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.

**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 remotely 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 2021

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 211 (S) Astronomical Observing and Data Analysis (QFR)**

How do astronomers make scientific measurements for objects that are light-years away from Earth? This course will introduce the basics of telescopes and observations and will give students hands-on training in the techniques astronomers use to obtain, process, and analyze scientific data. We will discuss observation planning, CCD detectors, signal statistics, image processing, and photometric and spectroscopic observations. We will begin by focusing on ground-based optical observations and will move on to non-optical observations, both electromagnetic (e.g., radio waves, X-rays) and non-electromagnetic (e.g., gravitational waves, neutrinos). Throughout the course, students will use computational techniques to work with real astronomical data, taken with our 24" telescope and from data archives.

**Class Format:** discussion, computer lab work, and observing

**Requirements/Evaluation:** weekly problem sets, lab work, and observing projects

**Prerequisites:** MATH 150 or 151; prior experience with Unix and computer programming is helpful, but not required

**Enrollment Limit:** 14
Enrollment Preferences: Astronomy or Astrophysics majors

Expected Class Size: 8

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: The course requires regular problem sets. Labs require computer programming and statistical and graphical analyses of data.

Spring 2022
LEC Section: 01 MR 1:10 pm - 2:25 pm Anne Jaskot, Kevin Flaherty
LAB Section: 02 W 1:10 pm - 3:50 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)

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

Spring 2022
IND Section: 01 TBA Jay M. Pasachoff

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 in-person laboratory provides further opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays. A laboratory section will also be provided for remote students, which will examine similar topics and techniques through literature and data analysis.

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

Requirements/Evaluation: quizzes, two midterm exams, 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 2021
LEC Section: 01  MWF 10:00 am - 10:50 am  Ben W. Thuronyi
LAB Section: 02  M 1:00 pm - 5:00 pm  Ben W. Thuronyi
LAB Section: 03  T 1:00 pm - 5:00 pm  Ben W. Thuronyi
LAB Section: 04  R 1:00 pm - 5:00 pm  Jenna L. MacIntire

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

BIOL 322 (D3) CHEM 322 (D3) BIMO 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 2022
LEC Section: 01  TR 9:55 am - 11:10 am  Cynthia K. Holland
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Janis E. Bravo
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 2021

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: ENVI 203 BIOL 203

Primary Cross-listing

This course combines lectures & discussion with field and indoor laboratory exercises 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 help students 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 101 or 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:
ENVI 203 (D3) BIOL 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  EVST Living Systems Courses

Fall 2021
LEC Section: 01  MWF 10:00 am - 10:50 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

BIOL 222  (S) Essentials of Biochemistry  (QFR)
This course will explore the biochemistry of cellular processes and contextualize these processes in healthy and diseased states. Lecture topics in this one semester course will include the structure and function of proteins (enzymes and non-enzymatic proteins), lipids, and carbohydrates. Lectures will also survey the major metabolic pathways (carbohydrates, lipids, and amino acids) with particular attention to enzyme regulation and the integration of metabolism in different tissues and under different metabolic conditions. In the discussion/laboratory component of the course a combination of primary literature, hypothesis-driven exercises, problem solving, and bench work will be used to illustrate how particular techniques and experimental approaches are used in biochemical fields.

Class Format: in-person lecture and lab
Requirements/Evaluation: regular quizzes, final exam, writing assignments (including problem sets), and lab assignments
Prerequisites: BIOL 101 and CHEM 156; not open to students who have taken BIOL 321 or BIOL 322
Enrollment Limit: 18
Enrollment Preferences: seniors who need to fulfill the biochemistry requirement for premedical school
Expected Class Size: 18
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 either BIOL 321 or BIOL 322; cannot be counted towards the BIMO concentration
Distributions:  (D3)  (QFR)
Quantitative/Formal Reasoning Notes: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Spring 2022
LEC Section: 01  TR 9:55 am - 11:10 am  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Pei-Wen Chen
LAB Section: 03  W 1:00 pm - 4:00 pm  Pei-Wen Chen

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 2022

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

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 in-person laboratory provides further opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays. A laboratory section will also be provided for remote students, which will examine similar topics and techniques through literature and data analysis.

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

Requirements/Evaluation: quizzes, two midterm exams, 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 2021

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

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

Cross-listings: BIOL 322  CHEM 322  BIMO 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 two 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: 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:

BIOL 322 (D3) CHEM 322 (D3) BIMO 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 2022

LEC Section: 01    TR 9:55 am - 11:10 am     Cynthia K. Holland
LAB Section: 02    T 1:00 pm - 4:00 pm     Janis E. Bravo
LAB Section: 03    W 1:00 pm - 4:00 pm     Janis E. Bravo
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 and discussion participation.

Prerequisites: BIOL 102, 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)

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 2021
LEC Section: 01  TR 11:20 am - 12:35 pm  Ron D. Bassar
LAB Section: 02  W 1:00 pm - 4:00 pm  Ron D. Bassar
LAB Section: 03  R 1:00 pm - 4:00 pm  Ron D. Bassar

CHEM 114 (S) The Science Behind Materials: Shaping the Past and Future of Society  (QFR)
We are surrounded by materials. They have fulfilled human needs since ancient times. From Phoenician glass to flexible OLED displays, materials have impacted society and changed the way humans lead their lives. What makes materials the way they are? Why are some brittle while others are ductile? How can we design materials with specific properties that will solve tomorrow’s problems? To answer these questions, we have to think about materials at the atomic scale, looking at how their smallest building blocks organize into specific structures. In this course, we will explore the relationships between structure, processing, and properties for a range of materials including metals, ceramics, polymers, and composites. We will talk about some of the cutting-edge research that materials scientists are working on today, concluding with an outlook to potential applications of emerging technologies.

Requirements/Evaluation: Weekly quizzes and problem sets, two exams, and a final paper
Prerequisites: not appropriate for CHEM, BIOL, PHYS majors, or for those who have taken CHEM 151, 153, or 155
Enrollment Limit: 20
Expected Class Size: 20
Grading: yes pass/fail option, yes fifth course option
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.

Spring 2022
LEC Section: 01  MR 1:10 pm - 2:25 pm  Amnon G Ortoll-Bloch

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); incoming first-year students are required to speak with a faculty member during First Days.
Enrollment Limit: 16/lab
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

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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. There may also be the opportunity for some hands-on laboratory experience for students who are on-campus. 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: quantitative weekly problem set assignments, laboratory work and reports, hour 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); incoming first-year students are required to speak with a faculty member during First Days.

Enrollment Limit: 35/lecture

Enrollment Preferences: incoming first year students also must speak with a faculty member during First Days

Expected Class Size: 70

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

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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); incoming first-year students are required to speak with a faculty member during First Days.

Enrollment Limit: 16/lab

Enrollment Preferences: first year students and sophomores; incoming first year students also must meet with a faculty member during First Days

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

Fall 2021
LEC Section: 01 MWF 8:00 am - 8:50 am Christopher Goh
LAB Section: 02 W 1:00 pm - 5:00 pm Christopher Goh
LAB Section: 03 R 1:00 pm - 5:00 pm Christopher Goh

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 placement exam or permission of instructor

Enrollment Limit: 50/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 2022
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 in-person laboratory provides further opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays. A laboratory section will also be provided for remote students, which will examine similar topics and techniques through literature and data analysis.

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

Requirements/Evaluation: quizzes, two midterm exams, 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 2021

LEC Section: 01  MWF 10:00 am - 10:50 am  Ben W. Thuronyi
LAB Section: 02  M 1:00 pm - 5:00 pm  Ben W. Thuronyi
LAB Section: 03  T 1:00 pm - 5:00 pm  Ben W. Thuronyi
LAB Section: 04  R 1:00 pm - 5:00 pm  Jenna L. McIntire

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

Cross-listings: BIOL 322  CHEM 322  BIMO 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 two 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: 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:

BIOL 322 (D3) CHEM 322 (D3) BIMO 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 2022

LEC Section: 01    TR 9:55 am - 11:10 am     Cynthia K. Holland

LAB Section: 02    T 1:00 pm - 4:00 pm     Janis E. Bravo
LAB Section: 03    W 1:00 pm - 4:00 pm     Janis E. Bravo
LAB Section: 04    R 1:00 pm - 4:00 pm     Janis E. Bravo

CHEM 368  (S) Computational Chemistry and Molecular Spectroscopy  (QFR)

This course 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)

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

Spring 2022
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: 36(12/lab)
Enrollment Preferences: if the course is over-enrolled, enrollment will be determined by lottery
Expected Class Size: 36
Grading: yes pass/fail option, yes fifth course option
Unit Notes: 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 2021
LEC Section: 01 MWF 10:00 am - 10:50 am Jeannie R Albrecht
LEC Section: 02 MWF 9:00 am - 9:50 am Shikha Singh
LAB Section: 03 M 1:10 pm - 2:25 pm Shikha Singh
LAB Section: 04 T 1:10 pm - 2:25 pm Jeannie R Albrecht
LAB Section: 05 M 1:10 pm - 2:25 pm Kelly A. Shaw
LAB Section: 06 M 2:35 pm - 3:50 pm Kelly A. Shaw
LAB Section: 07 T 1:10 pm - 2:25 pm Kelly A. Shaw
LAB Section: 08 T 2:35 pm - 3:50 pm Kelly A. Shaw
Spring 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Jeannie R Albrecht
LEC Section: 02 MWF 9:00 am - 9:50 am Rohit Bhattacharya
LAB Section: 03 M 1:10 pm - 2:25 pm Rohit Bhattacharya
LAB Section: 04 T 1:10 pm - 2:25 pm Jeannie R Albrecht
LAB Section: 05 M 1:10 pm - 2:25 pm Stephen N. Freund
LAB Section: 06 M 2:35 pm - 3:50 pm Stephen N. Freund
LAB Section: 07 T 1:10 pm - 2:25 pm Stephen N. Freund
LAB Section: 08 T 2:25 pm - 3:50 pm Stephen N. Freund

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:** 60 (12/lab)

**Enrollment Preferences:** if the course is over-enrolled, enrollment will be determined by lottery

**Expected Class Size:** 60

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

**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

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### Fall 2021

- **LEC Section: 01** MWF 9:00 am - 9:50 am  Duane A. Bailey
- **LEC Section: 02** MWF 10:00 am - 10:50 am  Duane A. Bailey
- **LEC Section: 03** MWF 11:00 am - 11:50 am  Aaron M. Williams
- **LAB Section: 04** R 9:55 am - 11:10 am  Duane A. Bailey
- **LAB Section: 05** R 1:10 pm - 2:25 pm  Duane A. Bailey
- **LAB Section: 06** R 2:35 pm - 3:50 pm  Aaron M. Williams
- **LAB Section: 07** W 1:10 pm - 2:25 pm  Aaron M. Williams
- **LAB Section: 08** W 2:35 pm - 3:50 pm  Duane A. Bailey

### Spring 2022

- **LEC Section: 01** MWF 9:00 am - 9:50 am  Daniel W. Barowy
- **LEC Section: 02** MWF 10:00 am - 10:50 am  Samuel McCauley
- **LEC Section: 03** MWF 11:00 am - 11:50 am  Samuel McCauley
- **LAB Section: 04** R 9:55 am - 11:10 am  Samuel McCauley
- **LAB Section: 05** R 1:10 pm - 2:25 pm  Samuel McCauley
- **LAB Section: 06** R 2:35 pm - 3:50 pm  Daniel W. Barowy
- **LAB Section: 07** R 1:10 pm - 2:25 pm  Daniel W. Barowy
- **LAB Section: 08** R 2:35 pm - 3:50 pm  Samuel McCauley

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**CSCI 237 (F)(S) Computer Organization** (QFR)

This course studies the basic instruction set architecture and organization of a modern computer. It provides a programmers 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:** 12 per 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.

Fall 2021
LEC Section: 01 MWF 12:00 pm - 12:50 pm Kelly A. Shaw
LAB Section: 02 R 9:55 am - 11:10 am Kelly A. Shaw
LAB Section: 03 R 11:20 am - 12:35 pm Kelly A. Shaw

Spring 2022
LEC Section: 01 MWF 12:00 pm - 12:50 pm Jeannie R Albrecht
LAB Section: 02 R 1:10 pm - 2:25 pm Jeannie R Albrecht
LAB Section: 03 R 2:35 pm - 3:50 pm Jeannie R Albrecht
LEC Section: 04 MWF 11:00 am - 11:50 am Kelly A. Shaw
LAB Section: 05 R 9:55 am - 11:10 am Kelly A. Shaw
LAB Section: 06 R 11:20 am - 12:35 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 2021
LEC Section: 01 MWF 11:00 am - 11:50 am Marina Barsky
LEC Section: 02 MWF 12:00 pm - 12:50 pm Marina Barsky

Spring 2022
LEC Section: 01 MWF 12:00 pm - 12:50 pm

CSCI 331 (F) Introduction to Computer Security (QFR)
This class explores common vulnerabilities in computer systems, how attackers exploit them, and how systems engineers design defenses to mitigate them. The goal is to be able to recognize potential vulnerabilities in one's own software and to practice defensive design. Hands-on experience writing assembly language and C code to inspect and modify the low-level operation of running programs is emphasized. Finally, regular reading and writing assignments round out the course to help students understand the cultural and historical background of the computer security "arms race."

Class Format: This course has twice-weekly lecture meetings as well as a weekly lab meeting.
**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:** 24

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

**Expected Class Size:** 24

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

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

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

Fall 2021

LEC Section: 01  MR 2:35 pm - 3:50 pm  Daniel W. Barowy

LAB Section: 02  W 1:10 pm - 2:25 pm  Daniel W. Barowy

LAB Section: 03  W 2:35 pm - 3:50 pm  Daniel W. Barowy

CSCI 357 (S) Algorithmic Game Theory  (QFR)

This course focuses on topics in game theory and mechanism design from a computational perspective. We will explore questions such as: how to design algorithms that incentivize truthful behavior, that is, where the participants have no incentive to cheat? Should we let drivers selfishly minimize their commute time or let a central algorithm direct traffic? Does Arrow's impossibility result mean that all voting protocols are doomed? The overarching goal of these questions is to understand and analyze selfish behavior and whether it can or should influence system design. Students will learn how to model and reason about incentives in computational systems both theoretically and empirically. Topics include types of equilibria, efficiency of equilibria, auction design and mechanism design with money, two-sided markets and mechanism design without money, incentives in computational applications such as P2P systems, and computational social choice.

**Requirements/Evaluation:** weekly problem sets and/or programming assignments, two midterm exams, and a final project.

**Prerequisites:** CSCI 256

**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 problem sets and programming assignments in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2022

LEC Section: 01 MR 2:35 pm - 3:50 pm Shikha Singh

CSCI 358 (F) Applied Algorithms (QFR)

This course is about bridging the gap between theoretical running time and writing fast code in practice. The course is divided into two basic topics. The first is algorithmic: we will discuss some of the most useful tools in a coder's toolkit. This includes topics like randomization (hashing, filters, approximate counters), linear and convex programming, similarity search, and cache-efficient algorithms. Our goal is to talk about why these efficient algorithms make seemingly difficult problems solvable in practice. The second topic is applications: we will discuss how to implement algorithms in an efficient way that takes advantage of modern hardware. Specific topics covered will include blocking, loop unrolling, pipelining, as well as strategies for performance analysis. Projects and assessments will include both basic theoretical aspects (understanding why the algorithms we discuss actually work), and practical aspects (implementing the algorithms we discuss to solve important problems, and optimizing the code so it runs as quickly as possible).

Requirements/Evaluation: Over the course of each week, there will be either an assignment or a mini-midterm. Assignments and mini-midterms have similar structure, with both a coding and problem set component, but mini-midterms will be weighted more heavily and must be completed individually. There will also be a take home final at the end of the year.

Prerequisites: CSCI 256 and 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 problem sets and programming assignments in which quantitative/formal reasoning skills are practiced and evaluated.

Fall 2021

LEC Section: 01 MR 1:10 pm - 2:25 pm Samuel McCauley

CSCI 361 (F)(S) 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: 24(12/con)
Enrollment Preferences: current or expected Computer Science majors

Expected Class Size: 24

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

Distributions: (D3) (QFR)

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

Quantitative/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 2021
LEC Section: 01    ASYN    Aaron M. Williams

CON Section: 02    TF 1:10 pm - 2:25 pm    Aaron M. Williams
CON Section: 03    MR 1:10 pm - 2:25 pm    Aaron M. Williams

Spring 2022
LEC Section: 01    ASYN    Aaron M. Williams

CON Section: 02    TF 1:10 pm - 2:25 pm    Aaron M. Williams
CON Section: 03    MR 1:10 pm - 2:25 pm    Aaron M. Williams

CSCI 379  (F)(S)  Causal Inference  (QFR)
Does X cause Y? If so, how? And what is the strength of this causal relation? Seeking answers to such causal (as opposed to associational) questions is a fundamental human endeavor; the answers we find can be used to support decision-making in various settings such as healthcare and public policy. But how does one tease apart causation from association—early in our statistical education we are taught that "correlation does not imply causation." In this course, we will re-examine this phrase and learn how to reason with confidence about the validity of causal conclusions drawn from messy real-world data. We will cover core topics in causal inference including causal graphical models, unsupervised learning of the structure of these models, expression of causal quantities as functions of observed data, and robust/efficient estimation of these quantities using statistical and machine learning methods. Concepts in the course will be contextualized via regular case studies.

Requirements/Evaluation: Problem sets, programming exercises, empirical analyses, case studies, and a final project.
Prerequisites: CSCI 136, and either CSCI 256 or STAT 201/202.

Enrollment Limit: 24

Enrollment Preferences: Computer science majors and prospective 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, algorithms, and elementary statistics. There will be regular assignments requiring rigorous quantitative or formal reasoning.

Attributes: COGS Interdepartmental Electives

Fall 2021
LEC Section: 01    TF 1:10 pm - 2:25 pm    Rohit Bhattacharya

Spring 2022
LEC Section: 01    TF 1:10 pm - 2:25 pm    Rohit Bhattacharya

CSCI 432  (S)  Operating Systems  (QFR)
This course explores the design and implementation of computer operating systems. Topics include historical aspects of operating systems development, systems programming, process scheduling, synchronization of concurrent processes, virtual machines, memory management and
virtual memory, I/O and file systems, system security, os/architecture interaction, and distributed operating systems.

Requirements/Evaluation: several implementation projects that will include significant programming, as well as written homework, and up to two exams

Prerequisites: CSCI 237 and either CSCI 256 or 334

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 substantial problem sets and/or programming assignments in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2022

LEC Section: 01    MW 8:30 am - 9:45 am     Duane A. Bailey
LAB Section: 02    M 1:10 pm - 2:25 pm     Duane A. Bailey
LAB Section: 03    M 2:35 pm - 3:50 pm     Duane A. Bailey

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

Fall 2021

LEC Section: 01    TR 9:55 am - 11:10 am     Susan Godlonton
LEC Section: 02    TR 11:20 am - 12:35 pm     Sara LaLumia
LEC Section: 03    TF 1:10 pm - 2:25 pm     Matthew Chao
LEC Section: 04    TF 2:35 pm - 3:50 pm     Matthew Chao
LEC Section: 05    MR 1:10 pm - 2:25 pm     Susan Godlonton
LEC Section: 06    MR 2:35 pm - 3:50 pm     Susan Godlonton

Spring 2022

LEC Section: 01    MWF 11:00 am - 12:15 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

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 2021
LEC Section: 01    TR 8:30 am - 9:45 am    Neal J. Rappaport

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 2021
LEC Section: 01    TF 1:10 pm - 2:25 pm    Pamela Jakiela
LEC Section: 02    TF 2:35 pm - 3:50 pm    Pamela Jakiela
LEC Section: 03    MR 1:10 pm - 2:25 pm    Ashok S. Rai
LEC Section: 04    MR 2:35 pm - 3:50 pm    Ashok S. Rai

Spring 2022
LEC Section: 01    TR 11:20 am - 12:35 pm    Pamela Jakiela

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: no 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.
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), 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)

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

Attributes: EVST Methods Courses PHLH Statistics Courses POEC Required Courses

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)

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 2022

SEM Section: 01 TR 11:20 am - 12:35 pm Quamrul H. Ashraf

ECON 360 (S) Monetary Economics (QFR)

This course covers a range of theoretical and applied issues bearing on monetary policy as conducted in the U.S. and abroad. Topics to be covered include: the causes of inflation, how central banks manage interest rates, the channels through which monetary policy affects the economy, and the costs and benefits of imposing rules on the conduct of policy. The class will also touch on a number of current issues facing central banks, such as unconventional monetary policy and cryptocurrencies.

Requirements/Evaluation: Two exams, a research paper and/or class presentation

Prerequisites: ECON 252 and 255. Multivariate calculus (MATH 150 or 151) is recommended but not required

Enrollment Limit: 20

Enrollment Preferences: junior and senior Economics majors

Expected Class Size: 20

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

Distributions: (D2) (QFR)

Quantative/Formal Reasoning Notes: The course entails the use of mathematical economic models, the presentation of quantitative information, and the interpretation of statistical analysis.

Attributes: GBST Economic Development Studies Electives POEC International Political Economy Courses

Spring 2022

LEC Section: 01 MWF 8:30 am - 9:45 am Kenneth N. Kuttner

ECON 373 (F) The Economics of Immigration (QFR)

This course will explore migration across national borders from an economic perspective, with a focus on migration to the United States. Who migrates, and why? What are the impacts on the economies of the origin country and the destination country, and on migrants themselves? What policies shape immigration and enforcement of immigration law, and what are their impacts? What is the role of immigrants in the broader society? We will emphasize empirical analysis as a data-driven way of understanding the economics of immigration.
**Class Format:** Class will periodically meet in a small-group seminar format.

**Requirements/Evaluation:** Requirements: active participation, 3 empirical assignments, 2 short papers, 2 presentations, and a final 12-15 page paper.

**Prerequisites:** Econ 251 and Econ 255, or permission of instructor

**Enrollment Limit:** 25

**Enrollment Preferences:** Economics majors

**Expected Class Size:** 25

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

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

**Quantitative/Formal Reasoning Notes:** This course will use quantitative tools of economics.

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**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)

**Quantitative/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

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**ECON 387  (F)  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:** 30

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

**Expected Class Size:** 30

**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

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**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, tax policy lessons are universal so we will 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:
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 2022

SEM Section: 01  MWF 8:30 am - 9:45 am  William M. Gentry
SEM Section: 01  MWF 8:30 am - 9:45 am  William M. Gentry

ECON 522  (F)  Economics of Climate Change  (QFR)
Cross-listings: ECON 522  ENVI 387  ECON 387

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: 30
Enrollment Preferences: Junior/Senior Economics majors and CDE fellows
Expected Class Size: 30
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

Fall 2021

LEC Section: 01  TF 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)

**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 2022

SEM Section: 01 TR 11:20 am - 12:35 pm Quamrul H. Ashraf

**ENVI 108 (F) Energy Science and Technology** (QFR)

**Cross-listings:** ENVI 108 PHYS 108

**Secondary Cross-listing**

Energy use has skyrocketed in the United States and elsewhere in the world, causing significant economic and political shifts, as well as concerns for the environment. This course will address the physics and technology of energy generation, consumption, and conservation. It will cover a wide range of energy sources, including fossil fuels, hydropower, solar energy, wind energy, and nuclear energy. We will discuss energy use in transportation, manufacturing, building heating, and building lighting. Students will learn to compare the efficiencies and environmental impacts of various energy sources and uses.

**Class Format:** twice a week, occasional lab exercises, and a field trip to the college heating plant, all during class hours

**Requirements/Evaluation:** weekly assignments, two hour tests, and a final project culminating in an oral presentation to the class and a 10-page paper; all of these will be substantially quantitative

**Prerequisites:** high school physics, high school chemistry, and mathematics at the level of MATH 130

**Enrollment Limit:** 20

**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:

ENVI 108 (D3) PHYS 108 (D3)

**Attributes:** ENVI Natural World Electives

Fall 2021

LEC Section: 01 TR 11:20 am - 12:35 pm Henrik Ronellenfitsch

**ENVI 203 (F) Ecology** (QFR)

**Cross-listings:** ENVI 203 BIOL 203

**Secondary Cross-listing**

This course combines lectures & discussion with field and indoor laboratory exercises 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 help students 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 101 or 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:**

ENVI 203 (D3) BIOL 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  EVST Living Systems Courses

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**ENVI 387  (F)  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:** 30

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

**Expected Class Size:** 30

**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.
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, tests, and an independent research project
Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor
Enrollment Limit: 12
Enrollment Preferences: senior Geosciences majors, then juniors
Expected Class Size: 10
Grading: yes pass/fail option, yes fifth course option

This course is cross-listed and the prefixes carry the following divisional credit:
ENVI 404 (D3) MAST 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
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:  30

Enrollment Preferences:  first-year students

Expected Class Size:  20

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

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

Distributions:  (D3)  (QFR)

Quantative/Formal Reasoning Notes:  This a calculus course.

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

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

MATH 140  (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 2021
LEC Section: 01    TR 9:55 am - 11:10 am     Thomas A. Garrity
LEC Section: 02    TR 11:20 am - 12:35 pm     Thomas A. Garrity

Spring 2022
LEC Section: 01    MWF 9:00 am - 9:50 am     Steven J. Miller

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 2021
SEM Section: 01 MWF 10:00 am - 10:50 am Julie C. Blackwood
SEM Section: 02 MWF 11:00 am - 11:50 am Julie C. Blackwood
SEM Section: 03 MWF 12:00 pm - 12:50 pm Julie C. Blackwood

Spring 2022
SEM Section: 01 MWF 10:00 am - 10:50 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: homework, quizzes, 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: 45

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)

Quantitative/Formal Reasoning Notes: This course builds quantitative skills

Fall 2021
LEC Section: 01 MWF 8:00 am - 8:50 am Colin C. Adams
LEC Section: 02 MWF 9:00 am - 9:50 am Colin C. Adams
LEC Section: 03 MWF 10:00 am - 10:50 am Colin C. Adams

MATH 200 (F)(S) Discrete Mathematics (QFR)
This course will help you understand the world through a mathematical lens and will develop your powers of argumentation and critical thinking. We will explore and utilize diverse areas of discrete mathematics including logic, set theory, functions and relations, combinatorics, probability, networks, and more. We also will discuss methods and styles of mathematical proofs in order to prepare you for more advanced math courses. Finally, while mathematical knowledge is often perceived as being “pure,” we will highlight some ways in which it is socially constructed and hence subject to human limitations and biases.

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

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

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

**Enrollment Limit:** 40

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

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

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

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

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Fall 2021
LEC Section: 01   TR 8:30 am - 9:45 am   Chad M. Topaz
LEC Section: 02   TR 9:55 am - 11:10 am   Chad M. Topaz

Spring 2022
LEC Section: 01   MWF 9:00 am - 9:50 am   Lori A. Pedersen
LEC Section: 02   MWF 10:00 am - 10:50 am   Lori A. Pedersen

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

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

**Secondary Cross-listing**

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

**Class Format:** three hours per week

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

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

**Enrollment Limit:** 50

**Enrollment Preferences:** sophomores and juniors

**Expected Class Size:** 30

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

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

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

PHYS 210 (D3) MATH 210 (D3)
Quantative/Formal Reasoning Notes: This course will have weekly problem sets using advanced calculus methods and some computer programming at the end of the course.

Spring 2022
LEC Section: 01   TR 9:55 am - 11:10 am   David R. Tucker-Smith

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

Requirements/Evaluation:  homework and exams
Prerequisites:  MATH 150/151 or MATH 200
Enrollment Limit:  40
Enrollment Preferences:  Students who have officially declared a major that requires Math 250.
Expected Class Size:  40
Grading:  yes pass/fail option,  yes fifth course option
Distributions:  (D3)  (QFR)
Quantative/Formal Reasoning Notes:  In this course, students will engage in both quantitative and formal reasoning.
Attributes:  COGS Related Courses

Fall 2021
LEC Section: 01   TR 9:55 am - 11:10 am   Allison Pacelli
LEC Section: 02   TR 11:20 am - 12:35 pm   Allison Pacelli

Spring 2022
LEC Section: 01   MWF 10:00 am - 10:50 am   Susan R. Loepp
LEC Section: 02   MWF 11:00 am - 11:50 am   Susan R. Loepp

MATH 303  (F) Introduction to Dynamics, p-Adics, and Measure  (QFR)
At its most basic level a dynamical system consists of a set of points and a transformation or map acting on the set (i.e., sending points in the set to other points in the set). In this setting we can already ask about the existence, and prevalence, of periodic points (points that come back to themselves). One can also ask about the orbit of a point: the set of points that is obtained as one iteratively applies the transformation the point. An important dynamical notion that comes up here is that of chaos. The course will start by studying basic dynamical systems using notions from calculus. Then we will introduce the p-adic numbers and use them to study dynamical systems. The course will end with an exploration of the notion of measure and its connection with dynamical systems.

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

Fall 2021
**MATH 307 (S) Computational Linear Algebra (QFR)**

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

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

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

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

**Enrollment Limit:** 30

**Enrollment Preferences:** Preference given to majors and prospective majors.

**Expected Class Size:** 30

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

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

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

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

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

**Class Format:** This is a research-based tutorial.

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

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

**Enrollment Limit:** 10

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

**Expected Class Size:** 10

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

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

**Difference, Power, and Equity Notes:** Students study issues of equity, diversity, and inclusion in areas such as criminal justice, arts/media, environmental justice, education, and health care, and along identity axes such as gender, race/ethnicity, disability status, and sexual orientation.
Quantative/Formal Reasoning Notes: Students use multiple mathematical, statistical, and computational frameworks to acquire, model, and analyze
real-world data.

Spring 2022
TUT Section: T1   TBA    Chad M. Topaz

MATH 309 (S) Differential Equations (QFR)
Ordinary differential equations (ODE) frequently arise as models of phenomena in the natural and social sciences. This course presents core ideas of
ODE from an applied standpoint. Topics covered early in the course may include numerical solutions, separation of variables, integrating factors,
constant coefficient linear equations, and power series solutions. Later, we will focus on nonlinear ODEs, for which it is usually impossible to find
analytical solutions. Tools from dynamical systems will be introduced to allow us to obtain some information about the behavior of the ODE without
explicitly knowing the solution.

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

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

Prerequisites: MATH 150/151 and MATH 250

Enrollment Limit: 20

Enrollment Preferences: discretion of the instructor

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: 300-level mathematics course

Spring 2022
LEC Section: 01   MWF 12:00 pm - 12:50 pm   Julie C. Blackwood

MATH 321 (S) Knot Theory (QFR)
Take a piece of string, tie a knot in it, and glue the ends together. The result is a knotted circle, known as a knot. For the last 100 years,
mathematicians have studied knots, asking such questions as, "Given a nasty tangled knot, how do you tell if it can be untangled without cutting it
open?" Some of the most interesting advances in knot theory have occurred in the last ten years. This course is an introduction to the theory of knots.
Among other topics, we will cover methods of knot tabulation, surfaces applied to knots, polynomials associated to knots, and relationships between
knot theory and chemistry and physics. In addition to learning the theory, we will look at open problems in the field.

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

Prerequisites: MATH 250 or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: seniors, junior, sophomores, first year

Expected Class Size: 25

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

Distributions: (D3) (QFR)

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

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

MATH 329 (F) Discrete Geometry (QFR)
Discrete geometry is one of the oldest and most consistently vibrant areas of mathematics, stretching from the Platonic Solids of antiquity to the
modern day applications of convex optimization and linear programming. In this course we will learn about polygons and their higher-dimensional cousins, polyhedra and polytopes, and the various ways to describe, compute, and classify such objects. We will learn how these objects and ideas can be applied to other areas, from computation and optimization to studying areas of math like algebraic geometry. Throughout this course we will be engaging with mathematical work and literature from as old as 500 BCE and as recent as "posted to the internet yesterday."

Requirements/Evaluation: Problem sets, exams, and a final project
Prerequisites: MATH 200 or Math 250, or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Sophomores, juniors, and seniors
Expected Class Size: 20
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: All of the content in this course is quantitative or formal reasoning.

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

MATH 335 (F) Decisions, Games, and Evolutionary Dynamics  (QFR)
Given goals, options, and uncertainty, how does one make a rational choice? What happens when we interact with others who are also choosing? How might this play out over time? We will first cover the principles of of decision theory including preference, uncertainty, utility, imperfect information, and rational choice. The majority of the course will be spent on the main topics of game theory: sequential games, bimatrix games, parlor games, Nash equilibria, bargaining, repeated games, Bayesian belief, and signaling. Applying these principles to populations that evolve over time through variation, selection, and copying, we will develop basic models of the dynamics of evolution.

Class Format: lecture
Requirements/Evaluation: Weekly homework, midterm exams, and a final.
Prerequisites: Math 150/151 and Math 250. Some background in probability and differential equations is highly recommended.
Enrollment Limit: 35
Enrollment Preferences: Math majors.
Expected Class Size: 35
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: Lots of math.

Fall 2021
LEC Section: 01  MWF 11:00 am - 11:50 am  Stewart D. Johnson

MATH 341 (F)(S) Probability  (QFR)
Cross-listings: STAT 341 MATH 341
Primary Cross-listing
The historical roots of probability lie in the study of games of chance. Modern probability, however, is a mathematical discipline that has wide applications in a myriad of other mathematical and physical sciences. Drawing on classical gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables (both discrete and continuous), distribution and expectation, independence, laws of large numbers, and the well-known Central Limit Theorem. Many interesting and important applications will also be presented, including some from classical Poisson processes, random walks and Markov Chains.

Requirements/Evaluation: homework, classwork, and exams
Prerequisites: MATH 150 and MATH 250 or permission of the instructor
Enrollment Limit: 30
Enrollment Preferences: Priority will be given to Mathematics majors and to Statistics Majors.

Expected Class Size: 20

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

Distributions: (D3) (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
STAT 341 (D3) MATH 341 (D3)

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

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

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

MATH 350 (F)(S) Real Analysis (QFR)
Real Analysis studies the theory behind calculus. We will first review properties of sets and basic logic. Then we will cover the real number system (What is a real number?), sequences of numbers, basic topology in the set of real numbers, metric spaces, continuity, differentiability, integration, series, and series and sequences of functions.

Requirements/Evaluation: homework, classwork, and exams
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: Juniors and Seniors.
Expected Class Size: 30
Grading: no pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: Math

Fall 2021
LEC Section: 01  MWF 11:00 am - 11:50 am  Cesar E. Silva

Spring 2022
LEC Section: 01  MWF 11:00 am - 11:50 am  Cesar E. Silva

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

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

Requirements/Evaluation: homework, classwork, and exams
Prerequisites: MATH 250 or permission of the instructor.
Enrollment Limit: 20
Enrollment Preferences: Seniors
Expected Class Size: 20
Grading: no pass/fail option, yes fifth course option
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

MATH 361  (F)(S)  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:  24(12/con)
Enrollment Preferences:  current or expected Computer Science majors
Expected Class Size:  24
Grading:  no pass/fail option,  no fifth course option
Distributions:  (D3)  (QFR)

This course is cross-listed and the prefixes carry the following divisional credit:
MATH 361 (D3)  CSCI 361 (D3)
Quantitative/Formal Reasoning Notes: This course includes regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Attributes: COGS Interdepartmental Electives

Fall 2021
LEC Section: 01  ASYN  Aaron M. Williams
CON Section: 02  TF 1:10 pm - 2:25 pm  Aaron M. Williams
CON Section: 03  MR 1:10 pm - 2:25 pm  Aaron M. Williams

Spring 2022
LEC Section: 01  ASYN  Aaron M. Williams
CON Section: 02  TF 1:10 pm - 2:25 pm  Aaron M. Williams
CON Section: 03  MR 1:10 pm - 2:25 pm  Aaron M. Williams

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

Requirements/Evaluation: homework, classwork, and exams
Prerequisites: MATH 350 or MATH 351 or permission of instructor
Enrollment Limit: 40
Enrollment Preferences: 40
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Unit Notes: this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major
Distributions: (D3)  (QFR)

Quantitative/Formal Reasoning Notes: Advanced mathematics course with weekly or daily problem sets.

Fall 2021
LEC Section: 01  MWF 11:00 am - 11:50 am  Steven J. Miller

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

Requirements/Evaluation: written homeworks, oral presentations, and exams
Prerequisites: MATH 355
Enrollment Limit: 50
Enrollment Preferences: discretion of the instructor
Expected Class Size: 10
Grading: no pass/fail option, yes fifth course option
Unit Notes: this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major
Distributions: (D3)  (QFR)
Functional analysis can be viewed as linear algebra on infinite-dimensional spaces. It is a central topic in Mathematics, which brings together and extends ideas from analysis, algebra, and geometry. Functional analysis also provides the rigorous mathematical background for several areas of theoretical physics (especially quantum mechanics). We will introduce infinite-dimensional spaces (Banach and Hilbert spaces) and study their properties. These spaces are often spaces of functions (for example, the space of square-integrable functions). We will consider linear operators on Hilbert spaces and investigate their spectral properties. A special attention will be dedicated to various operators arising from mathematical physics, especially the Schrodinger operator.

Class Format: lecture

Requirements/Evaluation: weekly problem sets, two midterm exams, final exam

Prerequisites: MATH 350 or 351 or permission of instructor

Enrollment Limit: 40

Enrollment Preferences: Mathematics and Physics majors; seniors

Expected Class Size: 30

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This is an advance course in Mathematical Analysis.

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

Requirements/Evaluation: By exams and homework

Prerequisites: Math 350 or Math 351, and Math 355

Enrollment Limit: 50

Enrollment Preferences: By instructor preference

Expected Class Size: 10

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This is a math course
**MATH 411 (F) Commutative Algebra (QFR)**

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

**Requirements/Evaluation:** homework and exams

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

**Enrollment Limit:** 25

**Enrollment Preferences:** Math majors

**Expected Class Size:** 15

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

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

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

Fall 2021

LEC Section: 01  MWF 9:00 am - 9:50 am  Susan R. Loepp

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

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

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

**Prerequisites:** Math 250 and Math 355

**Enrollment Limit:** 25

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

**Expected Class Size:** 15

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

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

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

Fall 2021

SEM Section: 01  MWF 10:00 am - 10:50 am  Ralph E. Morrison

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**MATH 458 (S) Algebraic Combinatorics (WS) (QFR)**

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

**Requirements/Evaluation:** Drafts of manuscript, oral presentations, reflections, peer collaboration skills

**Prerequisites:** MATH 200 and MATH 355
Enrollment Limit: 25

Enrollment Preferences: Senior mathematics majors, students with programming experience, students with interests in algebra and combinatorics.

Expected Class Size: 20

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

Distributions: (D3) (WS) (QFR)

Writing Skills Notes: This course will require multiple revisions of a manuscript on the mathematical tent and collaborative work. The final result will be a 10-20 page research article and the course will be designed as a writing intensive course.

Quantitative/Formal Reasoning Notes: This is a mathematics course in the area of algebraic combinatorics and is a quantitative and formal reasoning course.

Spring 2022

SEM Section: 01 Cancelled

PHIL 203  (F)  Logic and Language  (QFR)

Logic is the study of reasoning and argument. More particularly, it concerns itself with the difference between good and bad reasoning, between strong and weak arguments. We all examine the virtues and vices of good arguments in both informal and formal systems. The goals of this course are to improve the critical thinking of the students, to introduce them to sentential and predicate logic, to familiarize them with enough formal logic to enable them to read some of the great works of philosophy, which use formal logic (such as Wittgenstein's Tractatus), and to examine some of the connections between logic and philosophy.

Class Format: discussion

Requirements/Evaluation: a midterm, a final, frequent homework and problem sets

Prerequisites: none

Enrollment Limit: 40/sect

Enrollment Preferences: Philosophy majors, seniors, juniors, sophomores, first-years in that order.

Expected Class Size: 40/sect

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

Distributions: (D2) (QFR)

Quantitative/Formal Reasoning Notes: The main part of the course is learning two formal languages of logic: sentential logic predicate logic

Attributes: Linguistics  PHIL Contemp Metaphysics + Epistemology Courses

Fall 2021

LEC Section: 01  MWF 10:00 am - 10:50 am  Steven B. Gerrard

LEC Section: 02  MWF 12:00 pm - 12:50 pm  Steven B. Gerrard

PHIL 312  (S)  Philosophical Implications of Modern Physics  (QFR)

Cross-listings: STS 312  PHYS 312  PHIL 312

Secondary Cross-listing

Some of the discoveries made by physicists over the last century seem to show that our common sense views are deeply at odds with our most sophisticated and best confirmed scientific theories. The course will present the essential ideas of relativity theory and quantum theory and explore their implications for philosophy. We will ask, for example, what these theories tell us about the nature of space, time, probability and causality.

Requirements/Evaluation: attendance, participation, problem sets, exams, six 1- to 2-page papers and a 12- to 15-page term paper

Prerequisites: MATH 140, high-school physics, and either a 200-level course in PHIL or a 100-level course in PHYS

Enrollment Limit: 20

Enrollment Preferences: Philosophy majors and Physics 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:

STS 312 (D2) PHYS 312 (D3) PHIL 312 (D2)

Attributes:  PHIL Contemp Metaphysics + Epistemology Courses

Spring 2022
LEC Section: 01    MR 2:35 pm - 3:50 pm     Keith E. McPartland,  Frederick W. Strauch

PHYS 108  (F) Energy Science and Technology  (QFR)
Cross-listings:  ENVI 108  PHYS 108

Primary Cross-listing

Energy use has skyrocketed in the United States and elsewhere in the world, causing significant economic and political shifts, as well as concerns for the environment. This course will address the physics and technology of energy generation, consumption, and conservation. It will cover a wide range of energy sources, including fossil fuels, hydropower, solar energy, wind energy, and nuclear energy. We will discuss energy use in transportation, manufacturing, building heating, and building lighting. Students will learn to compare the efficiencies and environmental impacts of various energy sources and uses.

Class Format: twice a week, occasional lab exercises, and a field trip to the college heating plant, all during class hours

Requirements/Evaluation:  weekly assignments, two hour tests, and a final project culminating in an oral presentation to the class and a 10-page paper; all of these will be substantially quantitative

Prerequisites:  high school physics, high school chemistry, and mathematics at the level of MATH 130

Enrollment Limit:  20

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:

ENVI 108 (D3) PHYS 108 (D3)

Attributes:  ENVI Natural World Electives

Fall 2021
LEC Section: 01    TR 11:20 am - 12:35 pm     Henrik Ronellenfitsch

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)
**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.

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**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)
Fall 2021

LEC Section: 01    MWF 11:00 am - 11:50 am    Protik K. Majumder
LAB Section: 02    M 1:00 pm - 4:00 pm    Protik K. Majumder
LAB Section: 03    T 1:00 pm - 4:00 pm    Protik K. Majumder
LAB Section: 04    W 1:00 pm - 4:00 pm    Protik K. Majumder

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, two hours weekly; problem-solving conference session, one hour weekly; laboratory, 2-3 hours most weeks, alternating between 'hands-on' and computational sessions (limit 10 per lab, 14 per conference section)

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/C, 10/L

Enrollment Preferences: first-year students

Expected Class Size: 30

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

Spring 2022

LEC Section: 01    WF 11:00 am - 11:50 am    Catherine Kealhofer
CON Section: 02    M 11:00 am - 11:50 am    Catherine Kealhofer
CON Section: 03    M 7:00 pm - 7:50 pm    Catherine Kealhofer
LAB Section: 04    M 1:00 pm - 4:00 pm    Catherine Kealhofer
LAB Section: 05    T 1:00 pm - 4:00 pm    Catherine Kealhofer

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 expectations 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: Two 50-minute lectures per week, one 50-minute conference section per week, one 3-hour lab per week

Requirements/Evaluation: class participation, weekly lab/conference assignments, weekly problem sets, final paper, two hour-exams and a final exam;
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: besides the final paper, all assignments in the course have a substantial quantitative component

Fall 2021

LEC Section: 01 WF 11:00 am - 11:50 am Catherine Kealhofer
CON Section: 02 M 11:00 am - 11:50 am Catherine Kealhofer
CON Section: 03 M 7:00 pm - 7:50 pm Catherine Kealhofer
LAB Section: 04 W 1:00 pm - 4:00 pm Catherine Kealhofer

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: 15

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 2021

LEC Section: 01 MWF 10:00 am - 10:50 am David R. Tucker-Smith
LAB Section: 02 T 1:00 pm - 4:00 pm David R. Tucker-Smith
LAB Section: 03 W 1:00 pm - 4:00 pm David R. Tucker-Smith

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, in-class tests, 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 2022

LEC Section: 01    MWF 10:00 am - 10:50 am     Graham K. Giovanetti

LAB Section: 02    T 1:00 pm - 4:00 pm     Graham K. Giovanetti

LAB Section: 03    W 1:00 pm - 4:00 pm     Graham K. Giovanetti

**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. A series of optional sessions in Mathematica will be offered for students who are not already familiar with this computational tool.

**Class Format:** three hours per week

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

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

**Enrollment Limit:** 50

**Enrollment Preferences:** sophomores and juniors

**Expected Class Size:** 30

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

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

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

PHYS 210 (D3) MATH 210 (D3)

**Quantitative/Formal Reasoning Notes:** This course will have weekly problem sets using advanced calculus methods and some computer programming at the end of the course.

Spring 2022

LEC Section: 01    TR 9:55 am - 11:10 am     David R. Tucker-Smith

**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.

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**PHYS 301  (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

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**PHYS 312  (S)  Philosophical Implications of Modern Physics  (QFR)**

**Cross-listings:** STS 312  PHYS 312  PHIL 312

**Primary Cross-listing**
Some of the discoveries made by physicists over the last century seem to show that our common sense views are deeply at odds with our most sophisticated and best confirmed scientific theories. The course will present the essential ideas of relativity theory and quantum theory and explore their implications for philosophy. We will ask, for example, what these theories tell us about the nature of space, time, probability and causality.

Requirements/Evaluation: attendance, participation, problem sets, exams, six 1- to 2-page papers and a 12- to 15-page term paper
Prerequisites: MATH 140, high-school physics, and either a 200-level course in PHIL or a 100-level course in PHYS
Enrollment Limit: 20
Enrollment Preferences: Philosophy majors and Physics 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:
STS 312 (D2) PHYS 312 (D3) PHIL 312 (D2)
Attributes: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2022
LEC Section: 01 MR 2:35 pm - 3:50 pm Keith E. McPartland, Frederick W. Strauch

PHYS 405 (F) Electromagnetic Theory (QFR)
This course builds on the material of Physics 201, and explores the application of Maxwell's Equations to understand a range of topics including electric fields and matter, magnetic materials, light, and radiation. As we explore diverse phenomena, we will learn useful approximation techniques and beautiful mathematical tools. In addition to weekly tutorial meetings, the class will meet once a week as a whole to introduce new material.

Requirements/Evaluation: weekly problem sets, tutorial participation, presentations, and a final exam or final project, all of which have a substantial quantitative component
Prerequisites: PHYS 202 and PHYS/MATH 210 or MATH 209 or MATH 309
Enrollment Limit: 10/section
Expected Class Size: 16
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)

Fall 2021
TUT Section: T1 F 1:10 pm - 2:25 pm Frederick W. Strauch

PHYS 418 (S) Gravity (QFR)
This course is an introduction Einstein's theory of general relativity. We begin with a review of special relativity, emphasizing geometrical aspects of Minkowski spacetime. Working from the equivalence principle, we then motivate gravity as spacetime curvature, and study in detail the Schwarzschild geometry around a spherically symmetric mass. After this application, we use tensors to develop Einstein's equation, which describes how energy density curves spacetime. With this equation in hand we study the Friedmann-Robertson-Walker geometries for an expanding universe, and finally, we linearize Einstein's equation to develop the theory of gravitational waves.

Requirements/Evaluation: weekly problem sets, a midterm exam, and a final exam, all of which have a substantial quantitative component
Prerequisites: PHYS 301 or PHYS 405 or PHYS 411
Enrollment Limit: none
Enrollment Preferences: none
Expected Class Size: 10
Grading: no pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
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: EVST Methods Courses PHLH Statistics Courses POEC Required Courses

Fall 2021
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)
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 2021
LEC Section: A1   TF 1:10 pm - 2:25 pm   Kenneth K. Savitsky
LAB Section: A2   M 1:00 pm - 4:00 pm   Kenneth K. Savitsky
STAT 101 (F)(S) Elementary Statistics and Data Analysis (QFR)

It is impossible to be an informed citizen in the world today without an understanding of data and information. Whether opinion polls, unemployment rates, salary differences between men and women, the efficacy of vaccines or consumer webdata, we need to be able to separate the signal from the noise. We will learn the statistical methods used to analyze and interpret data from a wide variety of sources. The goal of the course is to help reach conclusions and make informed decisions based on data.

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 101/161/201 should enroll in STAT 202.
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: It is a quantitative course.
Attributes: COGS Related Courses PHLH Statistics Courses

Fall 2021
LEC Section: 01 TR 8:30 am - 9:45 am Shaoyang Ning
LEC Section: 02 TF 2:35 pm - 3:50 pm Elizabeth M. Upton

Spring 2022
LEC Section: 01 TR 11:20 am - 12:35 pm Annie Tang

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 and sciences. Topics include exploratory data analysis, elements of probability theory, basic statistical inference, and introduction to statistical modeling. The course focuses on the application of statistics tools to solve problems, to make decisions, and the use of statistical thinking to understand the world.

Requirements/Evaluation: students complete homework, quizzes and exams (including take-home exams. Students will need to get 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: no pass/fail option, no fifth course option
Unit Notes: Students with calculus background should consider STAT 201 or 202. Students without any calculus background should consider STAT
101. 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

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**Fall 2021**

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**Spring 2022**

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**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:** 45

**Expected Class Size:** 45

**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  EVST Methods Courses  PHLH Statistics Courses

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**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.

**Class Format:** Class meetings will discuss questions from lecture, dive further into the material, and work on examples. You'll use chat and discussion boards to build community, study with classmates, and ask questions outside of class time. The professor and TAs will also offer optional synchronous office hours/review sessions.

**Requirements/Evaluation:** Homework problems; quizzes; a final project (on a topic that interests 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 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:** AP Statistics 4 or 5, or STAT 101, or STAT 161, or STAT 201, 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, yes fifth course option

**Unit Notes:** students with a 4 on the AP Stats exam should contact the department for proper placement

**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:** EVST Methods Courses PHLH Statistics Courses

**Fall 2021**

LEC Section: 01  TR 11:20 am - 12:35 pm Shaoyang Ning

LEC Section: 02  TR 11:20 am - 12:35 pm Daniel B. Turek

**Spring 2022**

LEC Section: 01  TR 11:20 am - 12:35 pm Shaoyang Ning

LEC Section: 02  TR 11:20 am - 12:35 pm Daniel B. Turek

**STAT 319 (S) Statistical Computing (QFR)**

This course introduces a variety of computational and data-centric topics of applied statistics, which are broadly useful for acquiring, manipulating, visualizing, and analyzing data. We begin with the R language, which will be used extensively throughout the course. Then we'll introduce a variety of other useful tools, including the UNIX environment, scripting analyses using bash, databases and the SQL language, alternative data formats, techniques for visualizing high-dimensional data, and text manipulation using regular expressions. We'll also cover some modern statistical techniques along the way, which are made possible thanks to advances in computational power. This course is strongly computer oriented, and assignments will be project-based.

**Requirements/Evaluation:** based primarily on projects, homework, and exams

**Prerequisites:** STAT 201 or 202 and CSCI 134, 135, or 136

**Enrollment Limit:** 30

**Enrollment Preferences:** juniors and seniors, Statistics majors

**Expected Class Size:** 15

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

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

**Quantative/Formal Reasoning Notes:** This course uses statistical tools and programming techniques to acquire data, create visualizations, and make future predictions.

**Spring 2022**

LEC Section: 01  TF 1:10 pm - 2:25 pm 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)

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

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

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

STAT 342 (S) Introduction to Stochastic Processes (QFR)
Stochastic processes are mathematical models for random phenomena evolving in time or space. Examples include the number of people in a queue at time t or the accumulated claims paid by an insurance company in an interval of time t. This course introduces the basic concepts and techniques of stochastic processes used to construct models for a variety of problems of practical interest. The theory of Markov chains will guide our discussion as we cover topics such as martingales, random walks, Poisson process, birth and death processes, and Brownian motion.

Requirements/Evaluation: weekly homework/labs, classwork, and exams

Prerequisites: STAT 341

Enrollment Limit: 30

Enrollment Preferences: senior Statistics majors

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This is a statistics class with a focus on mathematical skills and translating real world phenomena into mathematical descriptions.

Spring 2022
LEC Section: 01 TF 2:35 pm - 3:50 pm Elizabeth M. Upton

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 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, 201, 202, or equivalent, and Math 140 or equivalent, 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 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 2021

LEC Section: 01  MWF 12:00 pm - 12:50 pm  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, logistic 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, midterm exam, final exam, end-of-year project.

Prerequisites: MATH 250, MATH/STAT 341 (may be taken concurrently) and at least one of STAT 201 or 202. Or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: Statistics Majors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

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

Attributes: EVST Methods Courses

Fall 2021

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

Spring 2022

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

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.

Class Format: For the Spring 2021 semester, synchronous zoom lectures are planned, where the instructor uses Google's jamboard to interact with students

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

Spring 2022
LEC Section: 01    TR 8:30 am - 9:45 am    Bernhard Klingenberg

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 2021
LEC Section: 01    TF 1:10 pm - 2:25 pm    Daniel B. Turek

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: 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: no 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 2022
LEC Section: 01    MR 2:35 pm - 3:50 pm    Shaoyang Ning
STS 312 (S) Philosophical Implications of Modern Physics (QFR)

Cross-listings: STS 312 PHYS 312 PHIL 312

Secondary Cross-listing

Some of the discoveries made by physicists over the last century seem to show that our common sense views are deeply at odds with our most sophisticated and best confirmed scientific theories. The course will present the essential ideas of relativity theory and quantum theory and explore their implications for philosophy. We will ask, for example, what these theories tell us about the nature of space, time, probability and causality.

Requirements/Evaluation: attendance, participation, problem sets, exams, six 1- to 2-page papers and a 12- to 15-page term paper

Prerequisites: MATH 140, high-school physics, and either a 200-level course in PHIL or a 100-level course in PHYS

Enrollment Limit: 20

Enrollment Preferences: Philosophy majors and Physics 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:

STS 312 (D2) PHYS 312 (D3) PHIL 312 (D2)

Attributes: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2022

LEC Section: 01 MR 2:35 pm - 3:50 pm Keith E. McPartland, Frederick W. Strauch

Quantitative and Formal Reasoning

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 remotely 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 2021

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 211 (S) Astronomical Observing and Data Analysis (QFR)
How do astronomers make scientific measurements for objects that are light-years away from Earth? This course will introduce the basics of telescopes and observations and will give students hands-on training in the techniques astronomers use to obtain, process, and analyze scientific data. We will discuss observation planning, CCD detectors, signal statistics, image processing, and photometric and spectroscopic observations. We will begin by focusing on ground-based optical observations and will move on to non-optical observations, both electromagnetic (e.g., radio waves, X-rays) and non-electromagnetic (e.g., gravitational waves, neutrinos). Throughout the course, students will use computational techniques to work with real astronomical data, taken with our 24" telescope and from data archives.

Class Format: discussion, computer lab work, and observing
Requirements/Evaluation: weekly problem sets, lab work, and observing projects
Prerequisites: MATH 150 or 151; prior experience with Unix and computer programming is helpful, but not required
Enrollment Limit: 14
Enrollment Preferences: Astronomy or Astrophysics majors
Expected Class Size: 8
Grading: no pass/fail option, no fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: The course requires regular problem sets. Labs require computer programming and statistical and graphical analyses of data.

Spring 2022
LAB Section: 02    W 1:10 pm - 3:50 pm    Kevin Flaherty
LEC Section: 01    MR 1:10 pm - 2:25 pm    Anne Jaskot, 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

Spring 2022
IND Section: 01    TBA    Jay M. Pasachoff

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 in-person laboratory provides further opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays. A laboratory section will also be provided for remote students, which will examine similar topics

Spring 2022
IND Section: 01    TBA    Jay M. Pasachoff
and techniques through literature and data analysis.

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

Requirements/Evaluation: quizzes, two midterm exams, 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: 16/1ab

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 2021

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

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

Cross-listings: BIOL 322 CHEM 322 BIMO 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 two 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: 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:

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

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

Attributes: BIGP Courses BIMO Required Courses
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

BIOL 203 (F) Ecology (QFR)

Cross-listings: ENVI 203  BIOL 203

Primary Cross-listing

This course combines lectures & discussion with field and indoor laboratory exercises 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 help students 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 101 or 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:

ENVI 203 (D3) BIOL 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  EVST Living Systems Courses

Fall 2021

LEC Section: 01  MWF 10:00 am - 10:50 am  Allison L. Gill
LAB Section: 03  W 1:00 pm - 4:00 pm  Allison L. Gill
LAB Section: 02  T 1:00 pm - 4:00 pm  Allison L. Gill
LAB Section: 04  R 1:00 pm - 4:00 pm  Allison L. Gill

BIOL 222  (S) Essentials of Biochemistry  (QFR)

This course will explore the biochemistry of cellular processes and contextualize these processes in healthy and diseased states. Lecture topics in this one semester course will include the structure and function of proteins (enzymes and non-enzymatic proteins), lipids, and carbohydrates. Lectures will also survey the major metabolic pathways (carbohydrates, lipids, and amino acids) with particular attention to enzyme regulation and the integration of metabolism in different tissues and under different metabolic conditions. In the discussion/laboratory component of the course a combination of primary literature, hypothesis-driven exercises, problem solving, and bench work will be used to illustrate how particular techniques and experimental approaches are used in biochemical fields.

Class Format: in-person lecture and lab

Requirements/Evaluation: regular quizzes, final exam, writing assignments (including problem sets), and lab assignments

Prerequisites: BIOL 101 and CHEM 156; not open to students who have taken BIOL 321 or BIOL 322

Enrollment Limit: 18

Enrollment Preferences: seniors who need to fulfill the biochemistry requirement for premedical school

Expected Class Size: 18

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 either BIOL 321 or BIOL 322; cannot be counted towards the BIMO concentration

Distributions: (D3) (QFR)

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

Spring 2022

LAB Section: 02  T 1:00 pm - 4:00 pm  Pei-Wen Chen
LEC Section: 01  TR 9:55 am - 11:10 am  Pei-Wen Chen
LAB Section: 03  W 1:00 pm - 4:00 pm  Pei-Wen Chen
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 2022
LAB Section: 03  R 1:00 pm - 4:00 pm  Luana S. Maroja
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

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 in-person laboratory provides further opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays. A laboratory section will also be provided for remote students, which will examine similar topics and techniques through literature and data analysis.

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

Requirements/Evaluation: quizzes, two midterm exams, 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
BIOL 322 (S) Biochemistry II: Metabolism (QFR)

Cross-listings: BIOL 322 CHEM 322 BIMO 322

Secondary Cross-listing

This 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 two 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: 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:
BIOL 322 (D3) CHEM 322 (D3) BIMO 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 2022

LEC Section: 01 TR 9:55 am - 11:10 am Cynthia K. Holland
LAB Section: 02 T 1:00 pm - 4:00 pm Janis E. Bravo
LAB Section: 03 W 1:00 pm - 4:00 pm Janis E. Bravo
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 and discussion participation.

Prerequisites: BIOL 102, 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)

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 2021

LAB Section: 02 W 1:00 pm - 4:00 pm Ron D. Bassar
LAB Section: 03 R 1:00 pm - 4:00 pm Ron D. Bassar
LEC Section: 01 TR 11:20 am - 12:35 pm Ron D. Bassar

CHEM 114  (S)  The Science Behind Materials: Shaping the Past and Future of Society  (QFR)

We are surrounded by materials. They have fulfilled human needs since ancient times. From Phoenician glass to flexible OLED displays, materials have impacted society and changed the way humans lead their lives. What makes materials the way they are? Why are some brittle while others are ductile? How can we design materials with specific properties that will solve tomorrow's problems? To answer these questions, we have to think about materials at the atomic scale, looking at how their smallest building blocks organize into specific structures. In this course, we will explore the relationships between structure, processing, and properties for a range of materials including metals, ceramics, polymers, and composites. We will talk about some of the cutting-edge research that materials scientists are working on today, concluding with an outlook to potential applications of emerging technologies.

Requirements/Evaluation: Weekly quizzes and problem sets, two exams, and a final paper
Prerequisites: not appropriate for CHEM, BIOL, PHYS majors, or for those who have taken CHEM 151, 153, or 155

Enrollment Limit: 20

Enrollment Preferences: juniors and seniors; not appropriate for CHEM, BIOL, PHYS majors, or for those who have taken CHEM 151, 153, or 155

Expected Class Size: 20

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

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.

Spring 2022

LEC Section: 01 MR 1:10 pm - 2:25 pm Amnon G. Ortol-Bloch

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); incoming first-year students are required to speak with a faculty member during First Days.

**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

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**Fall 2021**

| LAB Section 02 | M 1:00 pm - 5:00 pm | Laura R. Strauch |
| LAB Section 03 | T 1:00 pm - 5:00 pm | Laura R. Strauch |
| LEC Section 01 | MWF 8:30 am - 9:45 am | Sarah L. Goh |

**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. There may also be the opportunity for some hands-on laboratory experience for students who are on-campus. 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:** quantitative weekly problem set assignments, laboratory work and reports, hour 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); incoming first-year students are required to speak with a faculty member during First Days.

**Enrollment Limit:** 35/lecture

**Enrollment Preferences:** incoming first-year students also must speak with a faculty member during First Days

**Expected Class Size:** 70

**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

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**Fall 2021**

LAB Section 07 T 8:00 am - 12:00 pm Laura R. Strauch
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); incoming first-year students are required to speak with a faculty member during First Days.
Enrollment Limit: 16/lab
Enrollment Preferences: first year students and sophomores; incoming first year students also must meet with a faculty member during First Days
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

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 placement exam or permission of instructor
Enrollment Limit: 50/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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**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 in-person laboratory provides further opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays. A laboratory section will also be provided for remote students, which will examine similar topics and techniques through literature and data analysis.

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

**Requirements/Evaluation:** quizzes, two midterm exams, 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:** 16/1ab

**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
CHEM 322 (S) Biochemistry II: Metabolism  (QFR)

Cross-listings: BIOL 322 CHEM 322 BIMO 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 two 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: 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:

BIOL 322 (D3) CHEM 322 (D3) BIMO 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 2022

LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo

LEC Section: 01  TR 9:55 am - 11:10 am  Cynthia K. Holland

LAB Section: 03  W 1:00 pm - 4:00 pm  Janis E. Bravo

LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo

CHEM 368 (S) Computational Chemistry and Molecular Spectroscopy  (QFR)

This course 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)
Quantative/Formal Reasoning Notes: This course fulfills the QFC requirement with problem sets for assignments in which quantitative/formal reasoning skills are practiced.

Spring 2022
TUT Section: T1 TBA Enrique Peacock-López

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: 36(12/lab)
Enrollment Preferences: if the course is over-enrolled, enrollment will be determined by lottery
Expected Class Size: 36
Grading: yes pass/fail option, yes fifth course option
Unit Notes: 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 2021
LAB Section: 05 M 1:10 pm - 2:25 pm Kelly A. Shaw
LAB Section: 08 T 2:35 pm - 3:50 pm Kelly A. Shaw
LAB Section: 04 T 1:10 pm - 2:25 pm Jeannie R Albrecht
LEC Section: 02 MWF 9:00 am - 9:50 am Shikha Singh
LAB Section: 06 M 2:35 pm - 3:50 pm Kelly A. Shaw
LAB Section: 03 M 1:10 pm - 2:25 pm Shikha Singh
LAB Section: 07 T 1:10 pm - 2:25 pm Kelly A. Shaw
LEC Section: 01 MWF 10:00 am - 10:50 am Jeannie R Albrecht

Spring 2022
LAB Section: 04 T 1:10 pm - 2:25 pm Jeannie R Albrecht
LAB Section: 06 M 2:35 pm - 3:50 pm Stephen N. Freund
LAB Section: 05 M 1:10 pm - 2:25 pm Stephen N. Freund
LAB Section: 07 T 1:10 pm - 2:25 pm Stephen N. Freund
LAB Section: 08 T 2:25 pm - 3:50 pm Stephen N. Freund
LEC Section: 01 MWF 10:00 am - 10:50 am Jeannie R Albrecht
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:  60(12/lab)
Enrollment Preferences:  if the course is over-enrolled, enrollment will be determined by lottery
Expected Class Size:  60
Grading:  yes pass/fail option,  no fifth course option
Distributions:  (D3)  (QFR)
Quantative/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 2021
LAB Section: 04  R 9:55 am - 11:10 am  Duane A. Bailey
LAB Section: 02  MWF 10:00 am - 10:50 am  Duane A. Bailey
LAB Section: 05  R 1:10 pm - 2:25 pm  Duane A. Bailey
LAB Section: 06  R 2:35 pm - 3:50 pm  Aaron M. Williams
LAB Section: 07  W 1:10 pm - 2:25 pm  Aaron M. Williams
LAB Section: 08  W 2:35 pm - 3:50 pm  Duane A. Bailey
LAB Section: 01  MWF 9:00 am - 9:50 am  Duane A. Bailey
LAB Section: 03  MWF 11:00 am - 11:50 am  Aaron M. Williams

Spring 2022
LAB Section: 08  R 2:35 pm - 3:50 pm  Samuel McCauley
LAB Section: 05  R 1:10 pm - 2:25 pm  Samuel McCauley
LAB Section: 04  R 9:55 am - 11:10 am  Samuel McCauley
LAB Section: 03  MWF 11:00 am - 11:50 am  Samuel McCauley
LAB Section: 02  MWF 10:00 am - 10:50 am  Samuel McCauley
LAB Section: 01  MWF 9:00 am - 9:50 am  Daniel W. Barowy
LAB Section: 07  R 1:10 pm - 2:25 pm  Daniel W. Barowy
LAB Section: 06  R 2:35 pm - 3:50 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.
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 2021  
LEC Section: 02  MWF 12:00 pm - 12:50 pm  Marina Barsky  
LEC Section: 01  MWF 11:00 am - 11:50 am  Marina Barsky  
Spring 2022  
LEC Section: 01  MWF 12:00 pm - 12:50 pm
CSCI 331  (F)  Introduction to Computer Security  (QFR)
This class explores common vulnerabilities in computer systems, how attackers exploit them, and how systems engineers design defenses to mitigate them. The goal is to be able to recognize potential vulnerabilities in one's own software and to practice defensive design. Hands-on experience writing assembly language and C code to inspect and modify the low-level operation of running programs is emphasized. Finally, regular reading and writing assignments round out the course to help students understand the cultural and historical background of the computer security "arms race."

Class Format: This course has twice-weekly lecture meetings as well as a weekly lab meeting.
Requirements/Evaluation: weekly reading responses, lab assignments, midterm exam, and final project
Prerequisites: CSCI 136 and CSCI 237
Enrollment Limit: 24(12/lab)
Enrollment Preferences: upper-level students
Expected Class Size: 24
Grading: no 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.

Fall 2021
LAB Section: 03    W 2:35 pm - 3:50 pm    Daniel W. Barowy
LEC Section: 01    MR 2:35 pm - 3:50 pm    Daniel W. Barowy
LAB Section: 02    W 1:10 pm - 2:25 pm    Daniel W. Barowy

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: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
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.

Fall 2021
LEC Section: 01    TR 9:55 am - 11:10 am    Stephen N. Freund

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

CSCI 357  (S)  Algorithmic Game Theory  (QFR)
This course focuses on topics in game theory and mechanism design from a computational perspective. We will explore questions such as: how to design algorithms that incentivize truthful behavior, that is, where the participants have no incentive to cheat? Should we let drivers selfishly minimize
their commute time or let a central algorithm direct traffic? Does Arrow's impossibility result mean that all voting protocols are doomed? The overarching goal of these questions is to understand and analyze selfish behavior and whether it can or should influence system design. Students will learn how to model and reason about incentives in computational systems both theoretically and empirically. Topics include types of equilibria, efficiency of equilibria, auction design and mechanism design with money, two-sided markets and mechanism design without money, incentives in computational applications such as P2P systems, and computational social choice.

**Requirements/Evaluation:** weekly problem sets and/or programming assignments, two midterm exams, and a final project.

**Prerequisites:** CSCI 256

**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 problem sets and programming assignments in which quantitative/formal reasoning skills are practiced and evaluated.

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Spring 2022

LEC Section: 01    MR 2:35 pm - 3:50 pm     Shikha  Singh

**CSCI 358  (F) Applied Algorithms  (QFR)**

This course is about bridging the gap between theoretical running time and writing fast code in practice. The course is divided into two basic topics. The first is algorithmic: we will discuss some of the most useful tools in a coder’s toolkit. This includes topics like randomization (hashing, filters, approximate counters), linear and convex programming, similarity search, and cache-efficient algorithms. Our goal is to talk about why these efficient algorithms make seemingly difficult problems solvable in practice. The second topic is applications: we will discuss how to implement algorithms in an efficient way that takes advantage of modern hardware. Specific topics covered will include blocking, loop unrolling, pipelining, as well as strategies for performance analysis. Projects and assessments will include both basic theoretical aspects (understanding why the algorithms we discuss actually work), and practical aspects (implementing the algorithms we discuss to solve important problems, and optimizing the code so it runs as quickly as possible).

**Requirements/Evaluation:** Over the course of each week, there will be either an assignment or a mini-midterm. Assignments and mini-midterms have similar structure, with both a coding and problem set component, but mini-midterms will be weighted more heavily and must be completed individually. There will also be a take home final at the end of the year.

**Prerequisites:** CSCI 256 and 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.

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Fall 2021

LEC Section: 01    MR 1:10 pm - 2:25 pm     Samuel  McCauley

**CSCI 361  (F)(S) 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:** 24(12/con)

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

**Expected Class Size:** 24

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

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

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

MATH 361 (D3) CSCI 361 (D3)

**Quantitative/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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CSCI 379  (F)(S) Causal Inference  (QFR)

Does X cause Y? If so, how? And what is the strength of this causal relation? Seeking answers to such causal (as opposed to associational) questions
is a fundamental human endeavor; the answers we find can be used to support decision-making in various settings such as healthcare and public
policy. But how does one tease apart causation from association--early in our statistical education we are taught that "correlation does not imply
causation." In this course, we will re-examine this phrase and learn how to reason with confidence about the validity of causal conclusions drawn from
messy real-world data. We will cover core topics in causal inference including causal graphical models, unsupervised learning of the structure of these
models, expression of causal quantities as functions of observed data, and robust/efficient estimation of these quantities using statistical and machine
learning methods. Concepts in the course will be contextualized via regular case studies.

**Requirements/Evaluation:** Problem sets, programming exercises, empirical analyses, case studies, and a final project.

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

**Enrollment Limit:** 24

**Enrollment Preferences:** Computer science majors and prospective 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, algorithms, and elementary statistics. There will be regular
assignments requiring rigorous quantitative or formal reasoning.

**Attributes:** COGS Interdepartmental Electives
CSCI 432  (S) Operating Systems  (QFR)
This course explores the design and implementation of computer operating systems. Topics include historical aspects of operating systems development, systems programming, process scheduling, synchronization of concurrent processes, virtual machines, memory management and virtual memory, I/O and file systems, system security, os/architecture interaction, and distributed operating systems.

Requirements/Evaluation: several implementation projects that will include significant programming, as well as written homework, and up to two exams
Prerequisites: CSCI 237 and either CSCI 256 or 334
Enrollment Limit: 24
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 substantial problem sets and/or programming assignments in which quantitative/formal reasoning skills are practiced and evaluated.

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
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
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 describing those results in words.

Attributes: POEC Required Courses
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 2021

LEC Section: 01    TR 8:30 am - 9:45 am    Neal J. Rappaport

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 2021

LEC Section: 04    MR 2:35 pm - 3:50 pm    Ashok S. Rai
LEC Section: 03    MR 1:10 pm - 2:25 pm    Ashok S. Rai
LEC Section: 02    TF 2:35 pm - 3:50 pm    Pamela Jakiela
LEC Section: 01    TF 1:10 pm - 2:25 pm    Pamela Jakiela

Spring 2022

LEC Section: 01    TR 11:20 am - 12:35 pm    Pamela Jakiela

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: no 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.

Fall 2021
LEC Section: 01 TR 8:30 am - 9:45 am Kenneth N. Kuttner
LEC Section: 02 TF 2:35 pm - 3:50 pm Kenneth N. Kuttner

Spring 2022
LEC Section: 01 TF 1:10 pm - 2:25 pm Gregory P. Casey
LEC Section: 02 TF 2:35 pm - 3:50 pm Gregory P. Casey
LEC Section: 03 M 7:00 pm - 9:40 pm Peter L. Pedroni

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), 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)

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

Attributes: EVST Methods Courses PHLH Statistics Courses POEC Required Courses

Fall 2021
LEC Section: 01 TR 8:30 am - 9:45 am Owen Ozier
LEC Section: 02 MWF 11:00 am - 12:15 pm David J. Zimmerman

Spring 2022
LEC Section: 01 TF 1:10 pm - 2:25 pm Matthew Gibson
LEC Section: 02 TF 2:35 pm - 3:50 pm Matthew Gibson
LEC Section: 03 W 7:00 pm - 9:40 pm David J. Zimmerman

ECON 345 (S) Growth Diagnostics (QFR)

Cross-listings: ECON 545 ECON 345
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 2022

SEM Section: 01   TR 11:20 am - 12:35 pm   Quamrul H. Ashraf

ECON 360 (S) Monetary Economics  (QFR)

This course covers a range of theoretical and applied issues bearing on monetary policy as conducted in the U.S. and abroad. Topics to be covered include: the causes of inflation, how central banks manage interest rates, the channels through which monetary policy affects the economy, and the costs and benefits of imposing rules on the conduct of policy. The class will also touch on a number of current issues facing central banks, such as unconventional monetary policy and cryptocurrencies.

Requirements/Evaluation: Two exams, a research paper and/or class presentation

Prerequisites: ECON 252 and 255. Multivariate calculus (MATH 150 or 151) is recommended but not required

Enrollment Limit: 20

Enrollment Preferences: junior and senior Economics majors

Expected Class Size: 20

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

Distributions: (D2) (QFR)

Quantitative/Formal Reasoning Notes: The course entails the use of mathematical economic models, the presentation of quantitative information, and the interpretation of statistical analysis.

Attributes: GBST Economic Development Studies Electives  POEC International Political Economy Courses

Spring 2022
ECON 373  (F)  The Economics of Immigration  (QFR)
This course will explore migration across national borders from an economic perspective, with a focus on migration to the United States. Who migrates, and why? What are the impacts on the economies of the origin country and the destination country, and on migrants themselves? What policies shape immigration and enforcement of immigration law, and what are their impacts? What is the role of immigrants in the broader society? We will emphasize empirical analysis as a data-driven way of understanding the economics of immigration.
Class Format: Class will periodically meet in a small-group seminar format.
Requirements/Evaluation: Requirements: active participation, 3 empirical assignments, 2 short papers, 2 presentations, and a final 12-15 page paper.
Prerequisites: Econ 251 and Econ 255, or permission of instructor
Enrollment Limit: 25
Enrollment Preferences: Economics majors
Expected Class Size: 25
Grading: yes pass/fail option, yes fifth course option
Distributions: (D2) (QFR)
Quantative/Formal Reasoning Notes: This course will use quantitative tools of economics.

Fall 2021
LEC Section: 01  W 7:00 pm - 9:40 pm  Tara E. Watson

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
ECON 387 (F) 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: 30

Enrollment Preferences: Junior/Senior Economics majors and CDE fellows

Expected Class Size: 30

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

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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, tax policy lessons are universal so we will 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
ECON 522  (F)  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:  30

Enrollment Preferences:  Junior/Senior Economics majors and CDE fellows

Expected Class Size:  30

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

Fall 2021

LEC Section:  01  TF 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)

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 2022

SEM Section: 01 TR 11:20 am - 12:35 pm Quamrul H. Ashraf

ENVI 108 (F) Energy Science and Technology (QFR)

Cross-listings: ENVI 108 PHYS 108

Secondary Cross-listing

Energy use has skyrocketed in the United States and elsewhere in the world, causing significant economic and political shifts, as well as concerns for the environment. This course will address the physics and technology of energy generation, consumption, and conservation. It will cover a wide range of energy sources, including fossil fuels, hydropower, solar energy, wind energy, and nuclear energy. We will discuss energy use in transportation, manufacturing, building heating, and building lighting. Students will learn to compare the efficiencies and environmental impacts of various energy sources and uses.

Class Format: twice a week, occasional lab exercises, and a field trip to the college heating plant, all during class hours

Requirements/Evaluation: weekly assignments, two hour tests, and a final project culminating in an oral presentation to the class and a 10-page paper; all of these will be substantially quantitative

Prerequisites: high school physics, high school chemistry, and mathematics at the level of MATH 130

Enrollment Limit: 20

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:
ENVI 108 (D3) PHYS 108 (D3)

Attributes: ENVI Natural World Electives

Fall 2021

LEC Section: 01 TR 11:20 am - 12:35 pm Henrik Ronellenfitsch
ENVI 203 (F) Ecology (QFR)

**Cross-listings:** ENVI 203 BIOL 203

**Secondary Cross-listing**

This course combines lectures & discussion with field and indoor laboratory exercises 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 help students 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 101 or 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:

ENVI 203 (D3) BIOL 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 EVST Living Systems Courses

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ENVI 387 (F) 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:** 30

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

**Expected Class Size:** 30
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, tests, and an independent research project
Prerequisites: Either GEOS 104 or GEOS 210; or permission of instructor
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
Distributions: (D3) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
ENVI 404 (D3) MAST 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
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: 30

Enrollment Preferences: first-year students

Expected Class Size: 20

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

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This a calculus course.

Fall 2021

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

Spring 2022

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

MATH 140 (F)(S) Calculus II (QFR)

Calculus answers two basic question: 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 2021
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 2021

SEM Section:  03  MWF 12:00 pm - 12:50 pm   Julie C. Blackwood
SEM Section:  02  MWF 11:00 am - 11:50 am   Julie C. Blackwood
SEM Section:  01  MWF 10:00 am - 10:50 am   Julie C. Blackwood

Spring 2022

SEM Section:  01  MWF 10:00 am - 10:50 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:  homework, quizzes, 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:  45
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 2021
MATH 200  (F)(S)  Discrete Mathematics  (QFR)
This course will help you understand the world through a mathematical lens and will develop your powers of argumentation and critical thinking. We will explore and utilize diverse areas of discrete mathematics including logic, set theory, functions and relations, combinatorics, probability, networks, and more. We also will discuss methods and styles of mathematical proofs in order to prepare you for more advanced math courses. Finally, while mathematical knowledge is often perceived as being "pure," we will highlight some ways in which it is socially constructed and hence subject to human limitations and biases.

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

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

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

Enrollment Limit: 40

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

Expected Class Size: 40

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

Distributions: (D3) (QFR)

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 2021
LEC Section: 02    TR 9:55 am - 11:10 am     Chad M. Topaz
LEC Section: 01    TR 8:30 am - 9:45 am     Chad M. Topaz

Spring 2022
LEC Section: 02    MWF 10:00 am - 10:50 am     Lori A. Pedersen
LEC Section: 01    MWF 9:00 am - 9:50 am     Lori A. Pedersen

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

Cross-listings: PHYS 210  MATH 210

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

Class Format: three hours per week

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

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

Enrollment Limit: 50

Enrollment Preferences: sophomores and juniors
Expected Class Size: 30

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

Distributions: (D3) (QFR)

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

PHYS 210 (D3) MATH 210 (D3)

Quantitative/Formal Reasoning Notes: This course will have weekly problem sets using advanced calculus methods and some computer programming at the end of the course.

Spring 2022
LEC Section: 01    TR 9:55 am - 11:10 am    David R. Tucker-Smith

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

Requirements/Evaluation: homework and exams
Prerequisites: MATH 150/151 or MATH 200
Enrollment Limit: 40
Enrollment Preferences: Students who have officially declared a major that requires Math 250.
Expected Class Size: 40
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: In this course, students will engage in both quantitative and formal reasoning.
Attributes: COGS Related Courses

Fall 2021
LEC Section: 02    TR 11:20 am - 12:35 pm    Allison Pacelli
LEC Section: 01    TR 9:55 am - 11:10 am    Allison Pacelli

Spring 2022
LEC Section: 01    MWF 10:00 am - 10:50 am    Susan R. Loepp
LEC Section: 02    MWF 11:00 am - 11:50 am    Susan R. Loepp

MATH 303  (F) Introduction to Dynamics, p-Adics, and Measure  (QFR)
At its most basic level a dynamical system consists of a set of points and a transformation or map acting on the set (i.e., sending points in the set to other points in the set). In this setting we can already ask about the existence, and prevalence, of periodic points (points that come back to themselves). One can also ask about the orbit of a point: the set of points that is obtained as one iteratively applies the transformation the point. An important dynamical notion that comes up here is that of chaos. The course will start by studying basic dynamical systems using notions from calculus. Then we will introduce the p-adic numbers and use them to study dynamical systems. The course will end with an exploration of the notion of measure and its connection with dynamical systems.

Requirements/Evaluation: Homework, class participation, exams.
Prerequisites: Math 250.
Enrollment Limit: 30
Enrollment Preferences: Juniors
Expected Class Size: 20
MATH 307 (S) Computational Linear Algebra (QFR)

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

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

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

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

Enrollment Limit: 30

Enrollment Preferences: Preference given to majors and prospective majors.

Expected Class Size: 30

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

Distributions: (D3) (QFR)

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

Spring 2022

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

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

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

Class Format: This is a research-based tutorial.

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

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

Enrollment Limit: 10

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

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

Distributions: (D3) (DPE) (QFR)

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

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

Spring 2022

TUT Section: T1 TBA Chad M. Topaz

MATH 309 (S) Differential Equations (QFR)
Ordinary differential equations (ODE) frequently arise as models of phenomena in the natural and social sciences. This course presents core ideas of ODE from an applied standpoint. Topics covered early in the course may include numerical solutions, separation of variables, integrating factors, constant coefficient linear equations, and power series solutions. Later, we will focus on nonlinear ODEs, for which it is usually impossible to find analytical solutions. Tools from dynamical systems will be introduced to allow us to obtain some information about the behavior of the ODE without explicitly knowing the solution.

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

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

Prerequisites: MATH 150/151 and MATH 250

Enrollment Limit: 20

Enrollment Preferences: discretion of the instructor

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: 300-level mathematics course

Spring 2022

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

MATH 321 (S) Knot Theory (QFR)
Take a piece of string, tie a knot in it, and glue the ends together. The result is a knotted circle, known as a knot. For the last 100 years, mathematicians have studied knots, asking such questions as, "Given a nasty tangled knot, how do you tell if it can be untangled without cutting it open?" Some of the most interesting advances in knot theory have occurred in the last ten years. This course is an introduction to the theory of knots.
Among other topics, we will cover methods of knot tabulation, surfaces applied to knots, polynomials associated to knots, and relationships between knot theory and chemistry and physics. In addition to learning the theory, we will look at open problems in the field.

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

Prerequisites: MATH 250 or permission of instructor

Enrollment Limit: 30

Enrollment Preferences: seniors, junior, sophomores, first year

Expected Class Size: 25

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

Distributions: (D3) (QFR)

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

Spring 2022
MATH 329  (F) Discrete Geometry  
Discrete geometry is one of the oldest and most consistently vibrant areas of mathematics, stretching from the Platonic Solids of antiquity to the modern day applications of convex optimization and linear programming. In this course we will learn about polygons and their higher-dimensional cousins, polyhedra and polytopes, and the various ways to describe, compute, and classify such objects. We will learn how these objects and ideas can be applied to other areas, from computation and optimization to studying areas of math like algebraic geometry. Throughout this course we will be engaging with mathematical work and literature from as old as 500 BCE and as recent as "posted to the internet yesterday."

Requirements/Evaluation:  Problem sets, exams, and a final project
Prerequisites:  MATH 200 or Math 250, or permission of instructor
Enrollment Limit:  30
Enrollment Preferences:  Sophomores, juniors, and seniors
Expected Class Size:  20
Grading:  no pass/fail option, no fifth course option
Distributions:  (D3) (QFR)
Quantative/Formal Reasoning Notes:  All of the content in this course is quantitative or formal reasoning.

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

MATH 335  (F) Decisions, Games, and Evolutionary Dynamics  
Given goals, options, and uncertainty, how does one make a rational choice? What happens when we interact with others who are also choosing? How might this play out over time? We will first cover the principles of decision theory including preference, uncertainty, utility, imperfect information, and rational choice. The majority of the course will be spent on the main topics of game theory: sequential games, bimatrix games, parlor games, Nash equilibria, bargaining, repeated games, Bayesian belief, and signaling. Applying these principles to populations that evolve over time through variation, selection, and copying, we will develop basic models of the dynamics of evolution.

Class Format:  lecture
Requirements/Evaluation:  Weekly homework, midterm exams, and a final.
Prerequisites:  Math 150/151 and Math 250. Some background in probability and differential equations is highly recommended.
Enrollment Limit:  35
Enrollment Preferences:  Math majors.
Expected Class Size:  35
Grading:  yes pass/fail option, yes fifth course option
Distributions:  (D3) (QFR)
Quantative/Formal Reasoning Notes:  Lots of math.

Fall 2021
LEC Section:  01  MWF 11:00 am - 11:50 am  Stewart D. Johnson

MATH 341  (F)(S) Probability  
Cross-listings:  STAT 341  MATH 341
Primary Cross-listing
The historical roots of probability lie in the study of games of chance. Modern probability, however, is a mathematical discipline that has wide applications in a myriad of other mathematical and physical sciences. Drawing on classical gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables (both discrete and continuous), distribution and
expectation, independence, laws of large numbers, and the well-known Central Limit Theorem. Many interesting and important applications will also be presented, including some from classical Poisson processes, random walks and Markov Chains.

**Requirements/Evaluation:** homework, classwork, and exams

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

**Enrollment Limit:** 30

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

**Expected Class Size:** 20

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

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

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

STAT 341 (D3) MATH 341 (D3)

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

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**Fall 2021**

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

**Spring 2022**

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

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

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

**Requirements/Evaluation:** homework, classwork, and exams

**Prerequisites:** MATH 250 or permission of instructor

**Enrollment Limit:** 30

**Enrollment Preferences:** Juniors and Seniors.

**Expected Class Size:** 30

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

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

**Quantitative/Formal Reasoning Notes:** Math

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**Fall 2021**

LEC Section: 01  MWF 11:00 am - 11:50 am  Cesar E. Silva

**Spring 2022**

LEC Section: 01  MWF 11:00 am - 11:50 am  Cesar E. Silva

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**MATH 351  (S) Applied Real Analysis  (QFR)**

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

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

**Requirements/Evaluation:** homework, classwork, and exams
Prerequisites: MATH 250 or permission of the instructor.

Enrollment Limit: 20

Enrollment Preferences: Seniors

Expected Class Size: 20

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: Math

Spring 2022

LEC Section: 01 MWF 12:00 pm - 12:50 pm Cesar E. Silva

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 2021

LEC Section: 01 MWF 10:00 am - 10:50 am Susan R. Loepp

Spring 2022

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

LEC Section: 02 MWF 10:00 am - 10:50 am Ralph E. Morrison

MATH 361 (F)(S) 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: 24(12/con)

Enrollment Preferences: current or expected Computer Science majors
MATH 361 (D3) CSCI 361 (D3)

Quantitative/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 2021
CON Section: 02    TF 1:10 pm - 2:25 pm     Aaron M. Williams
LEC Section: 01    ASYN     Aaron M. Williams
CON Section: 03    MR 1:10 pm - 2:25 pm     Aaron M. Williams

Spring 2022
LEC Section: 01    ASYN     Aaron M. Williams
CON Section: 03    MR 1:10 pm - 2:25 pm     Aaron M. Williams
CON Section: 02    TF 1:10 pm - 2:25 pm     Aaron M. Williams

MATH 383 (F) Complex Analysis (QFR)

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

Requirements/Evaluation: homework, classwork, and exams
Prerequisites: MATH 350 or MATH 351 or permission of instructor
Enrollment Limit: 40
Enrollment Preferences: 40
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Unit Notes: this course is not a senior seminar, so it does not fulfill the senior seminar requirement for the Math major
Distributions: (D3) (QFR)
Quantitative/Formal Reasoning Notes: Advanced mathematics course with weekly or daily problem sets.

Fall 2021
LEC Section: 01    MWF 11:00 am - 11:50 am     Steven J. Miller

MATH 394 (S) Galois Theory (QFR)

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

Requirements/Evaluation: written homeworks, oral presentations, and exams
Prerequisites: MATH 355
Enrollment Limit: 50
Enrollment Preferences: discretion of the instructor

Expected Class Size: 10

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

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is a math class

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

MATH 401 (S) Functional Analysis (QFR)

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

Class Format: lecture

Requirements/Evaluation: weekly problem sets, two midterm exams, final exam

Prerequisites: MATH 350 or 351 or permission of instructor

Enrollment Limit: 40

Enrollment Preferences: Mathematics and Physics majors; seniors

Expected Class Size: 30

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

Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is an advance course in Mathematical Analysis.

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

MATH 405 (S) Representation Theory and Special Functions (QFR)

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

Requirements/Evaluation: By exams and homework

Prerequisites: Math 350 or Math 351, and Math 355

Enrollment Limit: 50

Enrollment Preferences: By instructor preference

Expected Class Size: 10

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

Distributions: (D3) (QFR)
Math 411 (F) Commutative Algebra (QFR)
Commutative Algebra is an essential area of mathematics that provides indispensable tools to many areas, including Number Theory and Algebraic Geometry. This course will introduce you to the fundamental concepts for the study of commutative rings, with a special focus on the notion of "prime ideals," and how they generalize the well-known notion of primality in the set of integers. Commutative algebra has applications ranging from algebraic geometry to coding theory. For example, one can use commutative algebra to create error correcting codes. It is perhaps most often used, however, to study curves and surfaces in different spaces. To understand these structures, one must study polynomial rings over fields. This course will be an introduction to commutative algebra. Possible topics include polynomial rings, localizations, primary decomposition, completions, and modules.

Requirements/Evaluation: homework and exams
Prerequisites: MATH 355 or permission of instructor
Enrollment Limit: 25
Enrollment Preferences: Math majors
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: It is a 400-level math course

Math 435 (F) Chip-firing Games on Graphs (QFR)
Starting with a graph (a collection of nodes connected by edges), place an integer number of poker chips on each vertex. Move these chips around according to "chip-firing moves", where a vertex donates a chip along each edge. These simple and intuitive games quickly lead to challenging mathematics with applications ranging from dynamical systems to algebraic geometry. In this course we'll build up a mathematical framework for studying chip-firing games, drawing on linear algebra and group theory. We'll discover algorithms for winning these games, and study their complexity; and we'll prove graph-theoretic versions of famous results like the Riemann-Roch theorem. A key component of this course will be research projects that draw on open questions about chip-firing.

Requirements/Evaluation: Weekly homework for the first eight weeks, four quizzes spaced evenly throughout the semester, and a cumulative project worked on throughout the semester (10-20 pages)
Prerequisites: Math 250 and Math 355
Enrollment Limit: 25
Enrollment Preferences: Math majors who need the course to graduate
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
Quantative/Formal Reasoning Notes: All topics are quantitative

Math 458 (S) Algebraic Combinatorics (WS) (QFR)
Algebraic combinatorics is a branch of mathematics at the intersection of combinatorics and algebra. On the one hand, we study combinatorial
structures using algebraic techniques, while on the other we use combinatorial arguments and methods to solve problems in algebra. In this collaborative project-based course, students will select among the presented topics, develop research questions, and undertake original research in the field. Student assessment is based building positive and supportive collaborative working relationships with their peers, drafts of research project manuscript, and oral presentations.

**Requirements/Evaluation:** Drafts of manuscript, oral presentations, reflections, peer collaboration skills

**Prerequisites:** MATH 200 and MATH 355

**Enrollment Limit:** 25

**Enrollment Preferences:** Senior mathematics majors, students with programming experience, students with interests in algebra and combinatorics.

**Expected Class Size:** 20

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

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

**Quantitative/Formal Reasoning Notes:** This is a mathematics course in the area of algebraic combinatorics and is a quantitative and formal reasoning course.

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**PHIL 203 (F) Logic and Language** (QFR)

Logic is the study of reasoning and argument. More particularly, it concerns itself with the difference between good and bad reasoning, between strong and weak arguments. We all examine the virtues and vices of good arguments in both informal and formal systems. The goals of this course are to improve the critical thinking of the students, to introduce them to sentential and predicate logic, to familiarize them with enough formal logic to enable them to read some of the great works of philosophy, which use formal logic (such as Wittgenstein's *Tractatus*), and to examine some of the connections between logic and philosophy.

**Class Format:** discussion

**Requirements/Evaluation:** a midterm, a final, frequent homework and problem sets

**Prerequisites:** none

**Enrollment Limit:** 40/sect

**Enrollment Preferences:** Philosophy majors, seniors, juniors, sophomores, first-years in that order.

**Expected Class Size:** 40/sect

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

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

**Attributes:** Linguistics PHIL Contemp Metaphysics + Epistemology Courses

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**PHIL 312 (S) Philosophical Implications of Modern Physics** (QFR)

Cross-listings: STS 312 PHYS 312 PHIL 312

**Secondary Cross-listing**

Some of the discoveries made by physicists over the last century seem to show that our common sense views are deeply at odds with our most sophisticated and best confirmed scientific theories. The course will present the essential ideas of relativity theory and quantum theory and explore their implications for philosophy. We will ask, for example, what these theories tell us about the nature of space, time, probability and causality.
Requirements/Evaluation: attendance, participation, problem sets, exams, six 1- to 2-page papers and a 12- to 15-page term paper
Prerequisites: MATH 140, high-school physics, and either a 200-level course in PHIL or a 100-level course in PHYS
Enrollment Limit: 20
Enrollment Preferences: Philosophy majors and Physics 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:
STSC 312 (D2) PHYS 312 (D3) PHIL 312 (D2)
Attributes: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2022
LEC Section: 01 MR 2:35 pm - 3:50 pm Keith E. McPartland, Frederick W. Strauch

PHYS 108 (F) Energy Science and Technology (QFR)
Cross-listings: ENVI 108 PHYS 108
Primary Cross-listing
Energy use has skyrocketed in the United States and elsewhere in the world, causing significant economic and political shifts, as well as concerns for the environment. This course will address the physics and technology of energy generation, consumption, and conservation. It will cover a wide range of energy sources, including fossil fuels, hydropower, solar energy, wind energy, and nuclear energy. We will discuss energy use in transportation, manufacturing, building heating, and building lighting. Students will learn to compare the efficiencies and environmental impacts of various energy sources and uses.
Class Format: twice a week, occasional lab exercises, and a field trip to the college heating plant, all during class hours
Requirements/Evaluation: weekly assignments, two hour tests, and a final project culminating in an oral presentation to the class and a 10-page paper; all of these will be substantially quantitative
Prerequisites: high school physics, high school chemistry, and mathematics at the level of MATH 130
Enrollment Limit: 20
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:
ENVI 108 (D3) PHYS 108 (D3)
Attributes: ENVI Natural World Electives

Fall 2021
LEC Section: 01 TR 11:20 am - 12:35 pm Henrik Ronellenfitsch

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)

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

Fall 2021

LEC Section: 01  MWF 11:00 am - 11:50 am  Graham K. Giovanetti
LAB Section: 03  T 1:00 pm - 4:00 pm  Graham K. Giovanetti
LAB Section: 02  M 1:00 pm - 4:00 pm  Graham K. Giovanetti

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 2022

LAB Section: 02  M 1:00 pm - 4:00 pm  Henrik Ronellenfitsch
LAB Section: 03  T 1:00 pm - 4:00 pm  Henrik Ronellenfitsch
LEC Section: 01  MWF 11:00 am - 12:15 pm  Henrik Ronellenfitsch

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)

Quantitative/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 2021
LAB Section: 03  T 1:00 pm - 4:00 pm  Protik K. Majumder
LAB Section: 04  W 1:00 pm - 4:00 pm  Protik K. Majumder
LAB Section: 02  M 1:00 pm - 4:00 pm  Protik K. Majumder
LEC Section: 01  MWF 11:00 am - 11:50 am  Protik K. Majumder

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, two hours weekly; problem-solving conference session, one hour weekly; laboratory, 2-3 hours most weeks, alternating between 'hands-on' and computational sessions (limit 10 per lab, 14 per conference section)

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/C, 10/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 2022
LAB Section: 04  M 1:00 pm - 4:00 pm  Catherine Kealhofer
LAB Section: 05  T 1:00 pm - 4:00 pm  Catherine Kealhofer
CON Section: 02  M 11:00 am - 11:50 am  Catherine Kealhofer
LEC Section: 01  WF 11:00 am - 11:50 am  Catherine Kealhofer
CON Section: 03  M 7:00 pm - 7:50 pm  Catherine Kealhofer

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: Two 50-minute lectures per week, one 50-minute conference section per week, one 3-hour lab per week

Requirements/Evaluation: class participation, weekly lab/conference assignments, weekly problem sets, final paper, two hour-exams and a final exam;

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: besides the final paper, all assignments in the course have a substantial quantitative component

Fall 2021
LEC Section: 01  WF 11:00 am - 11:50 am  Catherine Kealhofer
CON Section: 02  M 11:00 am - 11:50 am  Catherine Kealhofer
CON Section: 03  M 7:00 pm - 7:50 pm  Catherine Kealhofer
LAB Section: 04  W 1:00 pm - 4:00 pm  Catherine Kealhofer

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: 15

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 2021
LEC Section: 01  MWF 10:00 am - 10:50 am  David R. Tucker-Smith
LAB Section: 02  T 1:00 pm - 4:00 pm  David R. Tucker-Smith
LAB Section: 03  W 1:00 pm - 4:00 pm  David R. Tucker-Smith

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, in-class tests, 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 2022
LEC Section: 01 MWF 10:00 am - 10:50 am Graham K. Giovanetti
LAB Section: 03 W 1:00 pm - 4:00 pm Graham K. Giovanetti
LAB Section: 02 T 1:00 pm - 4:00 pm Graham K. Giovanetti

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. A series of optional sessions in Mathematica will be offered for students who are not already familiar with this computational tool.
Class Format: three hours per week
Requirements/Evaluation: several exams and on weekly problem sets, all of which have a substantial quantitative component
Prerequisites: MATH 150 or 151 and familiarity with Newtonian mechanics at the level of PHYS 131
Enrollment Limit: 50
Enrollment Preferences: sophomores and juniors
Expected Class Size: 30
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)
This course is cross-listed and the prefixes carry the following divisional credit:
PHYS 210 (D3) MATH 210 (D3)
Quantitative/Formal Reasoning Notes: This course will have weekly problem sets using advanced calculus methods and some computer programming at the end of the course.

Spring 2022
LEC Section: 01 TR 9:55 am - 11:10 am David R. Tucker-Smith
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 2021
LAB Section: 04  M 1:00 pm - 4:00 pm  Charlie Doret
LAB Section: 03  W 1:00 pm - 4:00 pm  Charlie Doret
LAB Section: 02  T 1:00 pm - 4:00 pm  Charlie Doret
LEC Section: 01  MWF 9:00 am - 9:50 am  Charlie Doret

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 2022
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 312  (S)  Philosophical Implications of Modern Physics  (QFR)

Cross-listings: STS 312  PHYS 312  PHIL 312

Primary Cross-listing

Some of the discoveries made by physicists over the last century seem to show that our common sense views are deeply at odds with our most sophisticated and best confirmed scientific theories. The course will present the essential ideas of relativity theory and quantum theory and explore their implications for philosophy. We will ask, for example, what these theories tell us about the nature of space, time, probability and causality.

Requirements/Evaluation: attendance, participation, problem sets, exams, six 1- to 2-page papers and a 12- to 15-page term paper

Prerequisites: MATH 140, high-school physics, and either a 200-level course in PHIL or a 100-level course in PHYS

Enrollment Limit: 20

Enrollment Preferences: Philosophy majors and Physics 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:

STS 312 (D2) PHYS 312 (D3) PHIL 312 (D2)

Attributes: PHIL Contemp Metaphysics + Epistemology Courses

Spring 2022

LEC Section: 01    MR 2:35 pm - 3:50 pm     Keith E. McPartland, Frederick W. Strauch

PHYS 405  (F)  Electromagnetic Theory  (QFR)

This course builds on the material of Physics 201, and explores the application of Maxwell's Equations to understand a range of topics including electric fields and matter, magnetic materials, light, and radiation. As we explore diverse phenomena, we will learn useful approximation techniques and beautiful mathematical tools. In addition to weekly tutorial meetings, the class will meet once a week as a whole to introduce new material.

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

Prerequisites: PHYS 202 and PHYS/MATH 210 or MATH 209 or MATH 309

Enrollment Limit: 10/section

Expected Class Size: 16

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

Distributions: (D3)  (QFR)

Fall 2021

TUT Section: T1    F 1:10 pm - 2:25 pm     Frederick W. Strauch

PHYS 418  (S)  Gravity  (QFR)

This course is an introduction Einstein's theory of general relativity. We begin with a review of special relativity, emphasizing geometrical aspects of Minkowski spacetime. Working from the equivalence principle, we then motivate gravity as spacetime curvature, and study in detail the Schwarzschild geometry around a spherically symmetric mass. After this application, we use tensors to develop Einstein's equation, which describes how energy density curves spacetime. With this equation in hand we study the Friedmann-Robertson-Walker geometries for an expanding universe, and finally, we linearize Einstein's equation to develop the theory of gravitational waves.

Requirements/Evaluation: weekly problem sets, a midterm exam, and a final exam, all of which have a substantial quantitative component

Prerequisites: PHYS 301 or PHYS 405 or PHYS 411

Enrollment Limit: none
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: EVST Methods Courses 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)

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.
STAT 101  (F)(S)  Elementary Statistics and Data Analysis  (QFR)

It is impossible to be an informed citizen in the world today without an understanding of data and information. Whether opinion polls, unemployment rates, salary differences between men and women, the efficacy of vaccines or consumer webdata, we need to be able to separate the signal from the noise. We will learn the statistical methods used to analyze and interpret data from a wide variety of sources. The goal of the course is to help reach conclusions and make informed decisions based on data.

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 101/161/201 should enroll in STAT 202.
Distributions: (D3)  (QFR)
Attributes: COGS Related Courses  PHLH Statistics Courses

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 and sciences. Topics include exploratory data analysis, elements of probability theory, basic statistical inference, and introduction to statistical modeling. The course focuses on the application of statistics tools to solve problems, to make decisions, and the use of statistical thinking to understand the world.

Requirements/Evaluation: students complete homework, quizzes and exams (including take-home exams. Students will need to get 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: no pass/fail option, no fifth course option

Unit Notes: Students with calculus background should consider STAT 201 or 202. Students without any calculus background should consider STAT 101. 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 2021
LEC Section: 02  TF 2:35 pm - 3:50 pm  Bernhard Klingenberg
LEC Section: 01  TF 1:10 pm - 2:25 pm  Bernhard Klingenberg

Spring 2022
LEC Section: 01  MWF 8:00 am - 8:50 am  Annie Tang
LEC Section: 02  MWF 10:00 am - 10:50 am  Annie Tang

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: 45

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

Expected Class Size: 45

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  EVST Methods Courses  PHLH Statistics Courses

Fall 2021
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Stewart D. Johnson

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

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.

Class Format: Class meetings will discuss questions from lecture, dive further into the material, and work on examples. You'll use chat and discussion boards to build community, study with classmates, and ask questions outside of class time. The professor and TAs will also offer optional synchronous office hours/review sessions.

Requirements/Evaluation: Homework problems; quizzes; a final project (on a topic that interests 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 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: AP Statistics 4 or 5, or STAT 101, or STAT 161, or STAT 201, 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, yes fifth course option

Unit Notes: students with a 4 on the AP Stats exam should contact the department for proper placement

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: EVST Methods Courses PHLH Statistics Courses

Fall 2021
LEC Section: 02 TR 11:20 am - 12:35 pm Daniel B. Turek
LEC Section: 01 TR 11:20 am - 12:35 pm Shaoyang Ning

Spring 2022
LEC Section: 01 TR 11:20 am - 12:35 pm Shaoyang Ning
LEC Section: 02 TR 11:20 am - 12:35 pm Daniel B. Turek

STAT 319 (S) Statistical Computing (QFR)
This course introduces a variety of computational and data-centric topics of applied statistics, which are broadly useful for acquiring, manipulating, visualizing, and analyzing data. We begin with the R language, which will be used extensively throughout the course. Then we'll introduce a variety of other useful tools, including the UNIX environment, scripting analyses using bash, databases and the SQL language, alternative data formats, techniques for visualizing high-dimensional data, and text manipulation using regular expressions. We'll also cover some modern statistical techniques along the way, which are made possible thanks to advances in computational power. This course is strongly computer oriented, and assignments will be project-based.

Requirements/Evaluation: based primarily on projects, homework, and exams

Prerequisites: STAT 201 or 202 and CSCI 134, 135, or 136

Enrollment Limit: 30

Enrollment Preferences: juniors and seniors, Statistics majors

Expected Class Size: 15

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

Distributions: (D3) (QFR)

Quantative/Formal Reasoning Notes: This course uses statistical tools and programming techniques to acquire data, create visualizations, and make future predictions.

Spring 2022
LEC Section: 01 TF 1:10 pm - 2:25 pm 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 2021
LEC Section: 01 MWF 9:00 am - 9:50 am Steven J. Miller

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

STAT 342 (S) Introduction to Stochastic Processes (QFR)
Stochastic processes are mathematical models for random phenomena evolving in time or space. Examples include the number of people in a queue at time t or the accumulated claims paid by an insurance company in an interval of time t. This course introduces the basic concepts and techniques of stochastic processes used to construct models for a variety of problems of practical interest. The theory of Markov chains will guide our discussion as we cover topics such as martingales, random walks, Poisson process, birth and death processes, and Brownian motion.

Requirements/Evaluation: weekly homework/labs, classwork, and exams
Prerequisites: STAT 341
Enrollment Limit: 30
Enrollment Preferences: senior Statistics majors
Expected Class Size: 15
Grading: yes pass/fail option, yes fifth course option
Distributions: (D3) (QFR)

Quantitative/Formal Reasoning Notes: This is a statistics class with a focus on mathematical skills and translating real world phenomena into mathematical descriptions.

Spring 2022
LEC Section: 01 TF 2:35 pm - 3:50 pm Elizabeth M. Upton

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 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, 201, 202, or equivalent, and Math 140 or equivalent, 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 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 2021

LEC Section: 01  MWF 12:00 pm - 12:50 pm  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, logistic 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, midterm exam, final exam, end-of-year project.

**Prerequisites:** MATH 250, MATH/STAT 341 (may be taken concurrently) and at least one of STAT 201 or 202. Or permission of instructor

**Enrollment Limit:** 30

**Enrollment Preferences:** Statistics Majors

**Expected Class Size:** 20

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

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

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

**Attributes:** EVST Methods Courses

Fall 2021

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

Spring 2022

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

**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.

**Class Format:** For the Spring 2021 semester, synchronous zoom lectures are planned, where the instructor uses Google's jamboard to interact with
**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

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Spring 2022

LEC Section: 01    TR 8:30 am - 9:45 am    Bernhard Klingenberg

**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.

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Fall 2021

LEC Section: 01    TF 1:10 pm - 2:25 pm    Daniel B. Turek

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

Distributions:  (D3) (QFR)

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

Spring 2022
LEC Section: 01    MR 2:35 pm - 3:50 pm    Shaoyang Ning

STS 312  (S)  Philosophical Implications of Modern Physics  (QFR)

Cross-listings:  STS 312  PHYS 312  PHIL 312

Secondary Cross-listing

Some of the discoveries made by physicists over the last century seem to show that our common sense views are deeply at odds with our most sophisticated and best confirmed scientific theories. The course will present the essential ideas of relativity theory and quantum theory and explore their implications for philosophy. We will ask, for example, what these theories tell us about the nature of space, time, probability and causality.

Requirements/Evaluation:  attendance, participation, problem sets, exams, six 1- to 2-page papers and a 12- to 15-page term paper

Prerequisites:  MATH 140, high-school physics, and either a 200-level course in PHIL or a 100-level course in PHYS

Enrollment Limit:  20

Enrollment Preferences:  Philosophy majors and Physics 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:

STS 312  (D2)  PHYS 312  (D3)  PHIL 312  (D2)

Attributes:  PHIL Contemp Metaphysics + Epistemology Courses

Spring 2022
LEC Section: 01    MR 2:35 pm - 3:50 pm    Keith E. McPartland,  Frederick W. Strauch