects. Laboratories will give students practical, hands-on experience in how to develop, plan, and carry out evolutionary ecology research from start to finish.

Class Format: lecture, 3 hours per week; laboratory and discussion, 3 hours per week

Requirements/Evaluation: Evaluation will be based on lab assignments, two exams, discussion participation, and a written paper.

Prerequisites: BIOL 102, plus either BIOL 202 or BIOL 203 or equivalent

Enrollment Limit: 24

Enrollment Preferences: preference given to biology majors, seniors, and juniors

Expected Class Size: 24

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

Unit Notes: Satisfies the distribution requirement for the Biology major

Distributions: (QFR)

Quantitative/Formal Reasoning Notes: Evolutionary ecology uses concepts in genetics and ecology to understand how the frequency of alleles in a population changes over time. These changes are formalized in equations that describe these processes. Students will gain experience in utilizing these equations to describe, analyze, and predict the evolutionary outcome of ecological interactions for both theoretical and experimental purposes. Thus, the students will gain experience in solving systems of equations using algebra and in stat

Fall 2022

LAB Section: 02 Cancelled
LEC Section: 01 Cancelled
LAB Section: 03 Cancelled

CHEM 151 (F) Introductory Chemistry (QFR)

This course provides an introduction to chemistry for those students with little or no high school chemistry. Students will be introduced to concepts fundamental to studying matter at the molecular level. Principal topics include introductions to the nature of atoms and molecules, stoichiometry, solubility rules and equilibria, gas laws, chemical equilibrium, acid-base reactions, periodic relationships, chemical bonding, molecular structure, intermolecular forces, oxidation-reduction reactions, and related applications. Laboratory work comprises a system of qualitative analysis and quantitative techniques. The course provides preparation for further study of organic chemistry, biochemistry, physical and inorganic chemistry and is intended for students who are anticipating professional study in chemistry, in related sciences, or in one of the health professions, as well as for those students who are interested in exploring the fundamental ideas of chemistry as part of their general education. This course may be taken pass/fail; however, students who are considering graduate study in science or in the health professions should elect to take this course for a grade.

Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: electronic and written weekly problem set assignments, laboratory work and analysis, quizzes, two tests, and a final exam

Prerequisites: Students are required to take the online Chemistry Placement Survey prior to registering for the course (chemistry.williams.edu/placement).

Enrollment Limit: 16/lab

Enrollment Preferences: first-year students; students who have studied chemistry for one or more years are directed to CHEM 153 or 155

Expected Class Size: 32

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

Unit Notes: CHEM 151 may be taken concurrently with MATH 102--see under Mathematics; CHEM 151 or its equivalent is a prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: BIMO Required Courses
CHEM 153 (F) Concepts of Chemistry (QFR)

This course broadens and deepens the foundation in chemistry of students who have had typically one year of chemistry at the high school level. Most students begin study of chemistry at Williams with this course. Familiarity with stoichiometry, basic concepts of equilibria, and the model of an atom is expected. Principal topics for this course include kinetic theory of gases, modern atomic theory, molecular structure and bonding, states of matter, chemical equilibrium (acid-base and solubility), and an introduction to atomic and molecular spectroscopies. Laboratory periods will largely focus on experiment design, data analysis, literature, scientific writing, ethics, and other skills critical to students’ development as scientists. The course is of interest to students who anticipate professional study in chemistry, related sciences, or one of the health professions, as well as to those who want to explore the fundamentals of chemistry as part of their general education. This course may be taken pass/fail; however, students who are considering graduate study in science or in the health professions should elect to take this course for a grade.

Class Format: lecture, three times per week and laboratory, four hours per week
Requirements/Evaluation: problem sets and/or quizzes, laboratory work, and exams
Prerequisites: Students are required to take the online Chemistry Placement Survey prior to registering for the course (chemistry.williams.edu/placement).
Enrollment Limit: 45/lecture
Enrollment Preferences: first-year students
Expected Class Size: 90
Grading: yes pass/fail option, no fifth course option
Unit Notes: CHEM 153 or its equivalent is a prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.
Attributes: BIMO Required Courses

CHEM 155 (F) Principles of Modern Chemistry (QFR)

This course is designed for students with a strong preparation in chemistry (including laboratory experience) in secondary school, such as provided by an Advanced Placement chemistry course (or equivalent) with a corresponding AP Chemistry Exam score of 5 (or a 6 or 7 on the IB Exam, or equivalent). Topics include chemical thermodynamics, kinetics, structure and bonding, coordination chemistry, electrochemistry and spectroscopy and their application to fields such as materials science, catalysis, environmental, biological, and medicinal chemistry. Laboratory periods will focus on hands-on skills, data representation and analysis, scientific writing, exploration of the scientific literature, and other skills critical to students’ development as scientists. This course is designed for students who are anticipating further study in chemistry, related sciences, or one of the health professions, as well as for students who want to explore the fundamental ideas of chemistry as part of their general education.

Class Format: lecture, three times per week and laboratory, four hours per week
Requirements/Evaluation: frequent short assignments in preparation for class, quantitative weekly problem sets, laboratory work and reports, an hour test, and a final exam

Prerequisites: Students are required to take the online Chemistry Placement Survey prior to registering for the course (chemistry.williams.edu/placement).

Enrollment Limit: 16/lab

Enrollment Preferences: first-year students and sophomores

Expected Class Size: 32

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

Unit Notes: CHEM 155 or its equivalent is a prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: BIMO Required Courses

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Fall 2022
LAB Section: 03 T 1:00 pm - 5:00 pm Anthony J. Carrasquillo
LAB Section: 02 M 1:00 pm - 5:00 pm Anthony J. Carrasquillo
LEC Section: 01 MWF 8:00 am - 8:50 am Lee Y. Park

CHEM 156 (S) Organic Chemistry: Introductory Level (QFR)

This course provides the necessary background in organic chemistry for students who are planning advanced study or a career in chemistry, the biological sciences, or the health professions. It initiates the systematic study of the common classes of organic compounds with emphasis on theories of structure and reactivity. The fundamentals of molecular modeling as applied to organic molecules are presented. Specific topics include basic organic structure and bonding, isomerism, stereochemistry, molecular energetics, the theory and interpretation of infrared and nuclear magnetic spectroscopy, substitution, elimination and addition reactions. The coordinated laboratory work includes purification and separation techniques, structure-reactivity studies, organic synthesis, IR and NMR spectroscopy, and the identification of unknown compounds.

Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: quantitative problem solving, laboratory performance, three midterm exams, and a final exam

Prerequisites: CHEM 151 or 153 or 155 or permission of instructor

Enrollment Limit: 55/lecture

Enrollment Preferences: Seniors, juniors, sophomores, first-year students

Expected Class Size: 100

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular and substantial problem solving in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: BIMO Required Courses

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Spring 2023
LAB Section: 04 T 1:00 pm - 5:00 pm
LAB Section: 09 T 1:00 pm - 5:00 pm
LAB Section: 08 W 1:00 pm - 5:00 pm
LAB Section: 07 M 1:00 pm - 5:00 pm
LAB Section: 03 M 1:00 pm - 5:00 pm
LAB Section: 06 R 1:00 pm - 5:00 pm
LEC Section: 01 MWF 8:00 am - 8:50 am Thomas E. Smith
CHEM 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 throughput 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: The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

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, no fifth course option

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)

Quantitative/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

Spring 2023

SEM Section: 01 TR 9:55 am - 11:10 am Lois M. Banta
LAB Section: 02 TR 1:00 pm - 4:00 pm Lois M. Banta

CHEM 321 (F) Biochemistry I: Structure and Function of Biological Molecules (QFR)

Cross-listings: BIMO 321 BIOL 321 CHEM 321

Secondary Cross-listing

This course introduces the foundational concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.
Class Format: lecture, three times per week and laboratory, four hours per week

Requirements/Evaluation: quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports

Prerequisites: BIOL 101 and CHEM 251/255 and CHEM 155/256

Enrollment Limit: 16/lab

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 48

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

Unit Notes: does not satisfy the distribution requirement for the Biology major; cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3) (QFR)

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

BIMO 321 (D3) BIOL 321 (D3) CHEM 321 (D3)

Quantative/Formal Reasoning Notes: This course fulfills the QFR requirement with regular problem sets in which quantitative/formal reasoning skills are practiced.

Attributes: BIGP Courses BIMO Required Courses

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CHEM 322 (S) Biochemistry II: Metabolism (QFR)

Cross-listings: BIOL 322 BIMO 322 CHEM 322

Secondary Cross-listing

This lecture course provides an in-depth presentation of the complex metabolic reactions that are central to life. Emphasis is placed on the biological flow of energy including alternative modes of energy generation (aerobic, anaerobic, photosynthetic); the regulation and integration of the metabolic pathways including compartmentalization and the transport of metabolites; and biochemical reaction mechanisms including the structures and mechanisms of coenzymes. This comprehensive study also includes the biosynthesis and catabolism of small molecules (carbohydrates, lipids, amino acids, and nucleotides). Laboratory experiments introduce the principles and procedures used to study enzymatic reactions, bioenergetics, and metabolic pathways.

Class Format: Lecture three hours per week and laboratory three hours per week.

Requirements/Evaluation: several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of data

Prerequisites: BIOL 101 and CHEM 251/255 or permission of instructor

Enrollment Limit: 60

Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 60

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

Unit Notes: cannot be counted towards the Biology major in addition to BIOL 222

Distributions: (D3) (QFR)

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

BIOL 322 (D3) BIMO 322 (D3) CHEM 322 (D3)

Quantative/Formal Reasoning Notes: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Attributes: BIGP Courses BIMO Required Courses

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CHEM 368 (S) Computational Chemistry and Molecular Spectroscopy  (QFR)
This tutorial provides an introduction to the principles of computational quantum mechanics and their application to problems of chemical interest such as chemical bonding, chemical reactivity, and molecular spectroscopy. Emphasis is placed upon modern electronic structure calculations, their fundamentals, practical considerations, interpretation, and applications to current research questions. Under guidance in sessions and through independent work, students will use computational methods to explore assigned weekly research problems. The research results will be presented to and discussed with the tutorial partner at the end of each week.

Requirements/Evaluation: tutorial participation, presentations, and submitted papers
Prerequisites: CHEM 361 or equivalent background in Physics
Enrollment Limit: 10
Enrollment Preferences: Chemistry majors
Expected Class Size: 10
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course fulfills the QFC requirement with problem sets for assignments in which quantitative/formal reasoning skills are practiced.

Spring 2023
TUT Section: T1 TBA Enrique Peacock-López

COGS 224 (F) Introduction to Formal Linguistics  (QFR)
Cross-listings: COGS 224 PHIL 221
Primary Cross-listing
The sentence “Every cookie is chocolate chip and three of them are oatmeal raisin” is a perfectly grammatical sentence of English, but it's self-contradictory. What does it take to realize this fact? One must grasp the meanings of the various parts of the sentence. In particular, one must grasp that “three of them” picks out a subset of the group picked out by “every cookie”, and that there’s no such thing as a cookie that is both chocolate chip and oatmeal raisin. There two ways to understand "Many students took every class". According to one, there is a single group of students that had their hands extremely full this semester. According to the other, every class was well-populated, potentially by different groups. The reason for this is that there are two underlying structures that the original sentence can realize. This course serves as an introduction to formal methods in the scientific study of language. Our goal will be to characterize phenomena like those above with logical and mathematical precision. The focus will be on model-theoretic semantics, the sub-field of linguistics that studies meanings. Along the way we will discuss principles of syntax, the sub-field that studies sentence structures, and pragmatics, the sub-field that studies inferences of non-literal content. This is a formal course, but no prior logical or mathematical background will be expected. Starting from scratch, students will learn the building blocks of current-day linguistic research. This introduction will be of use to students interested in language from a variety of perspectives, including philosophy, cognitive science, and computer science.

Requirements/Evaluation: Weekly problem sets, plus a final project (paper/presentation/other type, to be discussed with instructor)
Prerequisites: No prerequisites
Enrollment Limit: 20
Enrollment Preferences: Preference given to seniors and philosophy/cognitive science majors.
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D2) (QFR)
Quantitative/Formal Reasoning Notes: This course teaches the fundamentals of the formal analysis of language. Students will learn to provide translation schemes from English to a logical language (typed lambda calculus).

Attributes: COGS Interdepartmental Electives COGS Related Courses Linguistics PHIL Contemp Metaphysics + Epistemology Courses
Enrollment Limit: 24;12/lab

Enrollment Preferences: Not open to those who have completed or are currently enrolled in a Computer Science course numbered 136 or higher or a Statistics course. Preference given to first-year students and sophomores who have not previously taken a computer science course.

Expected Class Size: 24

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

Unit Notes: Please see the Computer Science Department website for more information on selecting an introductory computer science class: https://csci.williams.edu/

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course includes regular and substantial problem sets, labs, and/or projects in which quantitative/formal reasoning skills are practiced and evaluated.

CSCI 134  (F)(S)  Introduction to Computer Science  (QFR)

This course introduces students to the science of computation by exploring the representation and manipulation of data and algorithms. We organize and transform information in order to solve problems using algorithms written in a modern object-oriented language. Topics include organization of data using objects and classes, and the description of processes using conditional control, iteration, methods and classes. We also begin the study of abstraction, self-reference, reuse, and performance analysis. While the choice of programming language and application area will vary in different offerings, the skills students develop will transfer equally well to more advanced study in many areas. In particular, this course is designed to provide the programming skills needed for further study in computer science and is expected to satisfy introductory programming requirements in other departments.

Requirements/Evaluation: weekly programming projects, weekly written homeworks, and two examinations.

Prerequisites: none, except for the standard prerequisites for a (QFR) course; previous programming experience is not required

Enrollment Limit: 30;15/lab

Enrollment Preferences: if the course is over-enrolled, enrollment will be determined by lottery.

Expected Class Size: 30/sec

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

Unit Notes: Please see the Computer Science Department website for more information on selecting an introductory computer science class: https://csci.williams.edu/. Students with prior experience with object-oriented programming should discuss appropriate course placement with members of the department.

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course includes regular and substantial problem sets, labs, and/or projects in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: COGS Interdepartmental Electives
CSCI 136 (F)(S) Data Structures and Advanced Programming (QFR)

This course builds on the programming skills acquired in Computer Science 134. It couples work on program design, analysis, and verification with an introduction to the study of data structures. Data structures capture common ways in which to store and manipulate data, and they are important in the construction of sophisticated computer programs. Students are introduced to some of the most important and frequently used data structures: lists, stacks, queues, trees, hash tables, graphs, and files. Students will be expected to write several programs, ranging from very short programs to more elaborate systems. Emphasis will be placed on the development of clear, modular programs that are easy to read, debug, verify, analyze, and modify.

Requirements/Evaluation: programming and written assignments, quizzes, examinations

Prerequisites: CSCI 134 or equivalent; fulfilling the Discrete Mathematics Proficiency requirement is recommended, but not required

Enrollment Limit: 30;15/lab

Enrollment Preferences: if the course is over-enrolled, enrollment will be determined by lottery.

Expected Class Size: 30/lec

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

Unit Notes: Please see the Computer Science Department website for more information on selecting an introductory computer science class: https://csci.williams.edu/

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course include regular and substantial problem sets, labs, and/or projects in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: BIGP Courses

Fall 2022

LEC Section: 02 MWF 9:00 am - 9:50 am Daniel W. Barowy
LEC Section: 01 MWF 10:00 am - 10:50 am Kelly A. Shaw
LAB Section: 06 R 2:30 pm - 4:00 pm Daniel W. Barowy
LAB Section: 05 R 1:00 pm - 2:30 pm Daniel W. Barowy
LAB Section: 04 W 2:30 pm - 4:00 pm Kelly A. Shaw
LAB Section: 03 W 1:00 pm - 2:30 pm Kelly A. Shaw

Spring 2023

LAB Section: 06 R 2:30 pm - 4:00 pm Daniel W. Barowy
CSCI 237  (F)(S)  Computer Organization  (QFR)
This course studies the basic instruction set architecture and organization of a modern computer. It provides a programmer's view of how computer systems execute programs, store information, and communicate. Over the semester the student learns the fundamentals of translating higher level languages into assembly language, and the interpretation of machine languages by hardware. At the same time, a model of computer hardware organization is developed from the gate level upward.

Requirements/Evaluation: weekly programming assignments and/or problem sets, quizzes, midterm and final exams
Prerequisites: CSCI 136
Enrollment Limit: 24;12/lab
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Grading: no pass/fail option, no fifth course option
Distributions: (D3)  (QFR)
Quantative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Fall 2022
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Kelly A. Shaw
LAB Section: 02  R 1:00 pm - 2:30 pm  Kelly A. Shaw
LAB Section: 03  R 2:30 pm - 4:00 pm  Kelly A. Shaw

Spring 2023
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Kelly A. Shaw
LAB Section: 02  R 1:00 pm - 2:30 pm  Kelly A. Shaw
LAB Section: 03  R 2:30 pm - 4:00 pm  Kelly A. Shaw

CSCI 256  (F)(S)  Algorithm Design and Analysis  (QFR)
This course investigates methods for designing efficient and reliable algorithms. By carefully analyzing the structure of a problem within a mathematical framework, it is often possible to dramatically decrease the computational resources needed to find a solution. In addition, analysis provides a method for verifying the correctness of an algorithm and accurately estimating its running time and space requirements. We will study several algorithm design strategies that build on data structures and programming techniques introduced in Computer Science 136. These include greedy, divide-and-conquer, dynamic programming, and network flow algorithms. Additional topics of study include algorithms on graphs and strategies for handling potentially intractable problems.

Requirements/Evaluation: Problem sets, midterm and final examinations
Prerequisites: CSCI 136 and fulfillment of the Discrete Mathematics Proficiency requirement
Enrollment Limit: 24
Enrollment Preferences: Preference will be given to students who need the class in order to complete the major. Ties will be broken by seniority (seniors first, then juniors, etc.).
Expected Class Size: 24
Grading: no pass/fail option, no fifth course option
Distributions: (D3)  (QFR)
Quantative/Formal Reasoning Notes: This course will have weekly problem sets in which students will formally prove statements about the behavior
and performance of algorithms. In short, the course is about applying abstract and mathematical reasoning to the study of algorithms and computation.

Fall 2022
LEC Section: 01    MWF 10:00 am - 10:50 am    Bill K. Jannen

Spring 2023
LEC Section: 01    MWF 9:00 am - 9:50 am    Bill K. Jannen
LEC Section: 02    MWF 10:00 am - 10:50 am    Bill K. Jannen

CSCI 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 throughput 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: The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

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, no fifth course option

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)

Quantitative/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

Spring 2023
SEM Section: 01 TR 9:55 am - 11:10 am    Lois M. Banta
LAB Section: 02 TR 1:00 pm - 4:00 pm    Lois M. Banta

CSCI 334 (F)(S) Principles of Programming Languages (QFR)

This course examines the concepts and structures governing the design and implementation of programming languages. It presents an introduction to the concepts behind compilers and run-time representations of programming languages; features of programming languages supporting abstraction and polymorphism; and the procedural, functional, object-oriented, and concurrent programming paradigms. Programs will be required in languages
illustrating each of these paradigms.

Requirements/Evaluation: weekly problem sets and programming assignments, a midterm examination, and a final examination

Prerequisites: CSCI 136

Enrollment Limit: 30

Enrollment Preferences: current or expected Computer Science majors

Expected Class Size: 30

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

Distributions: (D3) (QFR)

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

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Fall 2022
LEC Section: 01 TR 9:55 am - 11:10 am Daniel W. Barowy

Spring 2023
LEC Section: 01 TR 9:55 am - 11:10 am Stephen N. Freund

CSCI 339 (S) Distributed Systems (QFR)

This course studies the key design principles of distributed systems, which are collections of independent networked computers that function as single coherent systems. Covered topics include communication protocols, processes and threads, naming, synchronization, consistency and replication, fault tolerance, and security. Students also examine some specific real-world distributed systems case studies, including Google and Amazon. Class discussion is based on readings from the textbook and research papers. The goals of this course are to understand how large-scale computational systems are built, and to provide students with the tools necessary to evaluate new technologies after the course ends.

Requirements/Evaluation: weekly homework assignments, midterm exam, 3 major programming projects, and a final project

Prerequisites: CSCI 237

Enrollment Limit: 24

Enrollment Preferences: current or expected Computer Science majors

Expected Class Size: 24

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2023
LEC Section: 01 MR 1:10 pm - 2:25 pm Jeannie R Albrecht

CSCI 361 (F) Theory of Computation (QFR)

Cross-listings: MATH 361 CSCI 361

Primary 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:** 48/12/con

**Enrollment Preferences:** current or expected Computer Science majors

**Expected Class Size:** 48

**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

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**Fall 2022**

CON Section: 03  MR 1:10 pm - 2:25 pm  Aaron M. Williams

CON Section: 05  TF 1:10 pm - 2:25 pm  Aaron M. Williams

LEC Section: 01  ASYN  Aaron M. Williams

CON Section: 04  MR 2:35 pm - 3:50 pm  Aaron M. Williams

CON Section: 02  MWF 11:00 am - 12:15 pm  Aaron M. Williams

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**CSCI 371** (F)(S) **Computer Graphics** (QFR)

This course covers the fundamental mathematics and techniques behind computer graphics, and will teach students how to represent and draw 2D and 3D geometry for real-time and photorealistic applications. Students will write challenging implementations from the ground up in C/C++, OpenGL, and GLSL. Topics include transformations, rasterization, ray tracing, immediate mode GUI, forward and inverse kinematics, and physically-based animation. Examples are drawn from video games, movies, and robotics.

**Requirements/Evaluation:** evaluation based on assignments, projects, and exams.

**Prerequisites:** CSCI 136 and CSCI 237 or permission of instructor

**Enrollment Limit:** 24;12/lab

**Enrollment Preferences:** current or expected Computer Science majors

**Expected Class Size:** 24

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

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

**Quantative/Formal Reasoning Notes:** The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

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**Fall 2022**

LAB Section: 03  T 2:30 pm - 4:00 pm  James M. Bern

LAB Section: 02  T 1:00 pm - 2:30 pm  James M. Bern

LEC Section: 01  MR 2:35 pm - 3:50 pm  James M. Bern

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**Spring 2023**

LEC Section: 01  MR 2:35 pm - 3:50 pm  James M. Bern

LAB Section: 03  T 2:30 pm - 4:00 pm  James M. Bern

LAB Section: 02  T 1:00 pm - 2:30 pm  James M. Bern

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**CSCI 373** (F)(S) **Artificial Intelligence** (QFR)

Artificial Intelligence (AI) has become part of everyday life, but what is it, and how does it work? This course introduces theories and computational
techniques that serve as a foundation for the study of artificial intelligence. Potential topics include the following: Problem solving by search, Logic, Planning, Constraint satisfaction problems, Reasoning under uncertainty, Probabilistic graphical models, and Automated Learning.

Requirements/Evaluation: Evaluation based on assignments, projects, and exams.

Prerequisites: CSCI 136 and (CSCI 256 or permission of instructor)

Enrollment Limit: 24

Enrollment Preferences: current or expected Computer Science majors

Expected Class Size: 24

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: COGS Interdepartmental Electives

Fall 2022
LEC Section: 01 MWF 9:00 am - 9:50 am Mark Hopkins

Spring 2023
LEC Section: 01 MWF 9:00 am - 9:50 am Mark Hopkins

CSCI 374 (F) Machine Learning (QFR)

Machine learning is a field that derives from artificial intelligence and statistics, and is concerned with the design and analysis of computer algorithms that "learn" automatically through the use of data. Computer algorithms are capable of discerning subtle patterns and structure in the data that would be practically impossible for a human to find. As a result, real-world decisions, such as treatment options and loan approvals, are being increasingly automated based on predictions or factual knowledge derived from such algorithms. This course explores topics in supervised learning (e.g., random forests and neural networks), unsupervised learning (e.g., k-means clustering and expectation maximization), and possibly reinforcement learning (e.g., Q-learning and temporal difference learning.) It will also introduce methods for the evaluation of learning algorithms (with an emphasis on analysis of generalizability and robustness of the algorithms to distribution/environmental shift), as well as topics in computational learning theory and ethics.

Requirements/Evaluation: Presentations, problem sets, programming exercises, empirical analyses of algorithms, critical analysis of current literature; the final two weeks are focused on a project of the student's design.

Prerequisites: CSCI 136 and CSCI 256 or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: Current or expected Computer Science majors.

Expected Class Size: 24

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course heavily relies on discrete mathematics, calculus, and elementary statistics. Students will be proving theorems, among many other mathematically oriented assignments. Additionally, they will be programming, which involves analytical and logical thinking.

Attributes: COGS Interdepartmental Electives

Fall 2022
LEC Section: 01 MR 2:35 pm - 3:50 pm Rohit Bhattacharya

CSCI 375 (S) Natural Language Processing (QFR)

Natural language processing (NLP) is a set of methods for making human language accessible to computers. NLP underlies many technologies we use on a daily basis including automatic machine translation, search engines, email spam detection, and automated personalized assistants. These
methods draw from a combination of algorithms, linguistics and statistics. This course will provide a foundation in building NLP models to classify, generate, and learn from text data.

**Requirements/Evaluation:** Evaluation based on assignments, projects, and exams.

**Prerequisites:** CSCI 136, and either CSCI 256 or STAT 201/202.

**Enrollment Limit:** 24

**Enrollment Preferences:** current or expected Computer Science majors.

**Expected Class Size:** 24

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

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

**Quantitative/Formal Reasoning Notes:** The course will consist of programming assignments and problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

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**ECON 110 (F)(S) Principles of Microeconomics (QFR)**

This course is an introduction to the study of the forces of supply and demand that determine prices and the allocation of resources in markets for goods and services, markets for labor, and markets for natural resources. The focus is on how and why markets work, why they may fail to work, and the policy implications of both their successes and failures. The course focuses on developing the basic tools of microeconomic analysis and then applying those tools to topics of popular or policy interest such as minimum wage legislation, pollution control, competition policy, international trade policy, discrimination, tax policy, and the role of government in a market economy.

**Requirements/Evaluation:** problem sets, quizzes, short essays, two midterms, final exam

**Prerequisites:** none

**Enrollment Limit:** 40

**Enrollment Preferences:** This course is required of Economics and Political Economy majors and highly recommended for those non-majors interested in Environmental Studies and Women's, Gender and Sexuality Studies.

**Expected Class Size:** 40

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

**Unit Notes:** The department recommends students follow this course with ECON 120 or with a lower-level elective that has ECON 110 as its prerequisite; students may alternatively proceed directly to ECON 251 after taking this introductory course.

**Distributions:** (D2) (QFR)

**Quantitative/Formal Reasoning Notes:** Course involves mathematical modeling of real-world phenomena, analyzing quantitative results, and describing those results in words.

**Attributes:** POEC Required Courses

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**Fall 2022**

LEC Section: 01  MWF 11:00 am - 12:15 pm  Ralph M. Bradburd

LEC Section: 03  TF 2:35 pm - 3:50 pm  Matthew Chao

LEC Section: 04  TR 8:30 am - 9:45 am  Neal J. Rappaport

LEC Section: 02  TF 1:10 pm - 2:25 pm  Matthew Chao

LEC Section: 06  TR 11:20 am - 12:35 pm  Owen Thompson

LEC Section: 05  TR 9:55 am - 11:10 am  Owen Thompson

**Spring 2023**

LEC Section: 01  TR 9:55 am - 11:10 am  Ralph M. Bradburd

LEC Section: 02  TR 11:20 am - 12:35 pm  Ralph M. Bradburd
ECON 120  (F)(S) Principles of Macroeconomics  (QFR)
This course provides an introduction to the study of the aggregate national economy. It develops the basic theories of macroeconomics and applies them to topics of current interest. Issues to be explored include: the causes of inflation, unemployment, recessions, and depressions; the role of government fiscal and monetary policy in stabilizing the economy; the determinants of long-run economic growth; the long- and short-run effects of taxes, budget deficits, and other government policies on the national economy; the role of financial frictions in amplifying recessions; and the workings of exchange rates and international finance.

Requirements/Evaluation: Depending on instructor, may include: problem sets, short essays, quizzes, reading assignments, either one or two midterms, and a final exam.
Prerequisites: ECON 110
Enrollment Limit: 40
Enrollment Preferences: First-year students and sophomores.
Expected Class Size: 40
Grading: yes pass/fail option, yes fifth course option
Distributions: (D2) (QFR)
Quantitative/Formal Reasoning Notes: Course involves mathematical modeling of real-world phenomena, analyzing quantitative results, and describing those results in words.
Attributes: POEC Required Courses

Fall 2022
LEC Section: 01    TR 9:55 am - 11:10 am     Will Olney
LEC Section: 02    TR 11:20 am - 12:35 pm     Will Olney

Spring 2023
LEC Section: 02    TR 11:20 am - 12:35 pm     Sara LaLumia
LEC Section: 03    MR 1:10 pm - 2:25 pm     Steven E. Nafziger
LEC Section: 01    TR 9:55 am - 11:10 am     Sara LaLumia
LEC Section: 04    MWF 9:00 am - 9:50 am     Neal J. Rappaport
LEC Section: 05    MWF 10:00 am - 10:50 am     Neal J. Rappaport

ECON 213  (F) Introduction to Environmental and Natural Resource Economics  (QFR)
Cross-listings: ECON 213  ENVI 213
Primary Cross-listing
We'll use economics to learn why we harm the environment and overuse natural resources, and what we can do about it. We'll talk about whether and how we can put a dollar value on nature and ecosystem services. We'll study cost benefit analysis, pollution in general, climate change, environmental justice, natural resources (like fisheries, forests, and fossil fuels), and energy. We will take an economic approach to global sustainability, and study the relationship between the environment and economic growth and trade. Consideration of justice and equity will be woven through the whole semester.

Requirements/Evaluation: problem sets, short essays, final paper; intermediate assignments may include poster, presentation, brief writing assignment
Prerequisites: ECON 110 or equivalent
Enrollment Limit: 30
Enrollment Preferences: first-year and sophomore students
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Unit Notes: this course will count toward both the Environmental Studies major and concentration
This course is cross-listed and the prefixes carry the following divisional credit:

ECON 213 (D2) ENVI 213 (D2)

Quantitative/Formal Reasoning Notes: We will use formal theory expressed in math and graphs, perform calculations, and consume statistical data.

Attributes: ENVI Environmental Policy  EVST Social Science/Policy  MAST Interdepartmental Electives  POEC Comparative POEC/Public Policy

Courses

Fall 2022
LEC Section: 01    MR 2:35 pm - 3:50 pm     Sarah A. Jacobson

ECON 232  (F)  Financial Markets, Institutions and Policies  (QFR)

The focus of the course will be on how firms, financial markets, and central banks interact in the economy. Key questions addressed in the course include: How do firms allocate their resources to enhance their value? How are firms evaluated by the financial markets? How are asset prices determined, and how are these prices related to interest rates? Are financial markets efficient, and what are the implications of their efficiency or lack thereof? How does the financial system help with the management of risks faced by society? We will also study the role of the central bank (the Federal Reserve in the US), monetary policy, and government regulation and their impacts on financial decision making. Key questions include: How do central banks set monetary policy and how do those policies affect the economy and the financial decision-making process? How does monetary policy change when interest rates are (virtually) zero?

Class Format: There will be a mix of lecture and discussion.

Requirements/Evaluation: 5-7 Problem Sets, Quantitative Exercises, Group Paper, and Final Exam

Prerequisites: ECON 110 and ECON 120

Enrollment Limit: 25

Enrollment Preferences: Sophomore and Junior Economics majors

Expected Class Size: 25

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

Distributions: (D2)  (QFR)

Quantitative/Formal Reasoning Notes: We will use mathematical models, graphs, and data analysis to understand financial decisions at the firm and economy-wide levels.

Attributes: POEC Comparative POEC/Public Policy Courses

Fall 2022
LEC Section: 01    TR 9:55 am - 11:10 am     Neal J. Rappaport

ECON 240  (S)  Colonialism and Underdevelopment in South Asia  (DPE)  (QFR)

Cross-listings: ECON 240  ASIA 241

Primary Cross-listing

British colonial rule in South Asia shaped economy and society in fundamental ways. As resistance to colonial rule emerged in the late nineteenth century, "nationalist" writers developed a critique of its economic impact via taxation, fiscal policy, trade, and many other policies. In their turn, supporters of British rule, "apologists," argued that British rule had laid the foundations of economic growth by securing property rights, enforcing contracts, and developing infrastructure. The debate between "nationalists" and "apologists" has never quite ended, but after the recent growth of the Indian economy it has lost some of its emotional charge. We will use this opportunity to revisit the controversy.

Requirements/Evaluation: essays (one every other week) and responses to partner's essays will be evaluated

Prerequisites: one course in ECON

Enrollment Limit: 10

Enrollment Preferences: Economics major, prior course on South Asia

Expected Class Size: 10
Grading: no pass/fail option, no fifth course option

Distributions: (D2) (DPE) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
ECON 240 (D2), ASIA 241 (D2)

Difference, Power, and Equity Notes: Issues of difference, power, and equity are at the heart of any analysis of colonialism, hence the DPE designation.

Quantitative/Formal Reasoning Notes: Students will write six essays, in which they will employ economic models and engage with quantitative evidence, so the course satisfies the QFR requirement.

Attributes: GBST South + Southeast Asia Studies Electives POEC Comparative POEC/Public Policy Courses

Spring 2023
TUT Section: T1 TBA Anand V. Swamy

ECON 251 (F)(S) Price and Allocation Theory (QFR)
A study of the determination of relative prices and their importance in shaping the allocation of resources and the distribution of income. Subjects include: behavior of households in a variety of settings, such as buying goods and services, saving, and labor supply; behavior of firms in various kinds of markets; results of competitive and noncompetitive markets in goods, labor, land, and capital; market failure; government policies as sources of and responses to market failure; welfare criteria; limitations of mainstream analysis.

Requirements/Evaluation: Requirements vary by professor, but typically include frequent problem sets and multiple exams, including a final exam. They may also include one or more quizzes, short essays, collaborative projects, or presentations.

Prerequisites: ECON 110 and MATH 130 or its equivalent

Enrollment Limit: 30

Enrollment Preferences: Current or prospective Economics majors.

Expected Class Size: 30

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

Distributions: (D2) (QFR)

Quantitative/Formal Reasoning Notes: Course involves developing and analyzing mathematical models of real-world phenomena, grounded in tools like calculus and game theory. Students are assumed to be comfortable with topics from introductory calculus, including differentiation and integration.

Fall 2022
LEC Section: 03 MR 2:35 pm - 3:50 pm Stephen C. Sheppard
LEC Section: 01 MW 11:00 am - 12:15 pm Pamela Jakiela
LEC Section: 02 MR 1:10 pm - 2:25 pm Stephen C. Sheppard

Spring 2023
LEC Section: 02 MWF 11:00 am - 12:15 pm Ashok S. Rai
LEC Section: 01 MWF 8:30 am - 9:45 am Sarah A. Jacobson

ECON 252 (F)(S) Macroeconomics (QFR)
A study of aggregate economic activity: output, employment, inflation, and interest rates. The class will develop a theoretical framework for analyzing economic growth and business cycles. The theory will be used to evaluate policies designed to promote growth and stability, and to understand economic developments in the U.S. and abroad. Instructors may use elementary calculus in assigned readings, exams and lectures.

Requirements/Evaluation: Requirements vary by professor, but typically include frequent problem sets and/or written assignments, midterm(s), and a final exam.

Prerequisites: ECON 110 and 120 and MATH 130 or its equivalent

Enrollment Limit: 30

Enrollment Preferences: Current or prospective Economics majors.
Expected Class Size: 30

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

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: Course involves mathematical modeling of real-world phenomena, analyzing quantitative results, and describing those results in words.

Fall 2022
LEC Section: 02 TR 11:20 am - 12:35 pm Andrew T. Hessler
LEC Section: 01 TF 2:35 pm - 3:50 pm Peter L. Pedroni

Spring 2023
LEC Section: 01 MR 1:10 pm - 2:25 pm Kenneth N. Kuttner
LEC Section: 02 TF 1:10 pm - 2:25 pm Andrew T. Hessler
LEC Section: 03 TF 2:35 pm - 3:50 pm Andrew T. Hessler

ECON 255 (F)(S) Econometrics (QFR)
An introduction to the theory and practice of applied quantitative economic analysis. This course familiarizes students with the strengths and weaknesses of the basic empirical methods used by economists to evaluate economic theory against economic data. Emphasizes both the statistical foundations of regression techniques and the practical application of those techniques in empirical research, with a focus on understanding when a causal interpretation is warranted. Computer exercises will provide experience in using the empirical methods, but no previous computer experience is expected. Highly recommended for students considering graduate training in economics or public policy.

Requirements/Evaluation: Requirements vary by professor, but typically include frequent problem sets, multiple exams, a group project, and possible additional assignments or quizzes.

Prerequisites: MATH 130, plus STAT 161, 201 or 202 (or equivalent, including a score of 5 on the AP Statistics Exam), plus one course in ECON; STAT 101 will also serve as a prerequisite, but only if taken prior to the fall of 2018

Enrollment Limit: 30

Enrollment Preferences: Current or prospective Economics and Political Economy majors.

Expected Class Size: 30

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

Unit Notes: Students may substitute the combination of STAT 201 and 346 for ECON 255

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: Course teaches research tools necessary to analyze data.

Attributes: PHLH Statistics Courses POEC Required Courses

Fall 2022
LEC Section: 02 MR 2:35 pm - 3:50 pm Matthew Gibson
LEC Section: 01 MR 1:10 pm - 2:25 pm Matthew Gibson
LEC Section: 03 TR 8:30 am - 9:45 am Owen Ozier

Spring 2023
LEC Section: 02 TR 9:55 am - 11:10 am David J. Zimmerman
LEC Section: 01 TR 8:30 am - 9:45 am David J. Zimmerman
LEC Section: 03 MWF 8:30 am - 9:45 am David J. Zimmerman

ECON 345 (S) Growth Diagnostics (QFR)

Cross-listings: ECON 545 ECON 345

Primary Cross-listing
Evidence from across the developing world suggests that the "binding constraints" to economic growth can be remarkably heterogeneous--i.e., the growth potential of stagnating or underperforming economies may be unlocked in a large variety of ways. For instance, pre-reform China had been constrained by poor supply incentives in agriculture, whereas Brazil has been held back by an inadequate supply of credit, South Africa by poor employment incentives in manufacturing, El Salvador by insufficient production incentives in tradables, Zimbabwe by bad governance, and so forth.

How can developing-country policymakers determine country-specific constraints like these, thus enabling them to pragmatically pursue a selected set of growth-promoting policies rather than attempting to implement a "laundry list" of reforms that are naively based on "best practice" rules-of-thumb? This course will serve as a primer on "growth diagnostics," an empirically-driven analytical framework for identifying the most binding constraints to economic growth in a given country at a point in time, thereby allowing policymakers to develop well-targeted reforms for relaxing these constraints while being cognizant of the nation's prevailing economic, political, and social context. The course will first build on the basic theories and empirics of economic growth to elucidate the diagnostic framework and will then employ a wide range of country-specific case studies to demonstrate how the framework can be operationalized for policy making. Throughout the semester, students will be required to work in groups, each representing a given developing or emerging-market economy, in order to build a growth diagnostic for their group's assigned country by the end of the course.

Requirements/Evaluation: extensive class participation, two short (5-page) papers, two 15-page team papers comprising a country growth diagnostic, and a team presentation on the diagnostic

Prerequisites: for undergraduates ECON 251, ECON 252, and either ECON 255 or STAT 346

Enrollment Limit: 19

Enrollment Preferences: CDE fellows and senior Economics majors

Expected Class Size: 19

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

Distributions: (D2) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
ECON 545 (D2) ECON 345 (D2)

Quantitative/Formal Reasoning Notes: The course material will be draw heavily on mathematical and statistical models of economic growth and macroeconomic development, and students will be required to routinely develop mathematical models and/or conduct econometric analysis in their assignments.

Spring 2023

SEM Section: 01 TR 9:55 am - 11:10 am Quamrul H. Ashraf

ECON 371 (F) Time Series Econometrics and Empirical Methods for Macro (QFR)

Econometric methods in many fields including macro and monetary economics, finance and international growth and development, as well as numerous fields beyond economics, have evolved a distinct set of techniques which are designed to meet the practical challenges posed by the typical empirical questions and available time series data of these fields. The course will begin with an introductory review of concepts of estimation and inference for large data samples in the context of the challenges of multivariate endogeneous systems, and will then focus on associated methods for analysis of short dynamics such as vector autoregressive techniques and methods for analysis of long run dynamics such as cointegration techniques. Students will be introduced to concepts and techniques analytically, but also by intuition, learning by doing, and by computer simulation and illustration. The course is particularly well suited for economics majors wishing to explore advanced empirical methods, or for statistics, mathematics or computer science majors wishing to learn more about the ways in which the subject of their majors interacts with the fields of economics. The method of evaluation will include a term paper. ECON 252 and either STATS 346 or ECON 255 are formal prerequisites, although for students with exceptionally strong math/stats backgrounds these can be waived subject to instructor permission. Credit may not be earned for both ECON 371 and ECON 356.

Requirements/Evaluation: term paper and regular homework assignments

Prerequisites: ECON 252 and either ECON 255 or STATS 346

Enrollment Limit: 19

Enrollment Preferences: students wishing to write an honors thesis, and students with strong MATH/STAT/CSCI backgrounds

Expected Class Size: 19

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

Distributions: (D2) (QFR)
Fall 2022

SEM Section: 01    TF 1:10 pm - 2:25 pm    Peter L. Pedroni

**ECON 378  (F)  Long-Run Comparative Development  (QFR)**

The world today is marred by vast disparities in the standard of living, with about a 30-fold difference in real GDP per capita between the poorest and most affluent of nations. What are the causes of such differences in prosperity across countries? Are the origins of global inequality to be found in underlying differences among societies over the past few decades, the past few centuries, or the past few millennia? If contemporary differences in living standards have such "deep" historical roots, what scope exists for policies to reduce global inequality today? Can we expect inequality to be reduced through some natural process of macroeconomic development, or is it likely to persist unless acted upon by policy? This course will present a unified theory of economic growth for thinking about these and related questions. Examples of issues to be covered include: the Neoclassical growth model and its inefficacy for answering questions about development over long time horizons; Malthusian stagnation across societies during the pre-industrial stage of economic development; the importance of the so-called demographic transition and of human capital formation in the course of industrialization; the persistent influence of colonialism, slavery, and ethnic fragmentation in shaping the quality of contemporary politico-economic institutions; and the enduring effects of geography on comparative development, through its impact on the emergence of agriculture in early human societies and its influence in shaping the composition of traits in populations across the globe.

**Class Format:** discussion

**Requirements/Evaluation:** problem sets, at least one exam, a research paper, and a class presentation

**Prerequisites:** ECON 251, ECON 252, and either ECON 255 or STAT 346

**Enrollment Limit:** 25

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

**Expected Class Size:** 25

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

**Distributions:** (D2)  (QFR)

**Quantative/Formal Reasoning Notes:** The course material will draw heavily on mathematical and statistical models of economic growth and macroeconomic development. Students will be required to routinely develop and solve sophisticated mathematical models of economic growth, involving the rigorous application of solution concepts from constrained optimization and from optimal control theory. Students will also be required to perform some econometric analyses in their assignments.

**Attributes:** GBST Economic Development Studies Electives  POEC Comparative POEC/Public Policy Courses

Fall 2022

LEC Section: 01    TR 11:20 am - 12:35 pm    Quamrul H. Ashraf

**ECON 384  (S)  Corporate Finance  (QFR)**

This course analyzes the major financial decisions facing firms. While the course takes the perspective of a manager making decisions about both what investments to undertake and how to finance these projects, it will emphasize the underlying economic models that are relevant for these decisions. Topics include capital budgeting, links between real and financial investments, capital structure choices, dividend policy, and firm valuation. Additional topics may include issues in corporate risk management, corporate governance and corporate restructuring, such as mergers and acquisitions.

**Class Format:** Lecture / discussion

**Requirements/Evaluation:** class participation, problem sets, short quizzes, short projects such as case write ups, a midterm exam, a final exam and a research paper (possibly written with a partner)

**Prerequisites:** ECON 251, 252, and some familiarity with statistics (e.g., ECON 255)

**Enrollment Limit:** 28

**Enrollment Preferences:** Economics majors; senority
Expected Class Size: 28
Grading: yes pass/fail option, yes fifth course option
Distributions: (D2) (QFR)
Quantitative/Formal Reasoning Notes: The course uses quantitative models to evaluate decisions.

Spring 2023
LEC Section: 01  MR 2:35 pm - 3:50 pm  William M. Gentry

ECON 387 (S) Economics of Climate Change  (QFR)
Cross-listings: ECON 522  ENVI 387  ECON 387

Primary Cross-listing
This course introduces the economic view of climate change, including both theory and empirical evidence. Given the substantial changes implied by the current stock of greenhouse gases (GHGs) in the atmosphere, we will begin by looking at impacts on agriculture, health, income, and migration. We will consider the distribution of climate damages across poor and wealthy people, both within and across countries. Next we will study adaptation, including capital investments and behavioral changes. We will examine the sources of climate change, especially electricity generation and transportation, and think about optimal policies. Throughout the course we will discuss the limits of the economic approach, pointing out normative questions on which economic theory provides little guidance.

Requirements/Evaluation: problem sets, midterm, group presentation, final exam
Prerequisites: ECON 251, familiarity with statistics
Enrollment Limit: 25
Enrollment Preferences: Junior/Senior Economics majors and CDE fellows
Expected Class Size: 25
Grading: no pass/fail option, no fifth course option
Distributions: (D2) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
ECON 522 (D2) ENVI 387 (D2) ECON 387 (D2)
Quantitative/Formal Reasoning Notes: The course involves simple calculus-based theory and applied statistics.
Attributes: ENVI Environmental Policy  MAST Interdepartmental Electives  POEC Comparative POEC/Public Policy Courses

Spring 2023
LEC Section: 01  MR 1:10 pm - 2:25 pm  Matthew Gibson

ECON 389 (S) Tax Policy in Global Perspective  (QFR)
Cross-listings: ECON 514  ECON 389

Secondary Cross-listing
Government policy is important for economic development. To finance their policies, governments must build the fiscal capacity to implement a tax system. In turn, fiscal capacity--the ability for the government to raise revenue--depends on economic development. This endogeneity between fiscal capacity and economic development creates challenges for tax policy in developing countries. Given these challenges, what types of taxes should countries use to raise revenues? How can governments build the fiscal capacity to generate revenue to finance critical services? This class explores tax policy from a global and comparative perspective. Because most students will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are pertinent to developing countries. However, many tax policy lessons are universal so we will also learn about tax policies in developed countries, especially issues relevant for transnational transactions. Topics addressed include: how economic principles can be applied to the efficiency and equity consequences of tax policies; how personal income taxes, corporate income taxes, and value-added taxes are designed and administered and how they influence the economy; ideas for fundamental tax reforms; the debate over progressive taxes versus "flat" taxes; how taxes affect incentives to save and invest; how market failures and administrative problems may influence the optimality of tax policy; the implications of global capital flows and corporate tax avoidance for tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on foreign direct investment, labor supply, and tax evasion; tax policy towards natural resources such as minerals and oil; case
studies of efforts to reform tax administration and reduce tax evasion and corruption; taxes on land and property; taxes on imports and exports; presumptive taxation; and the informal economy and its implications for tax policy.

Requirements/Evaluation: midterm exam, several problem sets, two 10-page essays

Prerequisites: one public economics course or microeconomics course (ECON 504 or ECON 110), and one empirical methods course (POEC 253 or ECON 255, 502, or 503); students who have previously taken ECON 351 will not be enrolled

Enrollment Limit: 19

Enrollment Preferences: CDE students, but undergraduates with the prerequisites are welcome

Expected Class Size: 15-19

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:
ECON 514 (D2) ECON 389 (D2)

Quantative/Formal Reasoning Notes: The course builds on other QFR Reasoning econ classes.

Attributes: POEC Comparative POEC/Public Policy Courses POEC International Political Economy Courses

Spring 2023

SEM Section: 01 MR 2:35 pm - 3:50 pm Jon M. Bakija

ECON 471 (S) Topics in Advanced Econometrics (QFR)
The course uses both a practical and conceptual/theory based approach, with emphasis on methods of structural identification of dynamics in VARs and long run cointegration and nonlinear function estimation and analysis, both in conventional time series and especially panel time series which contain spatial dimensions. The course will also investigate methods of computer simulation related to these techniques. The course is well suited for students considering empirically oriented honors theses in fields that employ these techniques, such as macro, finance, growth, trade and development, as well as fields outside of economics that use time series data. It is also well suited for students majoring in economics, statistics, computer sciences or mathematics who wish to expand their econometrics training and understanding to a more advanced level.

Requirements/Evaluation: periodic homework assignments, term paper

Prerequisites: ECON 371

Enrollment Limit: 19

Enrollment Preferences: students with strong quantitative backgrounds, and to students intending to write an honors thesis

Expected Class Size: 19

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

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: Course will make use of mathematics, statistics and computer analysis for the conceptualization and implementation of the econometric topics that are taught.

Spring 2023

SEM Section: 01 M 7:00 pm - 9:40 pm Peter L. Pedroni

ECON 477 (F) Economics of Environmental Behavior (QFR)

Cross-listings: ECON 477 ENVI 376

Primary Cross-listing

A community maintains a fishery; a firm decides whether to get a green certification; you choose to fly home or stay here for spring break: behaviors of people and firms determine our impact on the environment. We'll use economics to model environmental behavior and to consider how policies can help or hurt the environment. Topics we'll study include: voluntary conservation, social norms and nudges, firm responses to mandatory and voluntary rules, and boycotts and divestment.

Class Format: Class sessions will largely consist of presentations and discussions of academic research papers, as well as lab sessions to work on
empirical exercises; we may break the class into groups for some discussions

Requirements/Evaluation: regular reading responses, empirical exercises, class participation, 2 oral presentations, and a final original research paper using an experiment, existing data, or theory

Prerequisites: ECON 251 and (ECON 255 or STAT 346)

Enrollment Limit: 19

Enrollment Preferences: senior Economics majors

Expected Class Size: 19

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:
ECON 477 (D2) ENVI 376 (D2)

Quantitative/Formal Reasoning Notes: The research students will consume and produce in the class will be based on math-based theory and/or econometric-based empirical analysis.

Attributes: ENVI Humanities, Arts + Social Science Electives MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

Fall 2022

SEM Section: 01  M 7:00 pm - 9:40 pm  Sarah A. Jacobson

ECON 514  (S)  Tax Policy in Global Perspective  (QFR)

Cross-listings: ECON 514  ECON 389

Primary Cross-listing

Government policy is important for economic development. To finance their policies, governments must build the fiscal capacity to implement a tax system. In turn, fiscal capacity—the ability for the government to raise revenue—depends on economic development. This endogeneity between fiscal capacity and economic development creates challenges for tax policy in developing countries. Given these challenges, what types of taxes should countries use to raise revenues? How can governments build the fiscal capacity to generate revenue to finance critical services? This class explores tax policy from a global and comparative perspective. Because most students will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are pertinent to developing countries. However, many tax policy lessons are universal so we will also learn about tax policies in developed countries, especially issues relevant for transnational transactions. Topics addressed include: how economic principles can be applied to the efficiency and equity consequences of tax policies; how personal income taxes, corporate income taxes, and value-added taxes are designed and administered and how they influence the economy; ideas for fundamental tax reforms; the debate over progressive taxes versus "flat" taxes; how taxes affect incentives to save and invest; how market failures and administrative problems may influence the optimality of tax policy; the implications of global capital flows and corporate tax avoidance for tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on foreign direct investment, labor supply, and tax evasion; tax policy towards natural resources such as minerals and oil; case studies of efforts to reform tax administration and reduce tax evasion and corruption; taxes on land and property; taxes on imports and exports; presumptive taxation; and the informal economy and its implications for tax policy.

Requirements/Evaluation: midterm exam, several problem sets, two 10-page essays

Prerequisites: one public economics course or microeconomics course (ECON 504 or ECON 110), and one empirical methods course (POEC 253 or ECON 255, 502, or 503); students who have previously taken ECON 351 will not be enrolled

Enrollment Limit: 19

Enrollment Preferences: CDE students, but undergraduates with the prerequisites are welcome

Expected Class Size: 15-19

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:
ECON 514 (D2) ECON 389 (D2)

Quantitative/Formal Reasoning Notes: The course builds on other QFR Reasoning econ classes.

Attributes: POEC Comparative POEC/Public Policy Courses POEC International Political Economy Courses
ECON 522 (S) Economics of Climate Change (QFR)

Cross-listings: ECON 522 ENVI 387 ECON 387

Secondary Cross-listing

This course introduces the economic view of climate change, including both theory and empirical evidence. Given the substantial changes implied by the current stock of greenhouse gases (GHGs) in the atmosphere, we will begin by looking at impacts on agriculture, health, income, and migration. We will consider the distribution of climate damages across poor and wealthy people, both within and across countries. Next we will study adaptation, including capital investments and behavioral changes. We will examine the sources of climate change, especially electricity generation and transportation, and think about optimal policies. Throughout the course we will discuss the limits of the economic approach, pointing out normative questions on which economic theory provides little guidance.

Requirements/Evaluation: problem sets, midterm, group presentation, final exam

Prerequisites: ECON 251, familiarity with statistics

Enrollment Limit: 25

Expected Class Size: 25

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

Distributions: (D2) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
ECON 522 (D2) ENVI 387 (D2) ECON 387 (D2)

Quantative/Formal Reasoning Notes: The course involves simple calculus-based theory and applied statistics.

Attributes: ENVI Environmental Policy MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

ECON 545 (S) Growth Diagnostics (QFR)

Cross-listings: ECON 545 ECON 345

Secondary Cross-listing

Evidence from across the developing world suggests that the "binding constraints" to economic growth can be remarkably heterogeneous--i.e., the growth potential of stagnating or underperforming economies may be unlocked in a large variety of ways. For instance, pre-reform China had been constrained by poor supply incentives in agriculture, whereas Brazil has been held back by an inadequate supply of credit, South Africa by poor employment incentives in manufacturing, El Salvador by insufficient production incentives in tradables, Zimbabwe by bad governance, and so forth. How can developing-country policymakers determine country-specific constraints like these, thus enabling them to pragmatically pursue a selected set of growth-promoting policies rather than attempting to implement a "laundry list" of reforms that are naively based on "best practice" rules-of-thumb?

This course will serve as a primer on "growth diagnostics," an empirically-driven analytical framework for identifying the most binding constraints to economic growth in a given country at a point in time, thereby allowing policymakers to develop well-targeted reforms for relaxing these constraints while being cognizant of the nation's prevailing economic, political, and social context. The course will first build on the basic theories and empirics of economic growth to elucidate the diagnostic framework and will then employ a wide range of country-specific case studies to demonstrate how the framework can be operationalized for policy making. Throughout the semester, students will be required to work in groups, each representing a given developing or emerging-market economy, in order to build a growth diagnostic for their group's assigned country by the end of the course.

Requirements/Evaluation: extensive class participation, two short (5-page) papers, two 15-page team papers comprising a country growth diagnostic, and a team presentation on the diagnostic

Prerequisites: for undergraduates ECON 251, ECON 252, and either ECON 255 or STAT 346
Enrollment Limit: 19

Expected Class Size: 19

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

Distributions: (D2) (QFR)

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

ECON 545 (D2) ECON 345 (D2)

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

ECON 545 (D2) ECON 345 (D2)

Quantative/Formal Reasoning Notes: The course material will be draw heavily on mathematical and statistical models of economic growth and macroeconomic development, and students will be required to routinely develop mathematical models and/or conduct econometric analysis in their assignments.

Spring 2023

SEM Section: 01    TR 9:55 am - 11:10 am     Quamrul H. Ashraf

ENVI 203  (F) Ecology  (QFR)

Cross-listings: BIOL 203  ENVI 203

Secondary Cross-listing

This course combines lectures & discussion with field and indoor laboratory activities to explore factors that determine the distribution and abundance of plants and animals in natural systems. The course begins with an overview of global environmental patterns and then builds from the population to ecosystem level. Throughout the course, we will emphasize the connection between basic ecological principles and current environmental issues. Selected topics include population dynamics (competition, predation, mutualism); community interactions (succession, food chains and diversity) and ecosystem function (biogeochemical cycles, energy flow). Laboratory activities are designed to engage students in the natural history of the region and build skills in data analysis and scientific writing.

Class Format: Six hours per week. Students will view pre-class lecture videos; class meetings will focus on discussion, synthesis, and application of course content.

Requirements/Evaluation: pre-class quizzes, lab reports, two mid-term exams, and a final exam

Prerequisites: BIOL 102, or ENVI 102, or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: students planning to pursue Biology and/or ENVI

Expected Class Size: 30

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

Unit Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

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

BIOL 203 (D3) ENVI 203 (D3)

Quantative/Formal Reasoning Notes: Much of the material in this course centers on the interpretation and application of mathematical models used to describe ecological systems. The laboratory section of this course also contains a large data analysis component (based in R). Students are introduced to t-tests, chi-square analysis, and regression.

Attributes: ENVI Natural World Electives  EVST Environmental Science

Fall 2022

LAB Section: 03    W 1:00 pm - 4:00 pm     Allison L. Gill

LAB Section: 04    R 1:00 pm - 4:00 pm     Allison L. Gill

LEC Section: 01    MWF 9:00 am - 9:50 am     Allison L. Gill

LAB Section: 02    T 1:00 pm - 4:00 pm     Allison L. Gill
ENVI 213  (F)  Introduction to Environmental and Natural Resource Economics  (QFR)

Cross-listings:  ECON 213  ENVI 213

Secondary Cross-listing

We'll use economics to learn why we harm the environment and overuse natural resources, and what we can do about it. We'll talk about whether and how we can put a dollar value on nature and ecosystem services. We'll study cost benefit analysis, pollution in general, climate change, environmental justice, natural resources (like fisheries, forests, and fossil fuels), and energy. We will take an economic approach to global sustainability, and study the relationship between the environment and economic growth and trade. Consideration of justice and equity will be woven through the whole semester.

Requirements/Evaluation: problem sets, short essays, final paper; intermediate assignments may include poster, presentation, brief writing assignment

Prerequisites:  ECON 110 or equivalent

Enrollment Limit:  30

Enrollment Preferences:  first-year and sophomore students

Expected Class Size:  30

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

Unit Notes:  this course will count toward both the Environmental Studies major and concentration

Distributions:  (D2)  (QFR)

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

ECON 213 (D2)  ENVI 213 (D2)

Quantative/Formal Reasoning Notes:  We will use formal theory expressed in math and graphs, perform calculations, and consume statistical data.

Attributes:  ENVI Environmental Policy  EVST Social Science/Policy  MAST Interdepartmental Electives  POEC Comparative POEC/Public Policy Courses

Fall 2022

LEC Section:  01  MR 2:35 pm - 3:50 pm  Sarah A. Jacobson

ENVI 215  (S)  Climate Changes  (QFR)

Cross-listings:  ENVI 215  GEOS 215

Secondary Cross-listing

Paleoclimatology is the reconstruction of past climate variability and the forces that drove the climate changes. The Earth's climate system is experiencing unprecedented and catastrophic change because of anthropogenic emission of greenhouse gases and land use change. Paleoclimatology allows humans to put modern climate changes into the context of the history of this planet, and shows how and why it is unprecedented and catastrophic. Each climate event we study from Earth's past teaches us lessons on why the climate system responds to anthropogenic perturbations, what climate changes we're committed to in the future, how long-lasting they will be, and what climate consequences we can avoid if we take action and reduce greenhouse gas emissions sooner. In this course, we will discuss the major mechanisms that cause natural climate variability, how climate of the past is reconstructed, and how climate models are used to test mechanisms that drive climate variation. With these tools, you will analyze and interpret data and model simulations from climate events from Earth's history, and apply these findings to anthropogenic climate changes happening now and that are projected to happen in the future. Laboratories and homework will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change. This course is in the Oceans and Climate group for the Geosciences major.

Class Format:  This class has three scheduled lectures per week, and one lab meeting per week which will consist of field excursions, lab exercises, problem solving and discussion

Requirements/Evaluation: lab exercises and homework (25%), three quizzes (50%), and a final project (25%)

Prerequisites:  100-level course in GEOS, CHEM, or PHYS or ENVI 102 or permission of instructor

Enrollment Limit:  24

Enrollment Preferences:  Geosciences majors and Environmental Studies majors and concentrators and Maritime Studies concentrators

Expected Class Size:  16
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:
ENVI 215 (D3) GEOS 215 (D3)

Quantative/Formal Reasoning Notes: Labs and homework include quantitative problem solving, visualization and analysis of quantitative data, and scientific computing with Matlab. No previous programming experience is assumed.

Attributes: ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans MAST Interdepartmental Electives

Spring 2023
LAB Section: 02 W 1:00 pm - 4:00 pm Mea S. Cook
LEC Section: 01 MWF 9:00 am - 9:50 am Mea S. Cook
LAB Section: 03 T 1:00 pm - 4:00 pm Mea S. Cook

ENVI 376 (F) Economics of Environmental Behavior (QFR)

Cross-listings: ECON 477 ENVI 376

Secondary Cross-listing

A community maintains a fishery; a firm decides whether to get a green certification; you choose to fly home or stay here for spring break: behaviors of people and firms determine our impact on the environment. We'll use economics to model environmental behavior and to consider how policies can help or hurt the environment. Topics we'll study include: voluntary conservation, social norms and nudges, firm responses to mandatory and voluntary rules, and boycotts and divestment.

Class Format: Class sessions will largely consist of presentations and discussions of academic research papers, as well as lab sessions to work on empirical exercises; we may break the class into groups for some discussions

Requirements/Evaluation: regular reading responses, empirical exercises, class participation, 2 oral presentations, and a final original research paper using an experiment, existing data, or theory

Prerequisites: ECON 251 and (ECON 255 or STAT 346)

Enrollment Limit: 19

Enrollment Preferences: senior Economics majors

Expected Class Size: 19

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:
ECON 477 (D2) ENVI 376 (D2)

Quantative/Formal Reasoning Notes: The research students will consume and produce in the class will be based on math-based theory and/or econometric-based empirical analysis.

Attributes: ENVI Humanities, Arts + Social Science Electives MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

Fall 2022
SEM Section: 01 M 7:00 pm - 9:40 pm Sarah A. Jacobson

ENVI 387 (S) Economics of Climate Change (QFR)

Cross-listings: ECON 522 ENVI 387 ECON 387

Secondary Cross-listing

This course introduces the economic view of climate change, including both theory and empirical evidence. Given the substantial changes implied by the current stock of greenhouse gases (GHGs) in the atmosphere, we will begin by looking at impacts on agriculture, health, income, and migration. We will consider the distribution of climate damages across poor and wealthy people, both within and across countries. Next we will study adaptation,
including capital investments and behavioral changes. We will examine the sources of climate change, especially electricity generation and transportation, and think about optimal policies. Throughout the course we will discuss the limits of the economic approach, pointing out normative questions on which economic theory provides little guidance.

Requirements/Evaluation: problem sets, midterm, group presentation, final exam
Prerequisites: ECON 251, familiarity with statistics
Enrollment Limit: 25
Enrollment Preferences: Junior/Senior Economics majors and CDE fellows
Expected Class Size: 25
Grading: no pass/fail option, no fifth course option
Distributions: (D2) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
ECON 522 (D2) ENVI 387 (D2) ECON 387 (D2)
Quantitative/Formal Reasoning Notes: The course involves simple calculus-based theory and applied statistics.
Attributes: ENVI Environmental Policy MAST Interdepartmental Electives POEC Comparative POEC/Public Policy Courses

Spring 2023
LEC Section: 01 MR 1:10 pm - 2:25 pm Matthew Gibson

ENVI 404 (F) Coastal Processes and Geomorphology (QFR)
Cross-listings: MAST 404 ENVI 404 GEOS 404
Secondary Cross-listing

Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces—wind, waves, storms, and people—that shape the coastal zone, as well as the geologic formations—sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs—that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change. Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

Class Format: lecture two times a week with a lab one time per week
Requirements/Evaluation: lab reports, quizzes, and an independent research project
Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.
Enrollment Limit: 12
Enrollment Preferences: senior Geosciences majors, then juniors
Expected Class Size: 10
Grading: yes pass/fail option, yes fifth course option
Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.
Distributions: (D3) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)

**Quantitative/Formal Reasoning Notes:** This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.

**Attributes:** ENVI Natural World Electives GEOS Group B Electives - Sediments + Life

Fall 2022
LEC Section: 01    MWF 8:30 am - 9:45 am    Alex A. Apotsos

**GEOS 215 (S) Climate Changes** (QFR)

**Cross-listings:** ENVI 215 GEOS 215

**Primary Cross-listing**

Paleoclimatology is the reconstruction of past climate variability and the forces that drove the climate changes. The Earth's climate system is experiencing unprecedented and catastrophic change because of anthropogenic emission of greenhouse gases and land use change. Paleoclimatology allows humans to put modern climate changes into the context of the history of this planet, and shows how and why it is unprecedented and catastrophic. Each climate event we study from Earth's past teaches us lessons on why the climate system responds to anthropogenic perturbations, what climate changes we're committed to in the future, how long-lasting they will be, and what climate consequences we can avoid if we take action and reduce greenhouse gas emissions sooner. In this course, we will discuss the major mechanisms that cause natural climate variability, how climate of the past is reconstructed, and how climate models are used to test mechanisms that drive climate variation. With these tools, you will analyze and interpret data and model simulations from climate events from Earth's history, and apply these findings to anthropogenic climate changes happening now and that are projected to happen in the future. Laboratories and homework will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change. This course is in the Oceans and Climate group for the Geosciences major.

**Class Format:** This class has three scheduled lectures per week, and one lab meeting per week which will consist of field excursions, lab exercises, problem solving and discussion

**Requirements/Evaluation:** lab exercises and homework (25%), three quizzes (50%), and a final project (25%)

**Prerequisites:** 100-level course in GEOS, CHEM, or PHYS or ENVI 102 or permission of instructor

**Enrollment Limit:** 24

**Enrollment Preferences:** Geosciences majors and Environmental Studies majors and concentrators and Maritime Studies concentrators

**Expected Class Size:** 16

**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:
ENVI 215 (D3) GEOS 215 (D3)

**Quantitative/Formal Reasoning Notes:** Labs and homework include quantitative problem solving, visualization and analysis of quantitative data, and scientific computing with Matlab. No previous programming experience is assumed.

**Attributes:** ENVI Natural World Electives EVST Environmental Science EXPE Experiential Education Courses GEOS Group A Electives - Climate + Oceans MAST Interdepartmental Electives

Spring 2023

LAB Section: 03    T 1:00 pm - 4:00 pm    Mea S. Cook

LEC Section: 01    MWF 9:00 am - 9:50 am    Mea S. Cook

LAB Section: 02    W 1:00 pm - 4:00 pm    Mea S. Cook

**GEOS 404 (F) Coastal Processes and Geomorphology** (QFR)

**Cross-listings:** MAST 404 ENVI 404 GEOS 404
Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces—wind, waves, storms, and people—that shape the coastal zone, as well as the geologic formations—sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs—that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change. Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

Class Format: lecture two times a week with a lab one time per week

Requirements/Evaluation: lab reports, quizzes, and an independent research project

Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.

Enrollment Limit: 12

Enrollment Preferences: senior Geosciences majors, then juniors

Expected Class Size: 10

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

Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.

Distributions: (D3) (QFR)

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

MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)

Quantitative/Formal Reasoning Notes: This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.

Attributes: ENVI Natural World Electives GEOS Group B Electives - Sediments + Life

Fall 2022

LEC Section: 01 MWF 8:30 am - 9:45 am Alex A. Apotsos

GEOS 414 (S) Reading Deep Time (QFR)

Ancient sedimentary rocks and the fossils they contain are time machines - direct windows into the deep history of life on Earth and the environments that life inhabited. In this course you will learn to "read" these deep time records by collecting, interpreting, and analyzing paleontological, stratigraphic, and sedimentological data. The course will be organized around a week-long spring break trip to explore the rocks of the House Range of Utah. The Cambrian and Ordovician strata of the House Range offers an outstanding record of one of the most important periods in Earth history, tracking the rise of animal ecosystems and major increases in fossil diversity. The first 6 weeks of class will be spent learning the fundamentals of quantitative methods in paleontology and stratigraphy (often referred to as historical geology). Labs will focus on skill building including learning basic coding in R (no experience needed or expected), and learning how to interpret paleontological, sedimentological, and stratigraphic data. We will also read widely on the field locality and on the Cambrian and Ordovician Periods. During the field trip, we will explore the House Range. Students will learn skills including interpreting geological maps, measuring stratigraphic sections, finding and identifying fossils, and correlating rock units across basins. We will collect samples and data on the field trip and bring them back to Williams. The second 6 weeks of the course will be spent processing and analyzing the samples and data collected during the field trip, culminating in final projects to be done in small groups. Students will help determine what data we will collect in the field and what projects emerge. Examples might be interpreting carbon isotopic analyses to reconstruct ancient
oceanographic conditions, biostratigraphic correlation using fossils to reconstruct basin dynamics, determining paleoenvironment based on analyses of thin sections, or digging into trilobite fossil preservation and evolutionary trends. Students will draw on previous experiences and course content in the Geosciences and bring small group research projects to completion by the end of the semester, which will be presented in poster form. This course fulfills the Geosciences Group B Elective: Sediments and Life.

**Class Format:** weekly lectures, paper discussions, and hands-on labs. Required week-long spring break field course.

**Requirements/Evaluation:** Short papers and lab assignments, spring break field course participation (REQUIRED), and a final group project presented in poster form.

**Prerequisites:** GEOS majors who have taken at least one of the following courses: GEOS 212, GEOS 203, GEOS 201, GEOS 301, GEOS 302, GEOS 312T, or permission of instructor.

**Enrollment Limit:** 12

**Enrollment Preferences:** Senior, and then Junior, Geosciences majors

**Expected Class Size:** 12

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

**Unit Notes:** As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major

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

**Quantitative/Formal Reasoning Notes:** This course will rely on the programming language R. Students will learn how to code in R, and will use R to analyze large data sets of geological data. The majority of labs, as well as the final project, will rely on R, statistical analyses, and wrangling data.

**Attributes:** GEOS Group B Electives - Sediments + Life

Spring 2023

LAB Section: 02  M 1:00 pm - 4:00 pm  Phoebe A. Cohen

SEM Section: 01  MW 11:00 am - 12:15 pm  Phoebe A. Cohen

**MAST 404  (F)  Coastal Processes and Geomorphology  (QFR)**

**Cross-listings:** MAST 404  ENVI 404  GEOS 404

**Secondary Cross-listing**

Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces--wind, waves, storms, and people--that shape the coastal zone, as well as the geologic formations--sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs--that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change. Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

**Class Format:** lecture two times a week with a lab one time per week

**Requirements/Evaluation:** lab reports, quizzes, and an independent research project

**Prerequisites:** Either GEOS 104 or GEOS 210; or permission of instructor. No prior knowledge is necessary, but this course does build on principles used to explore complex scientific challenges.

**Enrollment Limit:** 12

**Enrollment Preferences:** senior Geosciences majors, then juniors
Expected Class Size: 10
Grading: yes pass/fail option, yes fifth course option

Unit Notes: As a 400-level seminar, this capstone course is intended to build on and extend knowledge and skills students have developed during previous courses in the major. This course counts toward the GEOS Group B Electives - Sediments + Life.

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
MAST 404 (D3) ENVI 404 (D3) GEOS 404 (D3)

Quantative/Formal Reasoning Notes: This course will involve the use of MATLAB software to quantitatively analyze coastal process and geomorphological data.

Attributes: ENVI Natural World Electives GEOS Group B Electives - Sediments + Life

Fall 2022
LEC Section: 01 MWF 8:30 am - 9:45 am Alex A. Apotsos

MATH 130 (F)(S) 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: 50
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 2022
LEC Section: 02 MWF 12:00 pm - 12:50 pm Lori A. Pedersen
LEC Section: 01 MWF 11:00 am - 11:50 am Lori A. Pedersen

Spring 2023
LEC Section: 01 MWF 10:00 am - 10:50 am Lori A. Pedersen

MATH 140 (F)(S) 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

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Bhagya Athukorallage
LEC Section: 02  MWF 10:00 am - 10:50 am  Bhagya Athukorallage

Spring 2023
LEC Section: 01  MWF 11:00 am - 11:50 am  Lori A. Pedersen

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

Fall 2022
LEC Section: 02  MWF 11:00 am - 11:50 am  Colin C. Adams
LEC Section: 01  MWF 10:00 am - 10:50 am  Colin C. Adams
LEC Section: 03  MWF 12:00 pm - 12:50 pm  Colin C. Adams

Spring 2023
LEC Section: 01  MWF 9:00 am - 9:50 am  Steven J. Miller

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.

Requirements/Evaluation: problem sets and exams

Prerequisites: AP BC 3 or higher or integral calculus with infinite series

Enrollment Limit: 50
Enrollment Preferences: First-years, sophomores, and juniors

Expected Class Size: 40

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

Unit Notes: MATH 151 satisfies any MATH 150 prerequisite; credit will not be given for both MATH 150 and MATH 151

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course builds quantitative skills

Fall 2022
LEC Section: 01  MWF 8:00 am - 8:50 am  Susan R. Loepp
LEC Section: 03  MWF 10:00 am - 10:50 am  Susan R. Loepp
LEC Section: 02  MWF 9:00 am - 9:50 am  Susan R. Loepp

MATH 200  (F)(S)  Discrete Mathematics  (QFR)
In contrast to calculus, which is the study of continuous processes, this course examines the structure and properties of finite sets. Topics to be covered include mathematical logic, elementary number theory, mathematical induction, set theory, functions, relations, elementary combinatorics and probability, and graphs. Emphasis will be given on the methods and styles of mathematical proofs, in order to prepare the students for more advanced math courses.

Requirements/Evaluation: Fall: Homework, proof portfolio, group work, presentations, quizzes/exams, reflections. Spring: The grade will be based on homework and 4 exams.

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)

Quantative/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.

Fall 2022
LEC Section: 01  TR 8:30 am - 9:45 am  Daniel Condon
LEC Section: 02  TR 9:55 am - 11:10 am  Daniel Condon

Spring 2023
LEC Section: 01  TR 8:30 am - 9:45 am  Daniel Condon
LEC Section: 02  TR 9:55 am - 11:10 am  Daniel Condon

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. An optional session 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 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

Spring 2023
LEC Section: 01 TR 9:55 am - 11:10 am Daniel P. Aalberts

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: 60

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

Fall 2022
LEC Section: 02 TR 9:55 am - 11:10 am Thomas A. Garrity
LEC Section: 01 TR 8:30 am - 9:45 am Thomas A. Garrity

Spring 2023
LEC Section: 01 MWF 10:00 am - 10:50 am Jenna Zomback
LEC Section: 02 MWF 11:00 am - 11:50 am Jenna Zomback

MATH 307 (F)(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:** 24

**Enrollment Preferences:** Preference given to majors and prospective majors.

**Expected Class Size:** 24

**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.

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**Fall 2022**
LEC Section: 01 TR 8:30 am - 9:45 am Chad M. Topaz

**Spring 2023**
LEC Section: 01 TR 8:30 am - 9:45 am Chad M. Topaz

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

**Cross-listings:** STS 363  WGSS 363  AMST 363  MATH 308

**Primary Cross-listing**
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 group will carry out a substantial project in an area such as criminal justice, education equity, environmental justice, health care equity, economic justice, or 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.

**Class Format:** This is a research-based tutorial.

**Requirements/Evaluation:** To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows an "ungrading" methodology.

**Prerequisites:** Across each 3 - 5 person tutorial group: 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:** 20

**Enrollment Preferences:** Students will be admitted in groups of 3 - 5 based on a proposal submitted prior to registration. The instructor is happy to facilitate formation of groups and to give feedback on draft proposals. Contact the instructor early, prior to preregistration.

**Expected Class Size:** 20

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

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

**This course is cross-listed and the prefixes carry the following divisional credit:**
STS 363 (D2) WGSS 363 (D2) AMST 363 (D2) MATH 308 (D3)

**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.

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**Fall 2022**
TUT Section: T1 TBA Chad M. Topaz

**Spring 2023**
TUT Section: T1 TBA Chad M. Topaz
**MATH 309  (F)(S)  Differential Equations  (QFR)**

Ordinary differential equations (ODEs) frequently arise as models of phenomena in the natural and social sciences. This course presents core ideas of ODEs from an applied standpoint. Topics covered early in the course may include numerical solutions, separation of variables, integrating factors, and constant coefficient linear equations. 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 information about the behavior of the ODEs without explicitly knowing the solution.

**Requirements/Evaluation:** quizzes/exams, problem sets, participation

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

**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)

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

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**Fall 2022**

LEC Section: 01  TR 11:20 am - 12:35 pm  Julie C. Blackwood

**Spring 2023**

LEC Section: 01  TR 9:55 am - 11:10 am  Julie C. Blackwood

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**MATH 311  (F)  Advanced topics in applied mathematics  (QFR)**

Applied mathematics is an expansive field that uses mathematical methods to explore problems that arise in biology, physics, engineering, and many other disciplines. In this course, we will explore a diversity of methods that may include stochastic processes, optimization, signal processing, and numerical analysis. We will also explore how these methods can be utilized to understand questions in other disciplines.

**Requirements/Evaluation:** This course will have some combination of problem sets, presentations, exams, and a final project

**Prerequisites:** Differential equations (Math 309) or permission of the instructor

**Enrollment Limit:** 10

**Enrollment Preferences:** If over-enrolled, the instructor will request a statement of interest

**Expected Class Size:** 10

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

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

**Quantitative/Formal Reasoning Notes:** Mathematics course

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**Fall 2022**

TUT Section: T1  TBA  Julie C. Blackwood

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**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.

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

**Prerequisites:** MATH 250 or permission of instructor

**Enrollment Limit:** 30

**Enrollment Preferences:** Students who have not taken Math 355 and seniors who need the course to complete the major and have no other options.
Expected Class Size: 30
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.

Spring 2023
LEC Section: 01     MWF 10:00 am - 10:50 am     Susan R. Loepp

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, or permission of the instructor.
Requirements/Evaluation: homework, exams, projects
Prerequisites: MATH 150, MATH 250 and one other 200-level or higher CSCI, MATH or STATS course, or permission from the instructor.
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)
Quantitative/Formal Reasoning Notes: 300 level mathematics course.

Fall 2022
LEC Section: 01     MWF 9:00 am - 9:50 am     Steven J. Miller

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: The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.

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, no fifth course option

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

Spring 2023

LAB Section: 02 TR 1:00 pm - 4:00 pm Lois M. Banta
SEM Section: 01 TR 9:55 am - 11:10 am Lois M. Banta

MATH 329 (S) Discrete Geometry (QFR)

Discrete geometry is one of the oldest and most consistently vibrant areas of mathematics, stretching from the Platonic Solids of the ancient Greeks to the modern day applications of convex optimization and linear programming. In this tutorial 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: Evaluation will be based primarily on participation, problem sets, oral presentations, a written midterm exam, an oral final exam, and a final project

Prerequisites: MATH 200 or Math 250, or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: First-years and sophomores

Expected Class Size: 10

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.

Spring 2023

TUT Section: T1 TBA Ralph E. Morrison

MATH 334 (F) 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, exams, and a short final project

Prerequisites: MATH 200 or MATH 250

Enrollment Limit: 30

Enrollment Preferences: Math majors
Expected Class Size: 25
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This course involves the writing of mathematical proofs.

Fall 2022
LEC Section: 01 MWF 11:00 am - 11:50 am Ralph E. Morrison

MATH 338 (S) Intermediate Logic (QFR)
Cross-listings: PHIL 338 MATH 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: (D3) (QFR)

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

Spring 2023
SEM Section: 01 Cancelled

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
**Math 341 (D3) Logic**

This course will introduce the main ideas and basic results of mathematical logic, and explain their applications to other areas of mathematics and computer science. We will begin with a study of first-order logic, covering structures and definability, theories, models and categoricity, as well as formal proofs. We will prove Gödel's completeness and compactness theorems and the Lowenheim-Skolem theorems. The course will briefly dive into computability theory, enough to prove Gödel's Incompleteness theorems and basic undecidability results.

**Requirements/Evaluation:** Evaluation based on homework, exams, and class participation.

**Prerequisites:** Math 250 - Linear Algebra

**Enrollment Limit:** 20

**Spring 2023**

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

**Math 344 (S) The Mathematics of Sports**

The purpose of this class is to use sports as a springboard to study applications of mathematics, especially in gathering data to build and test models and develop predictive statistics. Examples will be drawn from baseball, basketball, cross country, football, hockey, soccer, track, as well as class choices. Pre-requisites are linear algebra (Math 250) and either a 200 level statistics class or a 100 level programming class, or permission of the instructor.

**Requirements/Evaluation:** Homework, exams, projects

**Prerequisites:** Math 250: Linear Algebra

**Enrollment Limit:** 40

**Spring 2023**

LEC Section: 01  MWF 9:00 am - 9:50 am  Jenna Zomback

**Math 342 (F) Logic**

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

Spring 2023
LEC Section: 01    MWF 10:00 am - 10:50 am    Steven J. Miller

MATH 345 (S) Introduction to Numerical Analysis (QFR)
Numerical analysis is the study of algorithms that use numerical approximation to solve problems which arise in scientific applications. This course provides an introduction to the theory, development, and analysis of algorithms for obtaining numerical solutions. Topics discussed in the course include: Error Analysis and Convergence Rates of Algorithms; Root Finding for Nonlinear Equations; Approximating Functions using Lagrange Interpolation and Cubic Spline Approximation; Numerical Differentiation and Integration; Numerical Solution of Ordinary Differential Equations; Iterative Methods for Solving Linear Systems
Requirements/Evaluation: Evaluation will be based on homework, projects, and exams.
Prerequisites: Math 250
Enrollment Limit: 30
Enrollment Preferences: Mathematics and Statistics majors.
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is an advanced mathematics class that will cover the fundamental ideas of Numerical Analysis. The students will study in depths various algorithms that provide numerical solutions to various questions in science.

Spring 2023
LEC Section: 01    TR 8:30 am - 9:45 am    Bhagya Athukorallage

MATH 350 (F)(S) 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 do we mean when we say that? Perhaps most fundamentally, what is a real number? Real analysis addresses such questions, delving into the structure of real numbers and functions of them. Along the way we'll discuss sequences and limits, series, completeness, compactness, derivatives and integrals, and metric spaces. Results covered will include the Cantor-Schroeder-Bernstein theorem, the monotone convergence theorem, the Bolzano-Weierstrass theorem, the Cauchy criterion, Dirichlet's and Riemann's rearrangement theorem, the Heine-Borel theorem, the intermediate value theorem, and many others. This course is excellent preparation for graduate studies in mathematics, statistics, and economics.
Requirements/Evaluation: Problem sets, exams, and an expository essay.
Prerequisites: MATH 250 or permission of instructor.
Enrollment Limit: 40
Enrollment Preferences: Juniors and Seniors.
Expected Class Size: 25
Grading: no pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: It's math.

Fall 2022
LEC Section: 01    MR 2:35 pm - 3:50 pm    Leo Goldmakher

Spring 2023
LEC Section: 01    MR 2:35 pm - 3:50 pm    Leo Goldmakher

MATH 351 (S) Applied Real Analysis (QFR)
Real analysis or the theory of calculus (derivatives, integrals, continuity, convergence) starts with a deeper understanding of real numbers and limits. Applications in the calculus of variations or “infinite-dimensional calculus” include geodesics, harmonic functions, minimal surfaces, Hamilton's action and Lagrange's equations, optimal economic strategies, non-Euclidean geometry, and general relativity.

Requirements/Evaluation: homework, classwork, and exams
Prerequisites: MATH 150 and MATH 250 or permission of the instructor.

Enrollment Limit: 30
Enrollment Preferences: Seniors
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: Math

Spring 2023
LEC Section: 01  MR 2:35 pm - 3:50 pm  Mihai Stoiciu
LEC Section: 02  TR 11:20 am - 12:35 pm  Mihai Stoiciu

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
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Students who have officially declared a major that requires Math 355.
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: 300-level math course

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Ralph E. Morrison

Spring 2023
LEC Section: 02  MWF 12:00 pm - 12:50 pm  Thomas A. Garrity
LEC Section: 01  MWF 11:00 am - 11:50 am  Thomas A. Garrity

MATH 361  (F) Theory of Computation  (QFR)
Cross-listings: MATH 361  CSCI 361
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:** 48 (12/con)

**Enrollment Preferences:** current or expected Computer Science majors

**Expected Class Size:** 48

**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

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**Fall 2022**

CON Section: 04  MR 2:35 pm - 3:50 pm  Aaron M. Williams

CON Section: 05  TF 1:10 pm - 2:25 pm  Aaron M. Williams

CON Section: 03  MR 1:10 pm - 2:25 pm  Aaron M. Williams

LEC Section: 01  ASYN  Aaron M. Williams

CON Section: 02  MWF 11:00 am - 12:15 pm  Aaron M. Williams

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**MATH 374 (F) 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 plays an important role in math, physics, and data analysis. This course is excellent preparation for graduate programs in mathematics.

**Requirements/Evaluation:** Problem sets, exams, an expository essay.

**Prerequisites:** MATH 350 or 351; not open to students who have taken MATH 323. If you didn't cover metric spaces in real analysis, that's OK!

**Enrollment Limit:** 30

**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.

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**Fall 2022**

LEC Section: 01  TR 9:55 am - 11:10 am  Leo Goldmakher

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**MATH 393 (S) Research Topics in Combinatorics** (WS) (QFR)

Combinatorics provides techniques and tools to enumerate, examine, and investigate the existence of discrete mathematical structures with certain properties. There are numerous areas of applications including algebra, discrete geometry, and number theory. In this project-based research course students will work in small groups to learn combinatorial techniques and tools in order to develop research questions and begin tackling unsolved problems in combinatorics.

**Requirements/Evaluation:** Students will be evaluated through written drafts of a manuscript and its revisions and multiple in-class presentation.
Prerequisites: Math 355
Enrollment Limit: 19
Enrollment Preferences: Post-core mathematics majors
Expected Class Size: 19
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (WS) (QFR)

Writing Skills Notes: The main goal of this course is to undertake original research in combinatorics, as such student assessment is based on developing positive collaboration skills, and improving technical written and oral skills in mathematics through manuscript draft submissions and in-class presentations. Students will provide multiple drafts of their manuscript and in right of this the course will be writing intensive.

Quantative/Formal Reasoning Notes: The main goal of this course is to undertake original research in the math field of mathematics. See above for more details.

Spring 2023
SEM Section: 01 Cancelled

MATH 409  (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, exams, presentations.
Prerequisites: Real Analysis (either Math 350 or 351) and Abstract Algebra (Math 355), or permission of the instructor.
Enrollment Limit: 30
Enrollment Preferences: Math/stat senior 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 class.

Fall 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Steven J. Miller

MATH 412  (S)  Mathematical Biology  (QFR)
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 may include, but are not limited to, single and multi-species population dynamics, neural and biological oscillators, tumor cell growth, and infectious disease dynamics.

Requirements/Evaluation: problem sets, quizzes/exams, participation, final project and paper
Prerequisites: MATH 250 and MATH 309, or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: preference for senior math/stats major and also based on an interest statement
Expected Class Size: 30
Grading: yes pass/fail option, no fifth course option
Distributions: (D3) (QFR)

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

Attributes: PHLH Methods in Public Health

Spring 2023

LEC Section: 01  TR 11:20 am - 12:35 pm  Julie C. Blackwood

**MATH 413 (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: Evaluation will be based on weekly problem sets, three exams, and final project. Any students who have taken Math 411 should consult with the instructor before enrolling in this course.

Prerequisites: Math 355

Enrollment Limit: 30

Enrollment Preferences: Preference given to senior math majors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course is all quantitative and formal reasoning.

Spring 2023

LEC Section: 01  TR 9:55 am - 11:10 am  Ralph E. Morrison

**MATH 427 (S) Tiling Theory** (QFR)

Since people 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, types of tilings, random tilings, the classification of tilings and aperiodic tilings. We will also look at tilings of the sphere, tilings of the hyperbolic plane, and tilings in 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: 25

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: Mathematics course

Spring 2023

LEC Section: 01  MWF 9:00 am - 9:50 am  Colin C. Adams

**MATH 442 (F) Introduction to Descriptive Set Theory** (QFR)

Descriptive set theory (DST) combines techniques from analysis, topology, set theory, combinatorics, and other areas of mathematics to study...
definable (typically Borel) subsets of Polish spaces. The first part of this course will cover the topics necessary to understand the main objects of study in DST: we will develop comfort with point-set topology (enough to juggle with Polish spaces and Borel sets), and set theory (just well-orderings and cardinality). The second part of the course will feature selected topics in descriptive set theory: for example, trees, the perfect set property, Baire category, and infinite games.

**Requirements/Evaluation:** Evaluation based on homework, exams, and classroom participation.

**Prerequisites:** Math 250 - Linear Algebra, Math 350/351 Real Analysis/Applied Real Analysis

**Enrollment Limit:** 14

**Enrollment Preferences:** Senior Math Majors, then non-Senior Math Majors

**Expected Class Size:** 14

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

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

**Quantitative/Formal Reasoning Notes:** Mathematics course in descriptive set theory.
permission of instructor.

**Enrollment Limit:** 20

**Enrollment Preferences:** Juniors and seniors.

**Expected Class Size:** 10

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

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

**Quantative/Formal Reasoning Notes:** It's math.

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Spring 2023

LEC Section: 01    TF 2:35 pm - 3:50 pm     Leo Goldmakher

**PHIL 221** (F) **Introduction to Formal Linguistics** (QFR)

**Cross-listings:** COGS 224  PHIL 221

**Secondary Cross-listing**

The sentence “Every cookie is chocolate chip and three of them are oatmeal raisin” is a perfectly grammatical sentence of English, but it's self-contradictory. What does it take to realize this fact? One must grasp the meanings of the various parts of the sentence. In particular, one must grasp that “three of them” picks out a subset of the group picked out by “every cookie”, and that there's no such thing as a cookie that is both chocolate chip and oatmeal raisin. There two ways to understand "Many students took every class". According to one, there is a single group of students that had their hands extremely full this semester. According to the other, every class was well-populated, potentially by different groups. The reason for this is that there are two underlying structures that the original sentence can realize. This course serves as an introduction to formal methods in the scientific study of language. Our goal will be to characterize phenomena like those above with logical and mathematical precision. The focus will be on model-theoretic semantics, the sub-field of linguistics that studies meanings. Along the way we will discuss principles of syntax, the sub-field that studies sentence structures, and pragmatics, the sub-field that studies inferences of non-literal content. This is a formal course, but no prior logical or mathematical background will be expected. Starting from scratch, students will learn the building blocks of current-day linguistic research. This introduction will be of use to students interested in language from a variety of perspectives, including philosophy, cognitive science, and computer science.

**Requirements/Evaluation:** Weekly problem sets, plus a final project (paper/presentation/other type, to be discussed with instructor)

**Prerequisites:** No prerequisites

**Enrollment Limit:** 20

**Enrollment Preferences:** Preference given to seniors and philosophy/cognitive science majors.

**Expected Class Size:** 20

**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:

COGS 224 (D2) PHIL 221 (D2)

**Quantative/Formal Reasoning Notes:** This course teaches the fundamentals of the formal analysis of language. Students will learn to provide translation schemes from English to a logical language (typed lambda calculus).

**Attributes:** COGS Interdepartmental Electives  COGS Related Courses  Linguistics  PHIL Contemp Metaphysics + Epistemology Courses

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Fall 2022

SEM Section: 01    TF 1:10 pm - 2:25 pm     Christian De Leon

**PHIL 338** (S) **Intermediate Logic** (QFR)

**Cross-listings:** PHIL 338  MATH 338

**Primary 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:

PHIL 338 (D2) MATH 338 (D3)

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: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2023

SEM Section: 01 Cancelled

PHYS 109 (S) Sound, Light, and Perception (QFR)
Light and sound allow us to perceive the world around us, from appreciating music and art to learning the details of atomic structure. Because of their importance in human experience, light and sound have long been the subject of scientific inquiry. How are sound and light related? How do physiology and neural processing allow us to hear and see the world around us? What are the origins of color and musical pitch? This course introduces the science and technology of light and sound to students not majoring in physics. We will start with the origins of sound and light as wave phenomena, and go on to topics including color, the optics of vision, the meaning of musical pitch and tone, and the physical basis of hearing. We will also discuss some recent technological applications of light, such as lasers and optical communications. The class will meet for two 75-minute periods each week for a variable mixture of lecture, discussion, and hands-on, interactive experiments.

Class Format: each student will attend one lecture plus one conference section weekly

Requirements/Evaluation: class participation, problem sets, in-class exams, oral presentations, and a final exam, all with a quantitative component

Prerequisites: none

Enrollment Limit: 20

Enrollment Preferences: non-science majors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This class will have weekly problem sets requiring substantial quantitative reasoning

Spring 2023

LEC Section: 01 Cancelled

PHYS 131 (F) Introduction to Mechanics (QFR)
We focus first on the Newtonian mechanics of point particles: the relationship between velocity, acceleration, and position; the puzzle of circular motion; forces, Newton's laws, and gravitation; energy and momentum; and the physics of vibrations. Then we turn to the basic properties of waves, such as interference and refraction, as exemplified by sound and light waves. We also study the optics of lenses, mirrors and the human eye. This course is not intended for students who have successfully completed an AP physics course in high school.

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

**Prerequisites:** MATH 130; students who scored 4 or 5 on an AP physics exam, or 6 or 7 on the IB Physics HL exam may not take this course and are encouraged to take PHYS 141 instead

**Enrollment Limit:** 30

**Enrollment Preferences:** seniority

**Expected Class Size:** 60

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

**Unit Notes:** PHYS 131 can lead to either PHYS 132 (for students wanting a one-year survey of physics) or PHYS 142 (for students considering a Physics or Astrophysics major)

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

**Quantitative/Formal Reasoning Notes:** This class will have weekly problem sets requiring substantial quantitative reasoning

**Fall 2022**

LAB Section: 02  M 1:00 pm - 4:00 pm  Kevin R. Forkey, Brough Morris

LAB Section: 03  T 1:00 pm - 4:00 pm  Kevin R. Forkey, Brough Morris

LAB Section: 04  Cancelled

LEC Section: 01  MWF 11:00 am - 11:50 am  John H. Lacy

**PHYS 132 (S) Electromagnetism and the Physics of Matter (QFR)**

This course is intended as the second half of a one-year survey of physics with some emphasis on applications to medicine. In the first part of the semester we will focus on electromagnetic phenomena. We will introduce the concept of electric and magnetic fields and study in detail the way in which electrical circuits and circuit elements work. The deep connection between electric and magnetic phenomena is highlighted with a discussion of Faraday's Law of Induction. Following our introduction to electromagnetism we will discuss some of the most central topics in twentieth-century physics, including Einstein's theory of special relativity and some aspects of quantum theory. We will end with a treatment of nuclear physics, radioactivity, and uses of radiation.

**Class Format:** lecture three hours per week, laboratory three hours approximately every other week, and conference section 1 hour approximately every other week

**Requirements/Evaluation:** weekly problem sets, labs, quizzes and exams

**Prerequisites:** PHYS 131 or 141 or permission of instructor, and MATH 130 (formerly 103)

**Enrollment Limit:** 22 per lab

**Enrollment Preferences:** sophomores

**Expected Class Size:** 60

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

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

**Quantitative/Formal Reasoning Notes:** Significant homework, exams, quizzes requiring mathematical and physical reasoning.

**Spring 2023**

LAB Section: 02  M 1:00 pm - 4:00 pm  Kevin R. Forkey

LEC Section: 01  MWF 11:00 am - 11:50 am  Jennifer G. Winters

LAB Section: 03  T 1:00 pm - 4:00 pm  Kevin R. Forkey
PHYS 141  (F)  Mechanics and Waves  (QFR)
This is the typical first course for a prospective physics major. It covers most of the same topics as PHYS 131, but with a higher level of mathematical sophistication. It is intended for students with solid backgrounds in the sciences, either from high school or college, who are comfortable with basic calculus.

Class Format: lecture, three hours per week; laboratory, three hours approximately every other week; conference section, one hour approximately every other week

Requirements/Evaluation: weekly problem sets, labs, three or more short quizzes/tests, and a final exam, all of which have a substantial quantitative component

Prerequisites: high school physics and MATH 130 or equivalent placement, or permission of the instructor

Enrollment Limit: 30

Enrollment Preferences: first-year students and science majors

Expected Class Size: 30

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

Unit Notes: PHYS 141 can lead to either PHYS 132 (for students wanting a one-year survey of physics) or PHYS 142 (for students considering a Physics or Astrophysics major)

Distributions: (D3)  (QFR)

Quantative/Formal Reasoning Notes: This course consists of lectures, problem-solving conferences, lab exercises, problem sets and exams, all of which have a substantial quantitative component.

Fall 2022
LAB Section: 03  T 1:00 pm - 4:00 pm  Katharine E. Jensen

LEC Section: 01  MWF 11:00 am - 11:50 am  Katharine E. Jensen

LAB Section: 02  M 1:00 pm - 4:00 pm  Katharine E. Jensen

PHYS 142  (S)  Foundations of Modern Physics  (QFR)
Newtonian Mechanics, spectacular as it is in describing planetary motion and a wide range of other phenomena, only hints at the richness of behaviors seen in the universe. Special relativity, which extends physics into the realm of high speeds and high energies, requires we rethink our basic notions of space and time. Quantum mechanics successfully describes atoms, molecules, and solids while at the same time calling into question our expectation of what can be predicted by a physical theory. Statistical physics reveals new behaviors that emerge when many particles are present in a system. This course will survey ideas from each of these three arenas, and can serve either as a terminal course for those seeking to complete a year of physics or as the basis for future advanced study of these topics.

Class Format: lecture, three hours weekly; laboratory, 2-3 hours most weeks, alternating between 'hands-on' sessions and problem-solving/discussion sessions

Requirements/Evaluation: weekly homework, labs, two hour tests, and a final exam, all of which have a substantial quantitative component

Prerequisites: PHYS 141 and MATH 130, or equivalent; PHYS 131 may substitute for PHYS 141 with the permission of instructor; students may not take both PHYS 142 and PHYS 151

Enrollment Limit: 14/L

Enrollment Preferences: first-year students

Expected Class Size: 30

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

Distributions: (D3)  (QFR)

Quantative/Formal Reasoning Notes: Heavily problem-solving focused, involving algebraic manipulations, single-variable calculus, generating and reading graphs, etc.

Spring 2023
LAB Section: 03  T 1:00 pm - 4:00 pm  Jennifer G. Winters
PHYS 151 (F) Seminar in Modern Physics (QFR)
Newtonian Mechanics, spectacular as it is in describing planetary motion and a wide range of other phenomena, only hints at the richness of behaviors seen in the universe. Special relativity has extended physics into the realm of high speeds and high energies and requires us to rethink our basic notions of space and time. Quantum mechanics successfully describes atoms, molecules, and solids while at the same time calling into question our notions of what can be predicted by a physical theory. Statistical physics reveals new behaviors that emerge when many particles are present in a system. This course covers the same core material as PHYS 142 but in a small seminar format for students with strong prior preparation in physics.

Class Format: three 50-minute lecture/discussions per week, one 3-hour lab per week
Requirements/Evaluation: class participation, weekly lab assignments, weekly problem sets, exams
Prerequisites: placement by the department (see "advanced placement" section in the description about the department). Students may take either PHYS 142 or PHYS 151 but not both
Enrollment Limit: 18
Enrollment Preferences: first-years
Expected Class Size: 18
Grading: yes pass/fail option, yes fifth course option
Unit Notes: this is a small seminar designed for first-year students who have placed out of PHYS 141
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: all assignments in the course have a substantial quantitative component

Fall 2022
CON Section: 03 M 11:00 am - 11:50 am Jennifer G. Winters
LEC Section: 01 WF 11:00 am - 11:50 am Jennifer G. Winters
LAB Section: 02 W 1:00 pm - 4:00 pm Jennifer G. Winters

PHYS 201 (F) Electricity and Magnetism (QFR)
The classical theory of electricity and magnetism is very rich yet it can be written in a remarkably succinct form using Maxwell's equations. This course is an introduction to electricity and magnetism and their mathematical description, connecting electric and magnetic phenomena via the special theory of relativity. Topics include electrostatics, magnetic fields, electromagnetic induction, DC and AC circuits, and the electromagnetic properties of matter.
The laboratory component of the course is an introduction to electronics where students will develop skills in building and debugging electrical circuits.

Class Format: lecture, three hours per week; laboratory, three hours per week
Requirements/Evaluation: problem sets, labs/conference section assignments, two take-home midterms, and a final exam, all of which have a substantial quantitative component
Prerequisites: PHYS 142 OR 151; MATH 150 or 151; with a preference for MATH 151
Enrollment Limit: 10 per lab
Enrollment Preferences: prospective physics majors, then by seniority
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course involves significant problem-solving and mathematical analysis of phenomena using calculus, numerical methods, and other quantitative tools.

Fall 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Catherine Kealhofer
Waves and oscillations characterize many different physical systems, including vibrating strings, springs, water waves, sound waves, electromagnetic waves, and gravitational waves. Quantum mechanics even describes particles with wave functions. Despite these diverse settings waves exhibit several common characteristics, so that the understanding of a few simple systems can provide insight into a wide array of phenomena. In this course we begin with the study of oscillations of simple systems with only a few degrees of freedom. We then move on to study transverse and longitudinal waves in continuous media in order to gain a general description of wave behavior. The rest of the course focuses on electromagnetic waves and in particular on optical examples of wave phenomena. In addition to well known optical effects such as interference and diffraction, we will study a number of modern applications of optics such as short pulse lasers and optical communications. Throughout the course mathematical methods useful for higher-level physics will be introduced.

Class Format: lecture, three hours per week; laboratory, three hours per week

Requirements/Evaluation: problem sets, labs, midterm examinations, and a final exam, all of which have a substantial quantitative component

Prerequisites: PHYS 201; co-requisite: PHYS/MATH 210 or MATH 209 or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: sophomores

Expected Class Size: 20

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

Distributions: (D3) (QFR)

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

Spring 2023

PHYS 201 (S) Mathematical Methods for Scientists (QFR)

Cross-listings: PHYS 210 MATH 210

Primary 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. An optional session 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 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

Spring 2023

LEC Section: 01    TR 9:55 am - 11:10 am    Daniel P. Aalberts

**PHYS 301 (F) Quantum Physics (QFR)**

This course serves as a one-semester introduction to the formalism, and phenomenology of quantum mechanics. After a brief discussion of historical origins of the quantum theory, we introduce the Schrödinger wave equation, the concept of matter waves, and wave-packets. With this introduction as background, we will continue our discussion with a variety of one-dimensional problems such as the particle-in-a-box and the harmonic oscillator. We then extend this work to systems in two and three dimensions, including a detailed discussion of the structure of the hydrogen atom. Along the way we will develop connections between mathematical formalism and physical predictions of the theory. Finally, we conclude the course with a discussion of angular momentum and spins, with applications to atomic physics, entanglement, and quantum information.

**Class Format:** lecture, three hours per week; laboratory, three hours per week

**Requirements/Evaluation:** weekly problem sets, laboratory reports / write-ups, a midterm exam, and final exam, all of which have a substantial quantitative component

**Prerequisites:** PHYS 202 and PHYS/MATH 210 or MATH 309

**Enrollment Limit:** 20

**Enrollment Preferences:** physics majors

**Expected Class Size:** 15

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

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

**Quantitative/Formal Reasoning Notes:** Phys 301 relies heavily upon mathematics and quantitative reasoning in all elements, including problem sets, examinations, and laboratories.

Fall 2022

LAB Section: 02    T 1:00 pm - 4:00 pm    John H. Lacy

LEC Section: 01    MWF 9:00 am - 9:50 am    Protik K. Majumder

LAB Section: 04    M 1:00 pm - 4:00 pm    John H. Lacy

LAB Section: 03    W 1:00 pm - 4:00 pm    John H. Lacy

**PHYS 302 (S) Statistical Mechanics & Thermodynamics (QFR)**

Macroscopic objects are made up of huge numbers of fundamental particles interacting in simple ways--obeying the Schrödinger equation, Newton's and Coulomb's Laws--and these objects can be described by macroscopic properties like temperature, pressure, magnetization, heat capacity, conductivity, etc. In this course we will develop the tools of statistical physics, which will allow us to predict the cooperative phenomena that emerge in large ensembles of interacting particles. We will apply those tools to a wide variety of physical questions, including the behavior of gases, polymers, heat engines, biological and astrophysical systems, magnets, and electrons in solids.

**Class Format:** lecture/discussion three hours per week and weekly laboratory work

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

**Prerequisites:** required: PHYS 201, PHYS/MATH 210 or MATH 309; recommended: PHYS 202, PHYS 301

**Enrollment Limit:** 10 per lab

**Enrollment Preferences:** physics majors

**Expected Class Size:** 10 per lab

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

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

**Quantitative/Formal Reasoning Notes:** weekly problem sets, exams, and labs, all of which have a substantial quantitative component
PHYS 315 (S) Computational Biology (QFR)
This course will provide an overview of Computational Biology, the application of computational, mathematical, statistical, and physical
to interpret the rapidly expanding amount of biological data. Topics covered will include database searching, DNA
sequence alignment, clustering, RNA structure prediction, protein structural alignment, methods of analyzing gene expression, networks, and genome
assembly using techniques such as string matching, dynamic programming, hidden Markov models, and statistics.
Requirements/Evaluation: weekly Python programming assignments, code reviews, problem sets, plus a few quizzes and a final project
Prerequisites: programming experience (e.g., CSCI 136), mathematics (PHYS/MATH 210 or MATH 150), and physical science (PHYS 142 or 151, or
CHEM 151 or 153 or 155), or permission of instructor
Enrollment Limit: 10
Enrollment Preferences: courage
Expected Class Size: 8
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: problem sets and programming assignments
Attributes: BIGP Courses

PHYS 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: The lab for this course will meet for two afternoons per week. Some lab sessions will be shorter than 3 hours.
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, no fifth course option
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)

Quantitative/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

Spring 2023

SEM Section: 01  TR 9:55 am - 11:10 am  Lois M. Banta
LAB Section: 02  TR 1:00 pm - 4:00 pm  Lois M. Banta

PHYS 402  (S)  Applications of Quantum Mechanics  (QFR)

This course will explore a number of important topics in the application of quantum mechanics to physical systems, including perturbation theory, the variational principle and the semiclassical interaction of atoms and radiation. The course will finish up with three weeks on quantum optics including an experimental project on non-classical interference phenomena. Applications and examples will be taken mostly from atomic physics with some discussion of solid state systems.

Requirements/Evaluation: weekly problem sets, tutorial participation, presentations, and a final exam, all of which have a substantial quantitative component

Prerequisites: PHYS 301

Enrollment Limit: 10 per sec

Enrollment Preferences: Physics and Astrophysics Majors

Expected Class Size: 16

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

Distributions: (D3)  (QFR)

Quantitative/Formal Reasoning Notes: This course has weekly problem sets, all of which have a substantial quantitative component.

Spring 2023

TUT Section: T1  F 1:10 pm - 2:25 pm  David R. Tucker-Smith

PHYS 411  (F)  Classical Mechanics  (QFR)

This course will explore advanced topics in classical mechanics. Central ideas include the calculus of variations, the Lagrangian and Hamiltonian formulations of mechanics, phase space, central-force motion, non-inertial reference frames (including implications for physics on a rotating Earth), rigid-body rotations, and non-linear dynamics & chaos, with additional topics from continuum and fluid mechanics as time permits. Numerical and perturbative techniques will be developed and used extensively. We will also examine the ways in which classical mechanics informs other fields of physics. In addition to weekly tutorial meetings the class will meet weekly as a whole to introduce and discuss new material.

Requirements/Evaluation: weekly problem sets, tutorial participation, presentations, a final project, and a final exam, all of which have a substantial quantitative component

Prerequisites: PHYS 202 and PHYS/MATH 210 or MATH 309

Enrollment Limit: 10/section

Enrollment Preferences: majors

Expected Class Size: 20

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

Distributions: (D3)  (QFR)

Quantitative/Formal Reasoning Notes: weekly problem sets requiring substantial quantitative reasoning using analytical and numerical methods.
POEC 253 (F) Empirical Methods in Political Economy (QFR)

This course introduces students to common empirical tools used in policy analysis and implementation. The broad aim is to train students to be discriminating consumers of public policy-relevant research. The emphasis in the course is on intuitive understanding of the central concepts. Through hands-on work with data and critical assessment of existing empirical social scientific research, students will develop the ability to choose and employ the appropriate tool for a particular research problem, and to understand the limitations of the techniques. Topics to be covered include basic principles of probability; random variables and distributions; statistical estimation, inference and hypothesis testing; and modeling using multiple regression, with a particular focus on understanding whether and how relationships between variables can be determined to be causal—an essential requirement for effective policy formation. Throughout the course, the focus will be on public policy applications relevant to the fields of political science, sociology, and public health, as well as to economics.

Requirements/Evaluation: Problem sets, group project, midterm exam, final exam

Prerequisites: MATH 130 or its equivalent; one course in ECON; not open to students who have taken ECON 255

Enrollment Limit: 20

Enrollment Preferences: Political Economy majors, Environmental Policy majors and sophomores

Expected Class Size: 15

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

Unit Notes: does not satisfy the econometrics requirement for the Economics major; POEC 253 cannot be substituted for ECON 255, or count as an elective towards the Economics major

Distributions: (D2) (QFR)

Quantitative/Formal Reasoning Notes: The course teaches econometrics, i.e. statistics as economists use it, with applications in economics, political science, and other fields.

Attributes: PHLH Statistics Courses POEC Required Courses

PSYC 201 (F)(S) Experimentation and Statistics (QFR)

An introduction to the basic principles of research in psychology. We focus on how to design and execute experiments, analyze and interpret results, and write research reports. Students conduct a series of research studies in different areas of psychology that illustrate basic designs and methods of analysis. You must register for lab and lecture with the same instructor.

Requirements/Evaluation: research reports, exams, and problem sets

Prerequisites: PSYC 101; not open to first-year students except with permission of instructor

Enrollment Limit: 16

Enrollment Preferences: Psychology majors

Expected Class Size: 16

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course has problem sets focused on experimental design and quantitative data analysis. Students will help design and conduct experiments, analyze the data, and report their findings.

Attributes: COGS Related Courses PHLH Statistics Courses

Fall 2022

LAB Section: A2 R 1:00 pm - 4:00 pm Amie A. Hane

LAB Section: B4 W 1:00 pm - 4:00 pm Catherine B. Stroud
STAT 101 (F)(S)  Elementary Statistics and Data Analysis  (QFR)

It is impossible to be an informed citizen in today's world without an understanding of data. Whether it is opinion polls, unemployment rates, salary differences between men and women, the efficacy of vaccines, etc, we need to be able to interpret and gain information from statistics. This course will introduce the common methods used to analyze and present data with an emphasis on interpretation and informed decision making.

Requirements/Evaluation:  weekly homework, quizzes, exams, and a project

Prerequisites:  MATH 102 (or demonstrated proficiency on a diagnostic test)

Enrollment Limit:  50

Enrollment Preferences:  juniors and seniors

Expected Class Size:  35

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

Unit Notes:  students with MATH130 but no statistics should enroll in STAT161; students with MATH150 but no statistics should enroll in STAT201.

Students with AP Stat 4/5 or STAT 101/161 should enroll in STAT 202.

Distributions:  (D3)  (QFR)

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

Attributes:  COGS Related Courses  PHLH Statistics Courses

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Fall 2022

LEC Section: 01  TF 1:10 pm - 2:25 pm  Elizabeth M. Upton

Spring 2023

LEC Section: 01  TF 1:10 pm - 2:25 pm  Elizabeth M. Upton

STAT 161 (F)(S)  Introductory Statistics for Social Science  (QFR)

This course will cover the basics of modern statistical analysis with a view toward applications in the social sciences. Topics include exploratory data analysis, linear regression, basic statistical inference, and elements of probability theory. The course focuses on the application of statistical tools to solve problems, to make decisions, and the use of statistical thinking to understand the world.

Requirements/Evaluation:  Weekly homework, quizzes, two midterms and a final exam (midterms include take-home components), and a data analysis project. Students will need to become familiar with the statistical software STATA.

Prerequisites:  MATH 130 (or equivalent); not open to students who have completed STAT 101 or equivalent

Enrollment Limit:  40

Enrollment Preferences:  Economics majors, sophomores

Expected Class Size:  40

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

Unit Notes:  Students with calculus background should consider STAT 201. Students without any calculus background should consider STAT 101. Students with AP Stat 4 or 5 should consider Stat 202. Please refer to the placement chart on the Math&Stat department website for more information.

Distributions:  (D3)  (QFR)
Quantitative/Formal Reasoning Notes: Reasoning with data

Attributes: PHLH Statistics Courses

Fall 2022
LEC Section: 01  MWF 9:00 am - 9:50 am  Anna M. Plantinga
LEC Section: 02  MWF 10:00 am - 10:50 am  Anna M. Plantinga

Spring 2023
LEC Section: 01  MWF 10:00 am - 10:50 am  Richard D. De Veaux

STAT 201 (F)(S) Statistics and Data Analysis (QFR)
Statistics can be viewed as the art and science of turning data into information. Real world decision-making, whether in business or science is often based on data and the perceived information it contains. Sherlock Holmes, when prematurely asked the merits of a case by Dr. Watson, snapped back, "Data, data, data! I can't make bricks without clay." In this course, we will study the basic methods by which statisticians attempt to extract information from data. These will include many of the standard tools of statistical inference such as hypothesis testing, confidence intervals, and linear regression as well as exploratory and graphical data analysis techniques. This is an accelerated introductory statistics course that involves computational programming and incorporates modern statistical techniques.

Requirements/Evaluation: weekly homework and projects, midterm exams, and a final exam.
Prerequisites: MATH 150 or equivalent; not open to students who have completed STAT 101 or STAT 161 or equivalent
Enrollment Limit: 30
Enrollment Preferences: Prospective Statistics majors, students for whom the course is a major prerequisite, and seniors
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option

Unit Notes: Students with AP Stat 4/5 or STAT 101/161 should enroll in STAT 202. Students with no calc or stats background should enroll in STAT 101. Students with MATH 140 but no statistics should enroll in STAT 161.
Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: Students will learn to interpret, choose, carry out, and communicate analyses of data.
Attributes: COGS Related Courses  PHLH Statistics Courses

Fall 2022
LEC Section: 02  MWF 11:00 am - 11:50 am  Stewart D. Johnson
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Stewart D. Johnson

Spring 2023
LEC Section: 01  MWF 9:00 am - 9:50 am  Anna M. Plantinga

STAT 202 (F)(S) Introduction to Statistical Modeling (QFR)
Data come from a variety of sources: sometimes from planned experiments or designed surveys, sometimes by less organized means. In this course we'll explore the kinds of models and predictions that we can make from both kinds of data, as well as design aspects of collecting data. We'll focus on model building, especially multiple regression, and talk about its potential to answer questions about the world -- and about its limitations. We'll emphasize applications over theory and analyze real data sets throughout the course.

Requirements/Evaluation: Homework problems; quizzes; exams; a final project (on a topic that interests you!). Participation matters! Engagement with your peers is an important part of learning, of being a statistician in the Real World...and of your evaluation in this course. While your assignments will be submitted (and graded) individually, you'll be responsible for giving and receiving peer feedback, contributing to class discussions, and working together with classmates on practice problems.
Prerequisites: MATH 140 and STAT 101/161/201/AP Statistics 4/5, or permission of instructor.
Enrollment Limit: 40
Enrollment Preferences: Prospective Statistics majors and more senior students
Expected Class Size: 25

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

Unit Notes: Students with a 4 on the AP Stats exam should contact the department for proper placement. Students with STAT 201 are strongly encouraged to take STAT 346 or other 300-level statistics electives.

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This course uses mathematical tools and computing programs to create models, make predictions, assess uncertainty, and describe data. We'll also emphasize choosing appropriate mathematical tools and interpreting their results in a real-world context.

Attributes: PHLH Statistics Courses

Fall 2022
LEC Section: 02 MWF 12:00 pm - 12:50 pm Richard D. De Veaux
LEC Section: 01 TF 1:10 pm - 2:25 pm Xizhen Cai

Spring 2023
LEC Section: 01 MWF 12:00 pm - 12:50 pm Xizhen Cai
LEC Section: 02 TR 9:55 am - 11:10 am Daniel B. Turek

STAT 341 (F)(S) Probability (QFR)

Cross-listings: STAT 341 MATH 341

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

Spring 2023
LEC Section: 01 TF 2:35 pm - 3:50 pm Mihai Stoiciu

STAT 344 (F) Statistical Design of Experiments (QFR)

When you hear the word experiment you might be picturing white lab coats and pipettes, but businesses, especially e-commerce, are constantly experimenting as well. How do you get the most out of both scientific and business investigations? By doing the right experiment in the first place.
We'll explore the techniques used to plan experiments that are both efficient and statistically sound. We'll learn how to analyze the data that come from these experiments and the conclusions we can draw from that analysis. We'll look at both classical tools like fractional factorial designs as well as optimal design, and see how these two frameworks differ in their philosophy and in what they can do. Throughout the course, we'll make extensive use
of both R and JMP software to work with real-world data.

Requirements/Evaluation: Homework problems—both individual and in groups, midterm, final, and projects (on topics that interest you!).

Prerequisites: STAT 161 or 201 or 202, or equivalent, and Math 140 or equivalent, or permission of instructor

Enrollment Limit: 20

Enrollment Preferences: Statistics majors, seniors, juniors, sophomores, first years

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course uses mathematical tools and computing programs to design experiments, analyze their results, and assess their effectiveness. We'll also emphasize choosing appropriate mathematical tools and interpreting their results in a real-world context.

Fall 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Richard D. De Veaux

STAT 346 (F)(S) Regression Theory and Applications (QFR)

This course focuses on the building of empirical models through data in order to predict, explain, and interpret scientific phenomena. Regression modeling is the most widely used method for analyzing and predicting a response data and for understand the relationship with explanatory variables. This course provides both theoretical and practical training in statistical modeling with particular emphasis on simple linear and multiple regression, using R to develop and diagnose models. The course covers the theory of multiple regression and diagnostics from a linear algebra perspective with emphasis on the practical application of the methods to real data sets. The data sets will be taken from a wide variety of disciplines.

Requirements/Evaluation: Weekly homework, theory and data analysis exams, final course project.

Prerequisites: MATH 250, and at least one of STAT 201 or 202. Or permission of the instructor.

Enrollment Limit: 30

Enrollment Preferences: Statistics Majors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course prepares students in the use of quantitative methods for the modeling, prediction and understanding of scientific phenomena.

Fall 2022
LEC Section: 01 TR 9:55 am - 11:10 am Xizhen Cai

Spring 2023
LEC Section: 01 TR 9:55 am - 11:10 am Elizabeth M. Upton

STAT 356 (F) Time Series Analysis (QFR)

Time series -- data collected over time -- crop up in applications from economics to engineering to transit. But because the observations are generally not independent, we need special methods to investigate them. This course will include exploratory methods and modeling for time series, including descriptive methods and checking for significance, and a foray into the frequency domain. We will emphasize applications to a variety of real data, explored using R.

Requirements/Evaluation: Evaluation is primarily based on quizzes and projects (on topics that interest you!). You'll be given the opportunity to assess your own work and resubmit/reattempt assignments as you gain mastery of a topic. Participation matters! Engagement with your peers is an important part of learning, of being a statistician in the Real World...and of your evaluation in this course. While most assignments will be submitted (and graded) individually, you'll be responsible for giving and receiving peer feedback, contributing to live and online discussions, and working together with classmates on practice problems.

Prerequisites: STAT 346 (may be taken concurrently) or permission of instructor
Enrollment Limit: 15
Enrollment Preferences: Statistics majors, seniors
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course uses mathematical tools and computing programs to create models, make predictions, assess uncertainty, and describe data. We'll also emphasize choosing appropriate mathematical tools and interpreting their results in a real-world context.

Fall 2022
LEC Section: 01 Cancelled

STAT 360 (S) Statistical Inference (QFR)
How do we estimate unknown parameters and express the uncertainty we have in our estimate? Is there an estimator that works best? Many topics from introductory statistics such as random variables, the central limit theorem, point and interval estimation and hypotheses testing will be revisited and put on a more rigorous mathematical footing. The focus is on maximum likelihood estimators and their properties. Bayesian and computer intensive resampling techniques (e.g., the bootstrap) will also be considered.

Requirements/Evaluation: Homework, Quizzes, Exams
Prerequisites: MATH 250, STAT 201 or 202, STAT 341
Enrollment Limit: 15
Enrollment Preferences: Statistics majors
Expected Class Size: 15
Grading: no pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: A rigorous mathematical course laying the foundation for reasoning with data

Spring 2023
LEC Section: 01 TR 11:20 am - 12:35 pm Daniel B. Turek

STAT 365 (F) Bayesian Statistics (QFR)
The Bayesian approach to statistical inference represents a reversal of traditional (or frequentist) inference, in which data are viewed as being fixed and model parameters as unknown quantities. Interest and application of Bayesian methods have exploded in recent decades, being facilitated by recent advances in computational power. We begin with an introduction to Bayes’ Theorem, the theoretical underpinning of Bayesian statistics which dates back to the 1700’s, and the concepts of prior and posterior distributions, conjugacy, and closed-form Bayesian inference. Building on this, we introduce modern computational approaches to Bayesian inference, including Markov chain Monte Carlo (MCMC), Metropolis-Hastings sampling, and the theory underlying these simple and powerful methods. Students will become comfortable with modern software tools for MCMC using a variety of applied hierarchical modeling examples, and will use R for all statistical computing.

Requirements/Evaluation: homework and exams
Prerequisites: STAT 201 and MATH 150 and 250, or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: juniors and seniors, Statistics majors
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: This course utilizes mathematics and computer-based tools for the Bayesian approach for analyzing data and making statistical inferences.
STAT 372 (S) Longitudinal Data Analysis (QFR)
This course explores modern statistical methods for drawing scientific inferences from longitudinal data, i.e., data collected repeatedly on experimental units over time. The independence assumption made for most classical statistical methods does not hold with this data structure because we have multiple measurements on each individual. Topics will include linear and generalized linear models for correlated data, including marginal and random effect models, as well as computational issues and methods for fitting these models. As time permits, we will also investigate joint modeling of longitudinal and time-to-event data. We will consider many applications in the social and biological sciences.

Requirements/Evaluation: Weekly homework, midterm exams, a final exam, and a data analysis project
Prerequisites: STAT 346 (and an appropriate introductory statistics course, typically STAT 201 or 202)
Enrollment Limit: 20
Enrollment Preferences: junior and senior Statistics majors
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: The course will cover a variety of statistical analysis methods for longitudinal data.
Attributes: PHLH Statistics Courses

Spring 2023
LEC Section: 01 MWF 11:00 am - 11:50 am Anna M. Plantinga

STAT 442 (S) Statistical Learning and Data Mining (QFR)
In both science and industry today, the ability to collect and store data can outpace our ability to analyze it. Traditional techniques in statistics are often unable to cope with the size and complexity of today's data bases and data warehouses. New methodologies in Statistics have recently been developed, designed to address these inadequacies, emphasizing visualization, exploration and empirical model building at the expense of traditional hypothesis testing. In this course we will examine these new techniques and apply them to a variety of real data sets.

Class Format: Students cannot take both STAT 315 and STAT 442. Only one of the two can be taken for credit.
Requirements/Evaluation: weekly homework, exams and an end-of-term project
Prerequisites: MATH/STAT 341 and STAT 346, or permission of instructor
Enrollment Limit: 20
Enrollment Preferences: Statistics majors, juniors and seniors. Students cannot take both STAT 315 and STAT 442. Only one of the two can be taken for credit.
Expected Class Size: 15
Grading: yes pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: This is an advanced statistics class involving theory and application of statistical methods to data.

Spring 2023
LEC Section: 01 MWF 10:00 am - 10:50 am Xizhen Cai

STAT 458 (F) Generalized Linear Models- Theory and Applications (QFR)
This course will explore generalized linear models (GLMs)--the extension of linear models, discussed in Stat346, to response variables that have specific non-normal distributions, such as counts and proportions. We will consider the general structure and theory of GLMs and see their use in a range of applications. As time permits, we will also examine extensions of these models for clustered data such as mixed effects models and generalized estimating equations.

Spring 2023
LEC Section: 01 MWF 10:00 am - 10:50 am Xizhen Cai
**Requirements/Evaluation:** Weekly homework consisting of theoretical exercises and data analyses carried out in R. Short frequent quizzes and one midterm (with an in-class and take-home component). Final project and final exam.

**Prerequisites:** STAT 346, or permission of instructor

**Enrollment Limit:** 20

**Enrollment Preferences:** Seniors and Statistics majors

**Expected Class Size:** 10

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

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

**Quantitative/Formal Reasoning Notes:** This is an intensive statistics course, involving theoretical and mathematical reasoning as well as the application of mathematical ideas to data using software.

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### Fall 2022

**LEC Section:** 01  TF 2:35 pm - 3:50 pm  Elizabeth M. Upton

**STS 363 (F)/(S) Mathematical and Computational Approaches to Social Justice** (DPE) (QFR)

**Cross-listings:** STS 363  WGSS 363  AMST 363  MATH 308

**Secondary Cross-listing**

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 group will carry out a substantial project in an area such as criminal justice, education equity, environmental justice, health care equity, economic justice, or 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.

**Class Format:** This is a research-based tutorial.

**Requirements/Evaluation:** To move towards a non-hierarchical, transparent, and egalitarian grading system, the instructor follows an "ungrading" methodology.

**Prerequisites:** Across each 3 - 5 person tutorial group: 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:** 20

**Enrollment Preferences:** Students will be admitted in groups of 3 - 5 based on a proposal submitted prior to registration. The instructor is happy to facilitate formation of groups and to give feedback on draft proposals. Contact the instructor early, prior to preregistration.

**Expected Class Size:** 20

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

**Distributions:** (D2) (DPE) (QFR)

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

STS 363 (D2)  WGSS 363 (D2)  AMST 363 (D2)  MATH 308 (D3)

**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.

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**Spring 2023**

**TUT Section:** T1  TBA  Chad M. Topaz

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**Fall 2022**

**TUT Section:** T1  TBA  Chad M. Topaz