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)**

*How do stars work? This course answers that question from start to finish! In this course we undertake a survey of some of the main ideas in modern astrophysics, with an emphasis on the observed properties and evolution of stars; 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 radiation laws and stellar spectra, astronomical instrumentation, physical characteristics of the Sun and other stars, star formation and evolution, nucleosynthesis, white dwarfs and planetary nebulae, pulsars and neutron stars, supernovae, relativity, and black holes. We will also discuss the detections of long-sought gravitational waves' the first detection generated during the merging of two massive stellar black holes more than a billion light-years away, and, another from the merger of two neutron stars in a galaxy over 100 million light-years distant. Observing sessions include use of the 24-inch and other telescopes for observations of stars, nebulae, planets and galaxies, as well as daytime observations of the Sun.*

**Class Format:** lecture/discussion, observing sessions, and five labs per semester

**Requirements/Evaluation:** evaluation will be based on weekly problem sets, two hour tests, a final exam, lab reports, and an observing portfolio

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

**Enrollment Limit:** 28

**Expected Class Size:** 15

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

**Fall 2018**

**LEC Section: 01** TR 11:20 am - 12:35 pm  Marek Demianski

**LAB Section: 02** M 1:00 pm - 4:00 pm  Steven P. Souza, Kevin Flaherty

**LAB Section: 03** R 1:00 pm - 4:00 pm  Steven P. Souza, Kevin Flaherty

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

*Crosslistings: BIOL321 / CHEM321 / BIMO321*

**Primary Crosslisting**

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

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

**Requirements/Evaluation:** evaluation is based on quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports
BIMO 322 (S) Biochemistry II: Metabolism (QFR)

Crosslistings: CHEM322 / BIMO322 / BIOL322

Primary Crosslisting

This lecture course provides an in-depth presentation of the complex metabolic reactions which 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; laboratory, three hours per week

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 64

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

Expected Class Size: 64

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;
BIOL 202 (F) Genetics (QFR)

Genetics, classically defined as the study of heredity, has evolved into a discipline whose limits are continually expanded by innovative molecular technologies. 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. The laboratory part of the course provides an experimental introduction to modern genetic analysis. Laboratory experiments include linkage analysis, bacterial transformation with plasmids and DNA restriction mapping.

Class Format: lecture/laboratory, six hours per week

Requirements/Evaluation: evaluation will be based on bi-weekly problem sets, weekly laboratory exercises and laboratory reports, and examinations

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 101 and 102

Enrollment Limit: none

Expected Class Size: 84

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses; BIMO Required Courses;

Fall 2018

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)

Primary Crosslisting

Crosslistings: BIOL203 / ENVI203

This course combines lectures 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 overall view of global patterns and then builds from the population to the ecosystem level. An emphasis is given to basic ecological principles and relates them to 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).

Class Format: lecture/laboratory, six hours per week

Requirements/Evaluation: evaluation will be based on problem sets, lab reports, hour exams, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 101 and 102, or ENVI 101 or 102, or permission of instructor

Enrollment Limit: none

Expected Class Size: 35

Department Notes: satisfies the living system course requirement for the major in Environmental Studies; satisfies the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: ENVI Natural World Electives; EVST Environmental Science; EVST Living Systems Courses;

Fall 2018

LEC Section: 01 MWF 10:00 am - 10:50 am Ron D. Bassar
BIOL 210 (S) Mathematical Biology  (QFR)

Crosslistings: MATH310 / BIOL210

Secondary Crosslisting

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

Class Format: tutorial

Requirements/Evaluation: problem sets, weekly meetings, final project and paper

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: MATH 250, MATH 209 or 309, permission of instructor

Enrollment Limit: 10

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

Expected Class Size: 10

Distributions: (D3) (QFR)

Distribution Notes: QFR: The course will introduce methods for developing and analyzing mathematical models.

Attributes: PHLH Methods in Public Health;

Spring 2019

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: lecture/discussion/laboratory, six hours per week

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 24

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

Expected Class Size: 24

Department Notes: does not satisfy the distribution requirement for the 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)

Distribution Notes: QFR: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Spring 2019
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 the emergence of diversity). Topics include micro-evolutionary models, natural selection and adaptation, sexual selection, speciation, the inference of evolutionary history among others.

Class Format: lecture/discussion/laboratory, six hours per week
Requirements/Evaluation: evaluation will be based on independent research project, problem sets, participation in discussions and exams
Prerequisites: BIOL 202
Enrollment Limit: 24
Enrollment Preferences: Seniors and biology majors
Expected Class Size: 24
Department Notes: satisfies the distribution requirement in the Biology major
Distributions: (D3) (QFR)
Attributes: BGNP Recommended Courses; BIMO Interdepartmental Electives; COGS Related Courses;

BIOL 321 (F) Biochemistry I: Structure and Function of Biological Molecules (QFR)
Crosslistings: BIOL321 / CHEM321 / BIMO321
Secondary Crosslisting
This course introduces the basic concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

Class Format: lecture, three hours per week; laboratory, four hours per week
Requirements/Evaluation: evaluation is based on quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports
Extra Info: may not be taken on a pass/fail basis
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: 16/lab
Department Notes: does not satisfy the distribution requirement in the Biology major
Distributions: (D3) (QFR)
Attributes: BGNP Related Courses; BIMO Required Courses;
BIOL 322 (S)  Biochemistry II: Metabolism  (QFR)

Crosslistings: CHEM322 / BIMO322 / BIOL322

Secondary Crosslisting

This lecture course provides an in-depth presentation of the complex metabolic reactions which 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; laboratory, three hours per week

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 64

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

Expected Class Size: 64

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Spring 2019

LEC Section: 01  MWF 11:00 am - 11:50 am  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo

BIOL 329 (F)  Conservation Biology  (QFR)

Crosslistings: BIOL329 / ENVI339

Primary Crosslisting

Conservation biology is an interdisciplinary field that develops scientific and technical means for the protection, maintenance, and restoration of diversity at all levels of biological organization. This course provides an overview of the discipline including the causes and consequences of biodiversity loss as well as approaches and strategies used to combat biodiversity threats such as climate change, habitat fragmentation, and invasive species. Particular emphasis is placed on the ecological dimension of conservation and the application of biological principles (derived from physiological and behavioral ecology, population genetics, population ecology, community ecology, and systematics) to the conservation of biodiversity. The course combines lectures, readings, in-class discussion, and a laboratory that includes both field and lab projects.
Class Format: lecture and discussion three hours per week; lab three hours per week

Requirements/Evaluation: lab assignments, two exams, and discussion participation

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 203, or BIOL 202, or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: biology majors, seniors, and juniors

Expected Class Size: 24

Department Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

Distribution Notes: QFR: This course uses quantitative and statistical analyses in both the laboratory and lecture portion of the course. In lectures mathematical models will be covered to understand conservation dynamics. In lab, students will collect and analyze data and present results in graphical and statistical forms.

Attributes: ENVI Natural World Electives;

Fall 2018

LEC Section: 01 TR 11:20 am - 12:35 pm Sonya K. Auer
LAB Section: 02 M 1:00 pm - 4:00 pm Sonya K. Auer
LAB Section: 03 W 1:00 pm - 4:00 pm Sonya K. Auer

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.

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

Requirements/Evaluation: evaluation is based on frequent electronic and quantitative written weekly problem set assignments, laboratory work and reports, quizzes, two tests, and a final exam

Extra Info: information about the Chemistry Placement Test can be found at http://chemistry.williams.edu/placement/

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: all students planning to enroll are required to take the online Chemistry Placement Test prior to registering for the course (and incoming first year students are required to meet with a faculty member during First Days);

Enrollment Limit: 16/lab

Enrollment Preferences: incoming first year students are required to meet with a faculty member during First Days;

Expected Class Size: 48

Department Notes: CHEM 151 may be taken concurrently with MATH 102--see under Mathematics; CHEM 151 or its equivalent is prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Distribution Notes: students who have studied chemistry for one or more years are directed to CHEM 153 or 155

Attributes: BIMO Required Courses;

Fall 2018

LEC Section: 01 MWF 8:30 am - 9:45 am Christopher Goh
LAB Section: 02 M 1:00 pm - 5:00 pm Laura R. Strauch
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 work includes synthesis, qualitative and quantitative chemical analysis, and molecular modeling. 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 fundamental ideas of chemistry as part of their general education.

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

Requirements/Evaluation: evaluation is based on quantitative weekly problem set assignments, laboratory work and reports, hour tests, and a final exam

Extra Info: information about the Chemistry Placement Test can be found at http://chemistry.williams.edu/placement/

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: all students are required to take the online Chemistry Placement Test prior to registering for the course (and incoming first year students are required to meet with a faculty member during First Days)

Enrollment Limit: 16/lab

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

Expected Class Size: 70

Department Notes: one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Attributes: BIMO Required Courses;

Fall 2018

LEC Section: 01 MWF 9:00 am - 9:50 am John W. Thoman
LAB Section: 02 M 1:00 pm - 5:00 pm John W. Thoman
LAB Section: 03 T 1:00 pm - 5:00 pm Bob Rawle
LAB Section: 04 W 1:00 pm - 5:00 pm Bob Rawle
LAB Section: 05 R 1:00 pm - 5:00 pm Jenna L. MacIntire
LAB Section: 06 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 strong preparation in secondary school chemistry, including a laboratory experience, such as provided by an Advanced Placement chemistry course (or equivalent) with a corresponding score of 5 of the AP Chemistry Exam (or a 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, industrial, environmental, biological, and medicinal chemistry. Laboratory work includes synthesis, characterization, and reactivity of coordination complexes, electrochemical analysis, materials chemistry, qualitative analysis, and molecular modeling. This course is of interest for students who are anticipating professional 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 hours per week; laboratory, four hours per week

Requirements/Evaluation: evaluation is based on weekly problem sets, laboratory work and reports, an hour test, and a final exam

Extra Info: information about the Chemistry Placement Test can be found at http://chemistry.williams.edu/placement/

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: students planning to enroll are required to take the Chemistry Placement Survey prior to registering; incoming first year students are required to meet with faculty during First Days; for more information go to http://chemistry.williams.edu/placement/

Enrollment Limit: 16/lab

Enrollment Preferences: CHEM 151 is an introductory course for students with no or little chemistry background. Students who have studied chemistry for one or more years are directed to CHEM 153 or 155

Expected Class Size: 36

Department Notes: CHEM 151 may be taken concurrently with MATH 102--see under Mathematics; CHEM 151 or its equivalent is prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

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 and elimination reactions, and the addition reactions of alkenes and alkynes. 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 hours per week; laboratory, four hours per week

Requirements/Evaluation: evaluation will be based on quantitative problem sets, laboratory performance, including written lab reports, three midterm exams, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 16/lab

Expected Class Size: 120

Distributions: (D3) (QFR)

Attributes: BIMO Required Courses;

Spring 2019

LEC Section: 01  MWF 9:00 am - 9:50 am  Jimmy A. Blair
LAB Section: 02  M 1:00 pm - 5:00 pm  Jimmy A. Blair
LAB Section: 03  T 1:00 pm - 5:00 pm  Brooke Olson Blair
LAB Section: 04  W 1:00 pm - 5:00 pm  Brooke Olson Blair
LAB Section: 05  R 1:00 pm - 5:00 pm  Jenna L. Maclntire
LAB Section: 06  T 8:00 am - 12:00 pm  Jenna L. Maclntire
LAB Section: 07  M 1:00 pm - 5:00 pm  David P. Richardson
LAB Section: 08  W 1:00 pm - 5:00 pm  Jenna L. Maclntire

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

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

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

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

Extra Info: may not be taken on a pass/fail basis

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: 16/lab

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Fall 2018
LEC Section: 01  MWF 10:00 am - 10:50 am  Katie M. Hart
LAB Section: 02  M 1:00 pm - 5:00 pm  Katie M. Hart
LAB Section: 03  T 1:00 pm - 5:00 pm  Katie M. Hart
LAB Section: 04  W 1:00 pm - 5:00 pm  Amy Gehring

Spring 2019
LEC Section: 01  MWF 9:00 am - 9:50 am  Bob Rawle
LAB Section: 02  M 1:00 pm - 5:00 pm  Bob Rawle
LAB Section: 03  Cancelled

CHEM 322 (S) Biochemistry II: Metabolism  (QFR)
Crosslistings: CHEM322 / BIMO322 / BIOL322

Secondary Crosslisting

This lecture course provides an in-depth presentation of the complex metabolic reactions which 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; laboratory, three hours per week

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 64
Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 64

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Spring 2019

LEC Section: 01  MWF 11:00 am - 11:50 am  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  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 the laboratory session 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.

Class Format: tutorial, meeting time to be determined

Requirements/Evaluation: evaluation is based on tutorial participation, presentations, and submitted papers

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: CHEM 361 or equivalent background in Physics

Enrollment Limit: 10

Expected Class Size: 10

Distributions: (D3) (QFR)

Spring 2019

TUT Section: T1  Cancelled

CSCI 134 (F) Introduction to Computer Science: Diving into the Deluge of Data (QFR)

We are surrounded by information: weather forecasts, twitter feeds, restaurant reviews, stock market tickers, music recommendations, among others. This course introduces fundamental computational concepts for representing and manipulating data. Using the programming language Python, this course explores effective ways to organize and transform information in order to solve problems. Students will learn to design algorithms to search, sort, and manipulate data in application areas like text and image processing, social networks, scientific computing, databases, and the World Wide Web. Programming topics covered include object-oriented and functional programming, control structures, types, recursion, arrays, lists, streams, and dictionaries. This course is appropriate for all students who want to create software and learn computational techniques for manipulating and analyzing data. More details are available on the department website, http://www.cs.williams.edu

Class Format: lecture/laboratory

Requirements/Evaluation: evaluation will be based on weekly assignments, programming projects, and examinations

Prerequisites: none, except for the standard prerequisites for a (Q) course; previous programming experience is not required

Enrollment Limit: 75

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

Expected Class Size: 75

Department Notes: students with prior experience with object-oriented programming should discuss appropriate course placement with members of the department

Distributions: (D3) (QFR)
Attributes: BGNP Recommended Courses; COGS Interdepartmental Electives;

Fall 2018
LEC Section: C1  MWF 9:00 am - 9:50 am  Duane A. Bailey
LAB Section: C2  M 1:00 pm - 2:30 pm  Iris Howley
LAB Section: C3  Cancelled
LAB Section: C4  M 2:30 pm - 4:00 pm  Iris Howley
LAB Section: C5  T 2:30 pm - 4:00 pm  Iris Howley
LAB Section: C6  T 8:30 am - 10:00 am  Duane A. Bailey
LAB Section: C7  T 10:00 am - 11:30 am  Iris Howley

Spring 2019
LEC Section: C1  MWF 11:00 am - 11:50 am  Iris Howley
LAB Section: C2  M 1:00 pm - 2:30 pm  Iris Howley
LAB Section: C3  T 1:00 pm - 2:30 pm  Duane A. Bailey
LAB Section: C4  M 2:30 pm - 4:00 pm  Iris Howley
LAB Section: C5  T 2:30 pm - 4:00 pm  Duane A. Bailey
LAB Section: C6  Cancelled
LAB Section: C7  T 10:00 am - 11:30 am  Duane A. Bailey

CSCI 136 (F) 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.

Class Format: lecture/laboratory
Requirements/Evaluation: evaluation will be based on programming assignments, homework and/or examinations
Prerequisites: CSCI 134 or equivalent; fulfilling the Discrete Mathematics Proficiency requirement is recommended, but not required
Enrollment Limit: 60
Enrollment Preferences: If the course is over-enrolled, enrollment will be determined by lottery
Expected Class Size: 60
Distributions: (D3) (QFR)
Attributes: BGNP Recommended Courses;

Fall 2018
LEC Section: 01  MWF 9:00 am - 9:50 am  William J. Lenhart
LAB Section: 02  W 12:00 pm - 2:00 pm  William J. Lenhart
LAB Section: 03  W 12:00 pm - 2:00 pm  Bill K. Jannen
LAB Section: 04  W 2:00 pm - 4:00 pm  William J. Lenhart
LAB Section: 05  W 2:00 pm - 4:00 pm  Bill K. Jannen

Spring 2019
LEC Section: 01  MWF 11:00 am - 11:50 am  Daniel W. Barowy
LAB Section: 02  W 12:00 pm - 2:00 pm  Daniel W. Barowy
LAB Section: 03  W 12:00 pm - 2:00 pm  Bill K. Jannen
CSCI 237 (F) 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.

Class Format: lecture/laboratory
Requirements/Evaluation: evaluation will be based primarily on projects, and one or more exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 134, or both experience in programming and permission of instructor
Enrollment Limit: 30
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 30
Distributions: (D3) (QFR)

CSCI 256 (F) 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 induction, divide-and-conquer, dynamic programming, and greedy algorithms. Additional topics of study include algorithms on graphs and strategies for handling potentially intractable problems.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on problem sets and programming assignments, and midterm and final examinations
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136 and fulfillment of the Discrete Mathematics Proficiency requirement
Enrollment Limit: 30
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 30
Distributions: (D3) (QFR)
Attributes: BGNP Recommended Courses;
CSCI 326 (F) Software Methods (QFR)
Sophisticated software systems play a prominent role in many aspects of our lives, and while programming can be a very creative and exciting process, building a reliable software system of any size is no easy feat. Moreover, the ultimate outcome of any programming endeavor is likely to be incomplete, unreliable, and unmaintainable unless principled methods for software construction are followed. This course explores those methods. Specific topics include: software processes; specifying requirements and verifying correctness; abstractions; design principles; software architectures; concurrent and scalable systems design; testing and debugging; and performance evaluation.

Class Format: lecture/lab
Requirements/Evaluation: homework, programming assignments, group work, presentations, exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136, and at least one of CSCI 237, 256, or 334
Enrollment Limit: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Distributions: (D3) (QFR)

CSCI 333 (S) Storage Systems (QFR)
This course will examine topics in the design, implementation, and evaluation of storage systems. Topics include the memory hierarchy; ways that data is organized (both logically and physically); storage hardware and its influence on storage software designs; data structures; performance models; and system measurement/evaluation. Readings will be taken from recent technical literature, and an emphasis will be placed on identifying and evaluating design trade-offs.

Class Format: lecture/lab
Requirements/Evaluation: problem sets, programming assignments, and midterm and final examinations
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136; CSCI 237 or permission of instructor
Enrollment Limit: 24
Enrollment Preferences: current Computer Science majors, students with research experience or interest
Expected Class Size: 24
Distributions: (D3) (QFR)
Distribution Notes: QFR: This course will have students develop quantitative/formal reasoning skills through problem sets and programming assignments.

CSCI 334 (F) 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.
**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based on weekly problem sets and programming assignments, a midterm examination and a final examination

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** CSCI 136

**Enrollment Limit:** 30

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

**Expected Class Size:** 30

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

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Fall 2018
LEC Section: 01  TR 11:20 am - 12:35 pm  Daniel W. Barowy

Spring 2019
LEC Section: 01  TR 9:55 am - 11:10 am  Stephen N. Freund

**CSCI 336 (F)  Computer Networks** (QFR)

This course explores the design and implementation of computer networks. Topics include wired and wireless networks; techniques for efficient and reliable encoding and transmission of data; addressing schemes and routing mechanisms; resource allocation for bandwidth sharing; and security issues. An important unifying themes is the distributed nature of all network problems. We will examine the ways in which these issues are addressed by current protocols such as TCP/IP and 802.11 WiFi.

**Class Format:** This class will follow the meeting structure of a tutorial, with groups of three or four

**Requirements/Evaluation:** evaluation will be based on problem sets, programming assignments, and midterm and final examinations

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** CSCI 136 and 237

**Enrollment Limit:** 18

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

**Expected Class Size:** 18

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

Fall 2018
TUT Section: T1  Cancelled

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**CSCI 361 (F)  Theory of Computation** (QFR)

Crosslistings: CSCI361 / MATH361

**Primary Crosslisting**

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

**Requirements/Evaluation:** evaluation will be based on problem sets, a midterm examination, and a final examination

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

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

**Enrollment Limit:** 34

**Enrollment Preferences:** current or expected Computer Science majors
CSCI 432 (F) 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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on several implementation projects that will include significant programming, as well as written homework and exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 237 and either CSCI 256 or 334
Enrollment Limit: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Thomas P. Murtagh
LEC Section: 02  MWF 11:00 am - 11:50 am  Thomas P. Murtagh

CSCI 434 (S) Compiler Design  (QFR)
This tutorial covers the principles and practices for the design and implementation of compilers and interpreters. Topics include all stages of the compilation and execution process: lexical analysis; parsing; symbol tables; type systems; scope; semantic analysis; intermediate representations; run-time environments and interpreters; code generation; program analysis and optimization; and garbage collection. The course covers both the theoretical and practical implications of these topics. Students will construct a full compiler for a simple object-oriented language.

Class Format: This class will follow the meeting structure of a tutorial, with groups of three or four
Requirements/Evaluation: evaluation will be based on presentations, problem sets, a substantial implementation project, and two exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 237 and 256  CSCI 334 is recommended, but not required
Enrollment Limit: 10
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 10
Distributions: (D3) (QFR)

Spring 2019
TUT Section: T1  TBA  Stephen N. Freund
LAB Section: T2  T 2:35 pm - 4:00 pm  Stephen N. Freund
ECON 110 (F) 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.

Class Format: lecture/discussion

Requirements/Evaluation: problem sets, quizzes, short essays, two midterms (one for Bradburd’s sections), final exam

Extra Info: 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

Extra Info 2: not available for the fifth course option

Prerequisites: none

Enrollment Limit: 40

Expected Class Size: 40

Department 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)

Distribution Notes: Prof. Bradburd’s section ONLY; intends to use the issue of environmental protection in general, and climate change in particular, as the vehicle for presenting and applying many, though not all, of the economic concepts and tools developed in the course

Attributes: POEC Required Courses;

Fall 2018

LEC Section: 01 MR 1:10 pm - 2:25 pm Sara LaLumia
LEC Section: 02 MR 2:35 pm - 3:50 pm Sara LaLumia
LEC Section: 03 TR 8:30 am - 9:45 am Don Carlson
LEC Section: 04 TR 11:20 am - 12:35 pm Owen Thompson
LEC Section: 05 TF 1:10 pm - 2:25 pm Owen Thompson
LEC Section: 06 TF 2:35 pm - 3:50 pm Melinda Petre

Spring 2019

LEC Section: 01 TR 8:30 am - 9:45 am Susan Godlonton
LEC Section: 02 MWF 8:30 am - 9:45 am Don Carlson
LEC Section: 03 MR 1:10 pm - 2:25 pm Melinda Petre

ECON 120 (F) 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.

Class Format: lecture/discussion

Requirements/Evaluation: problem sets, short essays, midterm, final exam

Prerequisites: ECON 110

Enrollment Limit: 40

Expected Class Size: 40

Distributions: (D2) (QFR)

Attributes: POEC Required Courses;
ECON 213 (S)  Introduction to Environmental and Natural Resource Economics  (QFR)

Crosslistings: ECON213 / ENVI213

Primary Crosslisting

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

Class Format: lecture
Requirements/Evaluation: problem sets, short essays, paper(s); exam(s) are possible
Prerequisites: ECON 110
Enrollment Limit: 30
Enrollment Preferences: first-year and sophomore students
Expected Class Size: 30

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

Distributions: (D2) (QFR)
Attributes: ENVI Environmental Policy; POEC Comparative POEC/Public PolicyCourses;

Spring 2019
LEC Section: 01  MW 11:00 am - 12:15 pm  Sarah A. Jacobson

ECON 229 (S)  Law and Economics  (QFR)

This course applies the tools of microeconomic analysis to private (i.e., civil) law. This analysis has both positive and normative aspects. The positive aspects deal with how individuals respond to the incentives created by the legal system. Examples include: how intellectual property law encourages the creation of knowledge while simultaneously restricting the dissemination of intellectual property; how tort law motivates doctors to avoid malpractice suits; and how contract law facilitates agreements. The normative aspects of the analysis ask whether legal rules enhance economic efficiency (or, more broadly, social welfare). Examples include: what legal rules are most appropriate for mitigating pollution, ensuring safe driving, and guaranteeing workplace safety? The course will also cover the economics of legal systems; for example, what are the incentives for plaintiffs to initiate lawsuits and what role do lawyers play in determining outcomes. The course will also consider potential reforms of the legal system.

Class Format: lecture/discussion
Requirements/Evaluation: evaluation will be based on class participation, problem sets, short papers based on actual court cases and possible legal reforms, a midterm exam, and a final exam
Prerequisites: ECON 110
Enrollment Limit: 35
Enrollment Preferences: Open; prefer a mix of student backgrounds
Expected Class Size: 25
Distributions: (D2) (QFR)
British colonial rule in South Asia shaped economy and society in fundamental ways. As resistance to colonial rule emerged in the late nineteenth century, "nationalist" writers developed a critique of its economic impact via taxation, fiscal policy, trade, and many other policies. In their turn, supporters of British rule, "apologists," argued that British rule had laid the foundations of economic growth by securing property rights, enforcing contracts, and developing infrastructure. The debate between "nationalists" and "apologists" has never quite ended, but after the recent growth of the Indian economy it has lost some of its emotional charge. We will use this opportunity to revisit the controversy.

Class Format: tutorial

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: one course in ECON

Enrollment Limit: 10

Enrollment Preferences: Economics major, prior course on South Asia

Expected Class Size: 10

Distributions: (D2) (DPE) (WI) (QFR)

Distribution Notes: DPE: Issues of difference, power, and equity are at the heart of any analysis of colonialism, hence the DPE designation. QFR and WI: Students will write six essays, in which they will employ economic models and engage with quantitative evidence, so the course satisfies both the WI and QFR requirement.

Attributes: GBST South + Southeast Asia Studies Electives; POEC Comparative POEC/Public Policy Courses;
ECON 252 (F) 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.

Class Format: lecture/discussion
Requirements/Evaluation: problem sets and/or written assignments, midterm(s), and a final exam
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: ECON 110 and 120 and MATH 130 or its equivalent
Enrollment Limit: 30
Expected Class Size: 25
Distributions: (D2) (QFR)

Fall 2018
LEC Section: 01  MW 11:00 am - 12:15 pm  Peter J. Montiel
LEC Section: 02  TF 2:35 pm - 3:50 pm  Peter L. Pedroni

Spring 2019
LEC Section: 01  MW 11:00 am - 12:15 pm  Peter J. Montiel
LEC Section: 02  TF 2:35 pm - 3:50 pm  Peter L. Pedroni
LEC Section: 03  TR 8:30 am - 9:45 am  Greg Phelan
LEC Section: 04  TR 9:55 am - 11:10 am  Greg Phelan

ECON 255 (F) 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. 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.

Class Format: lecture
Requirements/Evaluation: problem sets, two midterms, group presentations, and possible additional assignments Swamy: problem sets, one midterm, final exam and a group project Gentry: problem sets, one midterm, final exam, a group project, and possible additional assignments
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
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
Expected Class Size: 30
Department Notes: students may substitute the combination of STAT 201 and 346 for ECON 255
Distributions: (D2) (QFR)
Attributes: EVST Methods Courses; PHLH Statistics Courses; POEC Required Courses;

Fall 2018
LEC Section: 01  TF 1:10 pm - 2:25 pm  Tara E. Watson
LEC Section: 02  MWF 8:30 am - 9:45 am  David J. Zimmerman

Spring 2019
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 discussed include: What causes inflation? What are the channels through which monetary policy affects the economy? Why should central banks commit to policy rules? How do exchange rates respond to monetary policy? How did the gold standard work? And will cryptocurrencies replace the dollar? In addition, we will develop and learn how to simulate the "New Keynesian" macroeconomic model, which has become the standard framework for monetary policy analysis for central banks around the world.
Class Format: lecture
Requirements/Evaluation: at least one exam, a research paper and a class presentation
Extra Info: not available for the fifth course option
Prerequisites: ECON 252 and 255. Multivariate calculus (MATH 150 or 151) is recommended but not required
Enrollment Limit: 25
Enrollment Preferences: junior and senior Economics majors
Expected Class Size: 25
Distributions: (D2) (QFR)
Attributes: GBST Economic Development Studies Electives;  POEC International Political Economy Courses;

Spring 2019
LEC Section: 01  MWF 8:30 am - 9:45 am  Kenneth N. Kuttner

ECON 364 (F) Theory of Asset Pricing  (QFR)
What is the price of time? What is the price of risk? How do markets allocate resources across time and uncertain states of the world? This course theoretically studies how markets allocate scarce resource across time and when outcomes are risky. The "goods" in such markets are called "assets" and the prices of "assets" determine the cost of trading resources across time and across uncertain states of the world. We theoretically investigate how equilibrium determines the price of time, then asset price implications; then asset allocations and prices in the presence of risk; finally, implications for new assets.
Class Format: lecture
Requirements/Evaluation: problem sets and exams
Extra Info: may not be taken on a pass/fail basis
Prerequisites: ECON 251 or ECON 252; and ECON 255 or STAT 201
Enrollment Limit: 25
Expected Class Size: 25
Distributions: (D2) (QFR)

Fall 2018
LEC Section: 01  TR 8:30 am - 9:45 am  Greg Phelan

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

Class Format: seminar

Requirements/Evaluation: term paper and regular homework assignments

Extra Info: may not be taken on a pass/fail basis

Prerequisites: ECON 252 and either ECON 255 or STATS 346

Enrollment Limit: 19

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

Expected Class Size: 19

Distributions: (D2) (QFR)

Distribution Notes: QFR: Uses quantitative/formal reasoning intensively in the form of mathematical and statistical arguments, as well as computer programming.

Fall 2018

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

ECON 378 (F)  Long-Run Perspectives on Economic Growth  (QFR)

The world today is marred by vast differences in the standard of living, with about a 30-fold difference in per-capita incomes between the poorest country and the most affluent. What explanations do long-run growth economists have to offer for these differences in levels of prosperity across nations? Are the explanations to be found in underlying differences between countries over the past few decades, the past few centuries, or the past few millennia? If contemporary differences in living standards have "deep" historically-rooted origins, what scope exists for policies to reduce global inequality today? Can we expect global inequality to be reduced gradually over time, through natural processes of economic development, or are they likely to persist unless action is taken to reduce them? 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 long-lasting effects of geography on comparative development, through its impact on the emergence of agriculture in early human societies and its influence in shaping the genetic composition of human populations across the globe.

Class Format: lecture/discussion

Requirements/Evaluation: at least one exam, a research paper and a class presentation

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Distributions: (D2) (QFR)

Attributes: POEC Comparative POEC/Public Policy Courses;

Fall 2018

LEC Section: 01  TR 11:20 am - 12:35 pm  Quamrul H. Ashraf
Development organizations face strict competition for scarce resources. Both public and private organizations are under increasing pressure to use rigorous program evaluation in order to justify funding for their programs and to design more effective programs. This course is an introduction to evaluation methodology and the tools available to development practitioners, drawing on examples from developing countries. It will cover a wide range of evaluation techniques and discuss the advantages and disadvantages of each. The course is a mix of applied econometrics and practical applications covering implementation, analysis, and interpretation. You will learn to be a critical reader of evaluations, and to develop your own plan to evaluate an existing program of your choice.

Class Format: seminar

Requirements/Evaluation: problem sets, midterm exam and one 7- to 10-page essay

Extra Info: may not be taken on a pass/fail basis

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)

Enrollment Limit: 20

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

Expected Class Size: 20

Distributions: (D2) (QFR)

Attributes: PHLH Methods in Public Health; POEC Comparative POEC/Public Policy Courses;

Spring 2019

SEM Section: 01    TR 11:20 am - 12:35 pm     Susan Godlonton

Taxes are half of what government does. So if you are interested in what government policy can do to promote efficiency, equity, and economic development, you should be interested in tax policy. Governments must raise tax revenue to finance critical public goods, address other market failures and distributional issues, and to avoid problems with debt and inflation. Taxes typically take up anywhere from ten to fifty percent of a country's income, they profoundly affect the incentives to undertake all varieties of economic activity, and the government expenditures that they finance have potentially large consequences for human welfare. So the stakes involved in improving tax policy are quite large. This class provides an in-depth exploration of tax policy, from a global and comparative perspective. Because most students in this class will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are most pertinent to developing countries, but we will also learn something about tax systems in the U.S. and other industrialized nations. Topics addressed in this class include: how basic economic principles can be applied to help one think about 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 reforms of these taxes; theory and evidence in the debate over progressive taxes versus "flat" taxes; how various elements of tax design affect incentives to save and invest; how market failures and administrative problems may influence the optimality of different tax policies; the implications of global capital flows and corporate tax avoidance for the design of tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on economic growth, 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.

Class Format: seminar

Requirements/Evaluation: midterm exam, 4 problem sets, two 8-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
ECON 453 (S)  Research in Labor Economics and Policy  (QFR)

The labor market plays a crucial role in people's lives worldwide. In industrialized countries, most households contain at least one wage earner, and income from working represents the largest component of total income. Thus analyses of the labor market are fundamentally relevant to both public policy and private decision-making. This seminar will explore the structure and functioning of the labor market using theoretical and empirical tools. Topics to be covered include labor supply and demand, minimum wages, labor market effects of social insurance and welfare programs, the collective bargaining relationship, discrimination, human capital, immigration, wage distribution, and unemployment. As labor economics is an intensely empirical subfield, students will be expected to analyze data as well as study the empirical work of others.

Class Format: seminar

Requirements/Evaluation: a series of short papers and empirical exercises, constructive contributions to class discussion, class presentations, and a 15- to 20-page original empirical research paper (written in stages)

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: ECON 251 and ECON 255 or POEC 253

Enrollment Limit: 19

Enrollment Preferences: senior Economics majors

Expected Class Size: 19

Distributions: (D2) (QFR)

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

Spring 2019

SEM Section: 01   TR 8:30 am - 9:45 am   Jon M. Bakija

ECON 471 (S)  Topics in Advanced Econometrics  (QFR)

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

Class Format: seminar

Requirements/Evaluation: periodic homework assignments, term paper

Extra Info: not available for the fifth course option

Prerequisites: ECON 371

Enrollment Limit: 10

Enrollment Preferences: students with strong quantitative backgrounds, and to students intending to write an honors thesis

Expected Class Size: 10

Distributions: (D2) (QFR)

Spring 2019

SEM Section: 01   TF 1:10 pm - 2:25 pm   Peter L. Pedroni
ECON 472 (F)  Macroeconomic Instability and Financial Markets  (QFR)
This advanced course in macroeconomics and financial theory attempts to explain the role and the importance of the financial system in the global economy. The course will provide an understanding of why there is financial intermediation, how financial markets differ from other markets, and the equilibrium consequences of financial activities. Rather than separating off the financial world from the rest of the economy, we will study financial equilibrium as a critical element of economic equilibrium. An important topic in the course will be studying how financial market imperfections amplify and propagate shocks to the aggregate economy. The course may cover the following topics: the determination of asset prices in general equilibrium; consequences of limited asset markets for economic efficiency; theoretical foundations of financial contracts and justifications for the existence of financial intermediaries; the roles of financial frictions in magnifying aggregate fluctuations and creating persistence and instability; the role of leverage and financial innovation in fueling financial crises.

Class Format: seminar
Requirements/Evaluation: evaluation will be based on problem sets, exams, and potentially student presentations
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: ECON 251 and ECON 252
Enrollment Limit: 19
Enrollment Preferences: Economics majors
Expected Class Size: 15
Distributions: (D2) (QFR)

Fall 2018
SEM Section: 01    MWF 8:30 am - 9:45 am    Greg Phelan

ECON 477 (S)  Economics of Environmental Behavior  (QFR)
Crosslistings: ENVI376 / ECON477
Primary Crosslisting
A community maintains a fishery; a firm decides whether to get a green certification; you choose to fly home or stay here for spring break: behaviors of people and firms determine our impact on the environment. We'll use economics to model environmental behavior and to consider how policies can help or hurt the environment. Topics we'll study include: voluntary conservation, social norms and nudges, firm responses to mandatory and voluntary rules, and boycotts and divestment.

Class Format: seminar
Requirements/Evaluation: short essays and empirical exercises, class participation, oral presentation(s), and a final original research paper using an experiment, existing data, or theory
Prerequisites: ECON 251 and (ECON 255 or STAT 346)
Enrollment Limit: 19
Enrollment Preferences: senior Economics majors
Expected Class Size: 15
Distributions: (D2) (QFR)
Attributes: MAST Interdepartmental Electives; POEC Comparative POEC/Public Policy Courses;

Spring 2019
SEM Section: 01    MWF 8:30 am - 9:45 am    Sarah A. Jacobson

ECON 514 (S)  Tax Policy in Global Perspective  (QFR)
Crosslistings: ECON514 / ECON389
Primary Crosslisting
Taxes are half of what government does. So if you are interested in what government policy can do to promote efficiency, equity, and economic
development, you should be interested in tax policy. Governments must raise tax revenue to finance critical public goods, address other market failures and distributional issues, and to avoid problems with debt and inflation. Taxes typically take up anywhere from ten to fifty percent of a country's income, they profoundly affect the incentives to undertake all varieties of economic activity, and the government expenditures that they finance have potentially large consequences for human welfare. So the stakes involved in improving tax policy are quite large. This class provides an in-depth exploration of tax policy, from a global and comparative perspective. Because most students in this class will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are most pertinent to developing countries, but we will also learn something about tax systems in the U.S. and other industrialized nations. Topics addressed in this class include: how basic economic principles can be applied to help one think about 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 reforms of these taxes; theory and evidence in the debate over progressive taxes versus "flat" taxes; how various elements of tax design affect incentives to save and invest; how market failures and administrative problems may influence the optimality of different tax policies; the implications of global capital flows and corporate tax avoidance for the design of tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on economic growth, 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.

Class Format: seminar

Requirements/Evaluation: midterm exam, 4 problem sets, two 8-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

Distributions: (D2) (QFR)

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

Spring 2019

SEM Section: 01    TR 8:30 am - 9:45 am     Jon M. Bakija

ECON 523 (S) Program Evaluation for International Development  (QFR)

Crosslistings: ECON379 / ECON523

Primary Crosslisting

Development organizations face strict competition for scarce resources. Both public and private organizations are under increasing pressure to use rigorous program evaluation in order to justify funding for their programs and to design more effective programs. This course is an introduction to evaluation methodology and the tools available to development practitioners, drawing on examples from developing countries. It will cover a wide range of evaluation techniques and discuss the advantages and disadvantages of each. The course is a mix of applied econometrics and practical applications covering implementation, analysis, and interpretation. You will learn to be a critical reader of evaluations, and to develop your own plan to evaluate an existing program of your choice.

Class Format: seminar

Requirements/Evaluation: problem sets, midterm exam and one 7- to 10-page essay

Extra Info: may not be taken on a pass/fail basis

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)

Enrollment Limit: 20

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

Expected Class Size: 20

Distributions: (D2) (QFR)

Attributes: PHLH Methods in Public Health; POEC Comparative POEC/Public Policy Courses;
ENVI 108 (F)  Energy Science and Technology  (QFR)
Crosslistings: ENVI108 / PHYS108

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

Requirements/Evaluation: evaluation will be based on 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

Distributions: (D3) (QFR)

Attributes: ENVI Natural World Electives;  SCST Related Courses

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ENVI 203 (F)  Ecology  (QFR)
Crosslistings: BIOL203 / ENVI203

Secondary Crosslisting
This course combines lectures 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 overall view of global patterns and then builds from the population to the ecosystem level. An emphasis is given to basic ecological principles and relates them to 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).

Class Format: lecture/laboratory, six hours per week

Requirements/Evaluation: evaluation will be based on problem sets, lab reports, hour exams, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 101 and 102, or ENVI 101 or 102, or permission of instructor

Enrollment Limit: none

Expected Class Size: 35

Department Notes: satisfies the living system course requirement for the major in Environmental Studies; satisfies the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: ENVI Natural World Electives;  EVST Environmental Science;  EVST Living Systems Courses;
ENVI 213 (S) Introduction to Environmental and Natural Resource Economics (QFR)

Crosslistings: ECON213 / ENVI213

Secondary Crosslisting

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

Class Format: lecture

Requirements/Evaluation: problem sets, short essays, paper(s); exam(s) are possible

Prerequisites: ECON 110

Enrollment Limit: 30

Enrollment Preferences: first-year and sophomore students

Expected Class Size: 30

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

Distributions: (D2) (QFR)

Attributes: ENVI Environmental Policy; POEC Comparative POEC/Public Policy Courses;

Spring 2019

LEC Section: 01    MW 11:00 am - 12:15 pm     Sarah A. Jacobson

ENVI 339 (F) Conservation Biology (QFR)

Crosslistings: BIOL329 / ENVI339

Secondary Crosslisting

Conservation biology is an interdisciplinary field that develops scientific and technical means for the protection, maintenance, and restoration of diversity at all levels of biological organization. This course provides an overview of the discipline including the causes and consequences of biodiversity loss as well as approaches and strategies used to combat biodiversity threats such climate change, habitat fragmentation, and invasive species. Particular emphasis is placed on the ecological dimension of conservation and the application of biological principles (derived from physiological and behavioral ecology, population genetics, population ecology, community ecology, and systematics) to the conservation of biodiversity. The course combines lectures, readings, in-class discussion, and a laboratory that includes both field and lab projects.

Class Format: lecture and discussion three hours per week; lab three hours per week

Requirements/Evaluation: lab assignments, two exams, and discussion participation

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 203, or BIOL 202, or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: biology majors, seniors, and juniors

Expected Class Size: 24

Department Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

Distribution Notes: QFR: This course uses quantitative and statistical analyses in both the laboratory and lecture portion of the course. In lectures mathematical models will be covered to understand conservation dynamics. In lab, students will collect and analyze data and present results in graphical and statistical forms.

Attributes: ENVI Natural World Electives;

Fall 2018
ENVI 376 (S) Economics of Environmental Behavior (QFR)

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

Class Format: seminar

Requirements/Evaluation: short essays and empirical exercises, class participation, oral presentation(s), and a final original research paper using an experiment, existing data, or theory

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

Enrollment Limit: 19

Enrollment Preferences: senior Economics majors

Expected Class Size: 15

Distributions: (D2) (QFR)

Attributes: MAST Interdepartmental Electives; POEC Comparative POEC/Public Policy Courses;

Spring 2019

SEM Section: 01 MWF 8:30 am - 9:45 am Sarah A. Jacobson

ENVI 404 (S) Coastal Processes and Geomorphology (QFR)

Secondary Crosslisting
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: GEOS 104 or permission of instructor

Enrollment Limit: none

Expected Class Size: 10
GEOS 301 (F) Structural Geology (QFR)

The structure of the Earth's crust is constantly changing and the rocks making up the crust must deform to accommodate these changes. Rock deformation occurs over many scales ranging from individual mineral grains to mountain belts. This course deals with the geometric description of structures, stress and strain analysis, deformation mechanisms in rocks, and the large scale forces responsible for crustal deformation. The laboratories cover geologic maps and cross sections, folds and faults, stereonet analysis, field techniques, strain, and stress.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week

Requirements/Evaluation: evaluation will be based on weekly laboratory exercises, problem sets, a midterm exam, and a final exam; many of the labs and problem sets use geometry, algebra, and several projection techniques to solve common problems in structural geology

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: GEOS 101 or 102, or permission of instructor

Enrollment Limit: 16

Enrollment Preferences: Geosciences majors

Expected Class Size: 12

Distributions: (D3) (QFR)

GEOS 404 (S) Coastal Processes and Geomorphology (QFR)

Crosslistings: ENVI404 / MAST404 / GEOS404

Primary Crosslisting

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: GEOS 104 or permission of instructor

Enrollment Limit: none
**MATH 110 (F) Logic and Likelihood (QFR)**

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

**Class Format:** lecture

**Requirements/Evaluation:** homework, essays, presentations, exams, and participation

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** none

**Enrollment Limit:** 25

**Enrollment Preferences:** first-year students

**Expected Class Size:** 25

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

**Distribution Notes:** QFR: This course will be covering formal logic and probability theory at sufficient depth to place this course on level with other QFR designated courses.

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**Fall 2018**

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

**MATH 130 (F) 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.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on exams, homework and quizzes

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

**Enrollment Limit:** 50

**Enrollment Preferences:** Professor's discretion

**Expected Class Size:** 30

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

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

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**Fall 2018**

LEC Section: 01    TR 8:30 am - 9:45 am    Pamela E. Harris

LEC Section: 02    TR 9:55 am - 11:10 am    Pamela E. Harris
MATH 140 (F)  Calculus II  (QFR)

Mastery of calculus requires understanding how integration computes areas and business profit and acquiring a stock of techniques. Further methods solve equations involving derivatives ("differential equations") for population growth or pollution levels. Exponential and logarithmic functions and trigonometric and inverse functions play an important role. This course is the right starting point for students who have seen derivatives, but not necessarily integrals, before.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on 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

Expected Class Size: 30

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

Distributions: (D3) (QFR)

MATH 150 (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, multiple integrals. There is also a unit on infinite series, sometimes with applications to differential equations.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on homework, quizzes, and/or exams

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

Enrollment Limit: 50

Expected Class Size: 50

Department Notes: this course is the right starting point for students who have seen differentiation and integration before; students with the equivalent of advanced placement of AB 4, BC 3 or above should enroll in MATH 150

Distributions: (D3) (QFR)

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.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on homework, quizzes, and/or exams

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

Enrollment Limit: 50

Expected Class Size: 50

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

Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01 MWF 9:00 am - 9:50 am Colin C. Adams
LEC Section: 02 MWF 10:00 am - 10:50 am Colin C. Adams
LEC Section: 03 MWF 11:00 am - 11:50 am Colin C. Adams

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

Class Format: lecture/discussion

Requirements/Evaluation: evaluation will be based primarily on homework and exams

Prerequisites: MATH 140 or MATH 130 with CSCI 134 or 135; or one year of high school calculus with permission of instructor; students who have taken a 300-level math course should obtain permission of the instructor before enrolling

Enrollment Limit: 40

Expected Class Size: 25

Distributions: (D3) (QFR)

Fall 2018
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

Spring 2019
LEC Section: 01 MWF 10:00 am - 10:50 am Leo Goldmakher
LEC Section: 02 MWF 11:00 am - 11:50 am Leo Goldmakher

MATH 210 (S) Mathematical Methods for Scientists  (QFR)
Crosslistings: PHYS210 / MATH210

Secondary Crosslisting

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:** lecture, three hours per week

**Requirements/Evaluation:** evaluation will be based on 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

**Expected Class Size:** 30

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

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Spring 2019

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

MATH 250 (F)  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.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on homework and exams

**Prerequisites:** MATH 150/151 or MATH 200

**Enrollment Limit:** 45

**Expected Class Size:** 35

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

**Attributes:** COGS Related Courses;

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Fall 2018

LEC Section: 01    TF 1:10 pm - 2:25 pm    Haydee M. A. Lindo

LEC Section: 02    TF 2:35 pm - 3:50 pm    Haydee M. A. Lindo

Spring 2019

LEC Section: 01    MWF 10:00 am - 10:50 am    Thomas A. Garrity

LEC Section: 02    MWF 11:00 am - 11:50 am    Thomas A. Garrity

MATH 307 (F)  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; and Monte Carlo techniques. This course could also be considered a course in numerical analysis or computational science.

**Class Format:** lecture

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

**Extra Info:** may not be taken on a pass/fail basis

**Prerequisites:** Math 250, some elementary computer programming experience is strongly recommended

**Enrollment Limit:** 30

**Enrollment Preferences:** Professor's discretion
Expected Class Size: 25
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01     TR 9:55 am - 11:10 am     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 include numerical solutions, separation of variables, integrating factors, constant coefficient linear equations, and power series solutions. Later, we focus on nonlinear ODE, for which it is usually impossible to find analytical solutions. Tools from dynamical systems allows us to obtain some information about the behavior of the ODE without explicitly knowing the solution.

Class Format: lecture, discussion, interactive activities
Requirements/Evaluation: quizzes/exams, problem sets, activities
Extra Info: may not be taken on a pass/fail basis
Prerequisites: MATH 150/151 and MATH 250
Enrollment Limit: 30
Enrollment Preferences: Professor's discretion
Expected Class Size: 30
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01     TR 11:20 am - 12:35 pm     Chad M. Topaz

MATH 310 (S) Mathematical Biology  (QFR)
Primary Crosslisting
This course will provide an introduction to the many ways in which mathematics can be used to understand, analyze, and predict biological dynamics. We will learn how to construct mathematical models that capture essential properties of biological processes while maintaining analytic tractability. Analytic techniques, such as stability and bifurcation analysis, will be introduced in the context of both continuous and discrete time models. Additionally, students will couple these analytic tools with numerical simulation to gain a more global picture of the biological dynamics. Possible biological applications include, but are not limited to, single and multi-species population dynamics, neural and biological oscillators, tumor cell growth, and infectious disease dynamics.

Class Format: tutorial
Requirements/Evaluation: problem sets, weekly meetings, final project and paper
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: MATH 250, MATH 209 or 309, permission of instructor
Enrollment Limit: 10
Enrollment Preferences: if over-enrolled, will have students submit reasons for taking class; preference to those with interest in both subjects
Expected Class Size: 10
Distributions: (D3) (QFR)
Distribution Notes: QFR: The course will introduce methods for developing and analyzing mathematical models.
Attributes: PHLH Methods in Public Health;

Spring 2019
TUT Section: T1     TBA     Julie C. Blackwood
MATH 313 (F) Introduction to Number Theory (QFR)
The study of numbers dates back thousands of years, and is fundamental in mathematics. In this course, we will investigate both classical and modern questions about numbers. In particular, we will explore the integers, and examine issues involving primes, divisibility, and congruences. We will also look at the ideas of number and prime in more general settings, and consider fascinating questions that are simple to understand, but can be quite difficult to answer.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on performance on homework, projects, and examinations
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 40
Expected Class Size: 25
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01    MR 2:35 pm - 3:50 pm    Leo Goldmakher

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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on problem sets, midterms, a paper and a final exam
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Expected Class Size: 25
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01    MWF 8:30 am - 9:45 am    Colin C. Adams

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

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homework, classwork, and exams
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Enrollment Preferences: members or alternates of the Putnam team, Mathematics, Physics or Computer Science majors
Expected Class Size: 25
Department Notes: http://web.williams.edu/Mathematics/sjmiller/public_html/331/
Distributions: (D3) (QFR)
**MATH 334 (S)  Graph Theory** (QFR)
A graph is a collection of vertices, joined together by edges. In this course, we will study the sorts of structures that can be encoded in graphs, along with the properties of those graphs. We'll learn about such classes of graphs as multi-partite, planar, and perfect graphs, and will see applications to such optimization problems as minimum colorings of graphs, maximum matchings in graphs, and network flows.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on problem sets and exams

**Prerequisites:** MATH 200 or MATH 250

**Enrollment Limit:** 35

**Enrollment Preferences:** Math majors

**Expected Class Size:** 20

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

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**Spring 2019**

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

**MATH 341 (F)  Probability** (QFR)
Crosslistings: STAT341 / MATH341

**Primary Crosslisting**
While probability began with a study of games, it has grown to become a discipline with numerous applications throughout mathematics and the sciences. Drawing on gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables, expectation, independence, laws of large numbers, and the Central Limit Theorem. Many interesting and important applications will also be presented, potentially including some from coding theory, number theory and nuclear physics.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on homework, classwork, and exams

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

**Enrollment Limit:** 40

**Expected Class Size:** 20

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

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**Fall 2018**

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

**MATH 350 (F)  Real Analysis** (QFR)
Real analysis is the theory behind calculus. It is based on a precise understanding of the real numbers, elementary topology, and limits. Topologically, nice sets are either closed (contain their limit points) or open (complement closed). You also need limits to define continuity, derivatives, integrals, and to understand sequences of functions.

**Class Format:** lecture/discussion

**Requirements/Evaluation:** evaluation will be based on homework, classwork, and exams

**Prerequisites:** MATH 150 or MATH 151 and MATH 250, or permission of instructor

**Enrollment Limit:** 40
**MATH 351 (F) Applied Real Analysis**  (QFR)
Real analysis or the theory of calculus--derivatives, integrals, continuity, convergence--starts with a deeper understanding of real numbers, limits, and some topology. Applications of Real Analysis involve questions of existence and uniqueness of solutions, implicit definition of functions, infinite dimensional function spaces, and tools from calculus of variations to construct optimal controls and minimizing curves and surfaces.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on exams, homework and quizzes

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

**Enrollment Limit:** 50

**Expected Class Size:** 20

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

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**Fall 2018**
LEC Section: 01  MWF 10:00 am - 10:50 am  Cesar E. Silva

**Spring 2019**
LEC Section: 01  MWF 10:00 am - 10:50 am  Cesar E. Silva

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**MATH 355 (F) 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.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on problem sets and exams

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

**Enrollment Limit:** 30

**Expected Class Size:** 25

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

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**Fall 2018**
LEC Section: 01  MWF 9:00 am - 9:50 am  Stewart D. Johnson

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**MATH 361 (F) Theory of Computation**  (QFR)

Crosslistings: CSCI361 / MATH361

**Secondary Crosslisting**

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

Requirements/Evaluation: evaluation will be based on problem sets, a midterm examination, and a final examination

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 34

Enrollment Preferences: current or expected Computer Science majors

Expected Class Size: 34

Distributions: (D3) (QFR)

Attributes: COGS Interdepartmental Electives;

Fall 2018
LEC Section: 01   MWF 12:00 pm - 12:50 pm   Thomas P. Murtagh
LEC Section: 02   MWF 11:00 am - 11:50 am   Thomas P. Murtagh

MATH 374 (F) Topology (QFR)

Topology is the study of when one geometric object can be continuously deformed and twisted into another object. Determining when two objects are topologically the same is incredibly difficult and is still the subject of a tremendous amount of research, including recent work on the Poincaré Conjecture, one of the million-dollar millennium-prize problems. The main part of the course on point-set topology establishes a framework based on "open sets" for studying continuity and compactness in very general spaces. The second part on homotopy theory develops refined methods for determining when objects are the same. We will prove for example that you cannot twist a basketball into a doughnut.

Class Format: lecture

Requirements/Evaluation: homework, tutorials, and exams

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: MATH 350 or 351; not open to students who have taken MATH 323

Enrollment Limit: 30

Expected Class Size: 10

Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01   MWF 10:00 am - 10:50 am   Andrew Bydlon

MATH 402 (S) Measure Theory and Probability (QFR)

The study of measure theory arose from the study of stochastic (probabilistic) systems. Applications of measure theory lie in biology, chemistry, physics as well as in economics. In this course, we develop the abstract concepts of measure theory and ground them in probability spaces. Included will be Lebesgue and Borel measures, measurable functions (random variables). Lebesgue integration, distributions, independence, convergence and limit theorems. This material provides good preparation for graduate studies in mathematics, statistics and economics.

Class Format: lecture/discussion

Requirements/Evaluation: evaluation will be based primarily on performance on homework assignments and exams

Prerequisites: MATH 350 or MATH 351 or permission of instructor

Enrollment Limit: 40

Expected Class Size: 30

Distributions: (D3) (QFR)
Spring 2019
LEC Section: 01  Cancelled

**MATH 403 (S) Measure and Ergodic Theory  (QFR)**
An introduction to measure theory and ergodic theory. Measure theory is a generalization of the notion of length and area, has been used in the study of stochastic (probabilistic) systems. The course covers the construction of Lebesque and Borel measures, measurable functions, and Lebesque integration. Ergodic theory studies the probabilistic behavior of dynamical systems as they evolve through time, and is based on measure theory. The course will cover basic notions, such as ergodic transformations, weak mixing, mixing, and Bernoulli transformations, and transformations admitting and not admitting an invariant measure. There will be an emphasis on specific examples such as group rotations, the binary odometer transformations, and rank-one constructions. The Ergodic Theorem will also be covered, and will be used to illustrate notions and theorems from measure theory.

**Class Format:** lecture

**Requirements/Evaluation:** homework and exams

**Prerequisites:** MATH 350 or MATH 351 or permission of instructor

**Enrollment Limit:** 25

**Enrollment Preferences:** Mathematics majors

**Expected Class Size:** 15-20

**Department Notes:** senior major course

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

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Spring 2019
LEC Section: 01  MWF 12:00 pm - 12:50 pm  Cesar E. Silva

**MATH 407 (F) Dance of the Primes  (QFR)**
Prime numbers are the building blocks for all numbers and hence for most of mathematics. Though there are an infinite number of them, how they are spread out among the integers is still quite a mystery. Even more mysterious and surprising is that the current tools for investigating prime numbers involve the study of infinite series. Function theory tells us about the primes. We will be studying one of the most amazing functions known: the Riemann Zeta Function. Finding where this function is equal to zero is the Riemann Hypothesis and is one of the great, if not greatest, open problems in mathematics. Somehow where these zeros occur is linked to the distribution of primes. We will be concerned with why anyone would care about this conjecture. More crassly, why should solving the Riemann Hypothesis be worth one million dollars? (Which is what you will get if you solve it, beyond the eternal fame and glory.)

**Class Format:** lecture

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

**Prerequisites:** MATH 350 or MATH 351, and MATH 355

**Enrollment Limit:** 30

**Enrollment Preferences:** seniors

**Expected Class Size:** 10

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

**Distribution Notes:** QFR: It is a math course

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Fall 2018
LEC Section: 01  TR 8:30 am - 9:45 am  Thomas A. Garrity

**MATH 411 (S) 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. Possible topics include Noetherian rings, primary
decomposition, localizations and quotients, height, dimension, basic module theory, and the Krull Altitude Theorem.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on homework and exams

Prerequisites: MATH 355 or permission of instructor

Enrollment Limit: 30

Expected Class Size: 15

Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01   MWF 10:00 am - 10:50 am   Andrew Bydlon

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

Class Format: discussion, research

Requirements/Evaluation: writing assignments, modeling activities, presentations, research project

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 24

Enrollment Preferences: Professor's discretion

Expected Class Size: 20

Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01   TR 11:20 am - 12:35 pm   Chad M. Topaz

MATH 458 (S) Algebraic Combinatorics (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. This course will focus on the study of symmetric functions, Young tableaux, matroids, graph theory, and other related topics.

Class Format: seminar

Requirements/Evaluation: homework assignments, proof portfolio, individual and group projects

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: MATH 200 and MATH 355

Enrollment Limit: 25

Enrollment Preferences: seniors

Expected Class Size: 20

Distributions: (D3) (QFR)

Distribution Notes: QFR: Mathematics course in the area of algebraic combinatorics

Spring 2019
SEM Section: 01   TR 8:30 am - 9:45 am   Pamela E. Harris
MATH 459 (S) Applied Partial Differential Equations (QFR)

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

Class Format: tutorial

Requirements/Evaluation: participation, problem sets, oral presentations, oral exams, and a final project

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: MATH 209 or MATH/PHYS 210 or MATH 309 or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: students with an interest in applied mathematics, selected to create a diverse set of tutorial participants

Expected Class Size: 10

Department Notes: students who have taken MATH 453 may not enroll in MATH 458T without permission of the instructor

Distributions: (D3) (QFR)

Distribution Notes: QFR: This tutorial involves regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2019

TUT Section: T1   TBA   Chad M. Topaz

MATH 487 (S) Computational Algebraic Geometry (QFR)

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

Class Format: lecture

Requirements/Evaluation: evaluation will be based on homework, exams, and final project

Extra Info: may not be taken on a pass/fail basis

Prerequisites: MATH 355

Enrollment Limit: 40

Enrollment Preferences: instructor decision

Expected Class Size: 15

Department Notes: This course is not a senior seminar, and so it does not fulfill the senior seminar requirement for the math major

Distributions: (D3) (QFR)

Spring 2019

LEC Section: 01   TR 8:30 am - 9:45 am   Ralph E. Morrison

PHIL 203 (S) 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: lecture/discussion

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

Prerequisites: none

Enrollment Limit: none

Expected Class Size: 50-80

Distributions: (D2) (QFR)

Attributes: Linguistics; PHIL Contemp Metaphysics & Epistemology Courses;

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Spring 2019

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

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

Crosslistings: PHIL312 / SCST312 / PHYS312

Secondary Crosslisting

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.

Class Format: lecture

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

Distributions: (D2) (QFR)

Distribution Notes: meets the Division 2 requirement if registration is under PHIL or SCST; Division 3 requirement if registration under PHYS

Attributes: PHIL Contemp Metaphysics & Epistemology Courses;

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Spring 2019

LEC Section: 01    TR 11:20 am - 12:35 pm     Frederick W. Strauch, Keith E. McPartland

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

Crosslistings: ENVI108 / PHYS108

Primary Crosslisting

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

Requirements/Evaluation: evaluation will be based on 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
**Distributions:** (D3) (QFR)

**Attributes:** ENVI Natural World Electives; SCST Related Courses

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**Fall 2018**

LEC Section: 01  MR 1:10 pm - 2:25 pm  Kevin M. Jones

**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.

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

**Requirements/Evaluation:** evaluation will be based on 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:** 24/lab

**Expected Class Size:** 60

**Department 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)

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**Spring 2019**

LEC Section: 01  MWF 11:00 am - 11:50 am  Savan Kharel

LAB Section: 02  M 1:00 pm - 4:00 pm  Savan Kharel

LAB Section: 03  T 1:00 pm - 4:00 pm  Savan Kharel

LAB Section: 04  W 1:00 pm - 4:00 pm  Savan Kharel

**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; conference section 1 hour approximately every other week

**Requirements/Evaluation:** evaluation will be based on 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

**Expected Class Size:** 60

**Distributions:** (D3) (QFR)
**PHYS 141 (F) Mechanics and Waves**  (QFR)

This is the typical first course for a prospective physics major. It covers 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:** evaluation will be based on weekly problem sets, labs, 2 one-hour tests, and a final exam, all of which have a substantial quantitative component

**Prerequisites:** high school physics and MATH 130 or equivalent placement

**Enrollment Limit:** 22 per lab

**Expected Class Size:** 50

**Department 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)

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**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, alternating between three hours and one hour approximately every other week

**Requirements/Evaluation:** evaluation will be based on weekly homework, labs, two hour tests, and a final exam, all of which have a substantial quantitative component

**Prerequisites:** PHYS 141 and MATH 130 (formerly 103), 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:** 18 per CON

**Expected Class Size:** 30

**Department Notes:** Limit: 22 per lab, 18 per conference section

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

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**Fall 2018**

LEC Section: 01  MWF 11:00 am - 11:50 am  Katharine E. Jensen
LAB Section: 02  M 1:00 pm - 4:00 pm  Katharine E. Jensen
LAB Section: 03  T 1:00 pm - 4:00 pm  Katharine E. Jensen
LAB Section: 04  W 1:00 pm - 4:00 pm  Katharine E. Jensen

**Spring 2019**

LEC Section: 01  MW 11:00 am - 11:50 am  Charlie Doret
CON Section: 02  F 11:00 am - 11:50 am  Charlie Doret
CON Section: 03  F 12:00 pm - 12:50 pm  Charlie Doret
LAB Section: 04  M 1:00 pm - 4:00 pm  Charlie Doret
LAB Section: 05  T 1:00 pm - 4:00 pm  Charlie Doret
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 basic material as PHYS 142 but in a small seminar format for students with strong prior preparation in physics.

**Class Format:** lecture/discussion, three hours per week; laboratory, 3 hours approximately every other week; conference section 1 hour approximately every other week

**Requirements/Evaluation:** evaluation will be based on class participation, labs, weekly problem sets, an oral presentation, two hour-exams and a final exam, all of which have a substantial quantitative component

**Extra Info:** this is a small seminar designed for first-year students who have placed out of PHYS 141

**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

**Expected Class Size:** 18

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

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**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:** evaluation will be based on problem sets, labs, 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:** 20 per lab

**Expected Class Size:** 25

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

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**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: evaluation will be based on problem sets, labs, two one-hour 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: none

Expected Class Size: 20

Distributions: (D3) (QFR)

Spring 2019

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 210 (S) Mathematical Methods for Scientists  (QFR)

Crosslistings: PHYS210 / MATH210

Primary Crosslisting

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: lecture, three hours per week

Requirements/Evaluation: evaluation will be based on 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

Expected Class Size: 30

Distributions: (D3) (QFR)

Spring 2019

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

PHYS 301 (F) Quantum Physics  (QFR)

This course serves as a one-semester introduction to the history, formalism, and phenomenology of quantum mechanics. We begin with a discussion of the historical origins of the quantum theory, and the Schroedinger wave equation. The concepts of matter waves and wave-packets are introduced. Solutions to one-dimensional problems will be treated prior to introducing the system which serves as a hallmark of the success of quantum theory, the three-dimensional hydrogen atom. In the second half of the course, we will develop the important connection between the underlying mathematical formalism and the physical predictions of the quantum theory and introduce the Heisenberg formalism. We then go on to apply this knowledge to several important problems within the realm of atomic and nuclear physics concentrating on applications involving angular momentum and spins.

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

Requirements/Evaluation: evaluation will be based on weekly problem sets, labs, a midterm exam, and final exam, all of which have a substantial quantitative component
**Prerequisites:** PHYS 202 and PHYS/MATH 210 or MATH 209

**Enrollment Limit:** none

**Expected Class Size:** 15

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

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**Fall 2018**

**LEC Section:** 01  MWF 9:00 am - 9:50 am  Charlie Doret

**LAB Section:** 02  T 1:00 pm - 4:00 pm  Kevin M. Jones

**LAB Section:** 03  W 1:00 pm - 4:00 pm  Kevin M. Jones

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**PHYS 302 (S) Stat 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; laboratory, three hours per week

**Requirements/Evaluation:** evaluation will be based on weekly problem sets, exams, and labs, all of which have a substantial quantitative component

**Prerequisites:** required: PHYS 201, PHYS/MATH 210 or MATH 209; recommended: PHYS 202, PHYS 301

**Enrollment Limit:** 24

**Expected Class Size:** 15

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

**Attributes:** BGNP Related Courses;

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**Spring 2019**

**LEC Section:** 01  MWF 10:00 am - 10:50 am  Protik K. Majumder

**LAB Section:** 02  W 1:00 pm - 4:00 pm  Protik K. Majumder

**LAB Section:** 03  T 1:00 pm - 4:00 pm  Protik K. Majumder

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

Crosslistings: PHIL312 / SCST312 / PHYS312

**Primary Crosslisting**

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.

**Class Format:** lecture

**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

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

**Distribution Notes:** meets the Division 2 requirement if registration is under PHIL or SCST; Division 3 requirement if registration under PHYS

**Attributes:** PHIL Contemp Metaphysics & Epistemology Courses;
**PHYS 402 (S) Applications of Quantum Mechanics (QFR)**

This course will explore a number of important topics in the application of quantum mechanics to physical systems, including perturbation theory, the variational principle and the semiclassical interaction of atoms and radiation. The course will finish up with three weeks on quantum optics including an experimental project on non-classical interference phenomena. Applications and examples will be taken mostly from atomic physics with some discussion of solid state systems.

**Class Format:** tutorial, 1 and 1/4 hours per week; lecture, one hour per week

**Requirements/Evaluation:** evaluation will be based on weekly problem sets, tutorial participation, presentations, and a final exam, all of which have a substantial quantitative component

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** PHYS 301

**Enrollment Limit:** 10 per section

**Expected Class Size:** 16

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

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

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

**Class Format:** tutorial, 1 and 1/4 hours per week; lecture, one hour per week

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

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

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

**Enrollment Limit:** 10/section

**Expected Class Size:** 25

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

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**PHYS 451 (S) Condensed Matter Physics (QFR)**

Condensed matter physics is an important area of current research and serves as the basis for modern electronic technology. We plan to explore the physics of metals, insulators, semiconductors, superconductors, and photonic crystals, with particular attention to structure, thermal properties, energy bands, and electronic properties.

**Class Format:** seminar

**Requirements/Evaluation:** weekly readings and problem sets, and exams
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.
Class Format: lecture/discussion
Requirements/Evaluation: problem sets, group projects, and three exams
Prerequisites: MATH 130 or its equivalent; one course in ECON; not open to students who have taken ECON 255
Enrollment Limit: 25
Enrollment Preferences: Political Economy majors, Environmental Policy majors and sophomores
Expected Class Size: 15

PSYC 201 (F) 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.
Class Format: lecture/lab
Requirements/Evaluation: papers, exams, and problem sets
Extra Info: two sections; must register for the lab and lecture with the same instructor
Extra Info 2: may not be taken on a pass/fail basis
Prerequisites: PSYC 101; not open to first-year students except with permission of instructor
Enrollment Limit: 22
Enrollment Preferences: Psychology majors
Distributions: (D2) (QFR)
Attributes: COGS Related Courses; PHLH Statistics Courses;
SCST 312 (S) Philosophical Implications of Modern Physics  (QFR)
Crosslistings: PHIL312 / SCST312 / PHYS312

Secondary Crosslisting
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.

Class Format: lecture
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
Distributions: (D2) (QFR)
Distribution Notes: meets the Division 2 requirement if registration is under PHIL or SCST; Division 3 requirement if registration under PHYS
Attributes: PHIL Contemp Metaphysics & Epistemology Courses;

Spring 2019
LEC Section: 01    TR 11:20 am - 12:35 pm    Frederick W. Strauch, Keith E. McPartland

STAT 101 (F) 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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on performances on quizzes and exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: MATH 102 (or demonstrated proficiency on a diagnostic test)
Enrollment Limit: 50
Expected Class Size: 40
Department Notes: Students with calculus background and social science interest should consider STAT 161. Students with MATH 150 should enroll in STAT 201. Students with a 5 on AP Stats should enroll in STAT 202. Students with a 4 on AP Stat should consult the department.
Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses; COGS Related Courses; PHLH Statistics Courses;

Fall 2018
LEC Section: 01    MWF 9:00 am - 9:50 am    Xizhen Cai
LEC Section: 02    MWF 10:00 am - 10:50 am    Xizhen Cai

Spring 2019
LEC Section: 01    MWF 11:00 am - 11:50 am    Xizhen Cai

STAT 161 (F) 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.

Class Format: lecture

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Department Notes: Students with MATH 150 should consider STAT 201. Students with a 5 on AP Stats should enroll in STAT 202. Students with a 4 on AP Stats should consult the department. Students without any calculus background should consider STAT 101.

Distributions: (D3) (QFR)

Distribution Notes: QFR: It is a quantitative course

Fall 2018
LEC Section: 01    TF 1:10 pm - 2:25 pm    Richard D. De Veaux

Spring 2019
LEC Section: 01    TF 1:10 pm - 2:25 pm    Richard D. De Veaux

STAT 201 (F) 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.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on performance on quizzes and exams

Prerequisites: MATH 150 or equivalent. Not open to students who have completed STAT 101 or STAT 161 or equivalent.

Enrollment Limit: 40

Expected Class Size: 40

Department Notes: Students with a 5 on AP Stats should enroll in STAT 202. Students with a 4 on AP Stats should consult the department. Students with MATH 130/140 background should consider STAT 161. Students with no calc. should consider STAT 101.

Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses; COGS Related Courses; EVST Methods Courses; PHLH Statistics Courses;
STAT 202 (F) Introduction to Statistical Modeling (QFR)

Data come from a variety of sources sometimes from planned experiments or designed surveys, but also arise by much 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 as well as its limits to answer questions about the world. We'll emphasize applications over theory and analyze real data sets throughout the course.

Class Format: lecture

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: AP Statistics 5 or STAT 101, 161 or 201 or permission of instructor

Enrollment Limit: 25

Expected Class Size: 20

Department Notes: Students with a 4 on the AP Stats exam should contact the department for proper placement.

Distributions: (D3) (QFR)

Attributes: EVST Methods Courses; PHLH Statistics Courses;

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STAT 341 (F) Probability (QFR)

Crosslistings: STAT341 / MATH341

Secondary Crosslisting

While probability began with a study of games, it has grown to become a discipline with numerous applications throughout mathematics and the sciences. Drawing on gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables, expectation, independence, laws of large numbers, and the Central Limit Theorem. Many interesting and important applications will also be presented, potentially including some from coding theory, number theory and nuclear physics.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on homework, classwork, and exams

Prerequisites: MATH 250 or permission of the instructor

Enrollment Limit: 40

Expected Class Size: 20

Distributions: (D3) (QFR)
STAT 344 (F) Statistical Design of Experiments (QFR)

What does statistics have to do with designing and carrying out experiments? The answer is, surprisingly perhaps, a great deal. In this course, we will study how to design experiments with the fewest number of observations possible that are still capable of understanding which factors influence the results. After reviewing basic statistical theory and two sample comparisons, we cover one and two-way ANOVA and (fractional) factorial designs extensively. The culmination of the course will be a project where each student designs, carries out, analyzes, and presents an experiment of interest to him or her. Throughout the course, we will use both the statistics program R and the package JMP to carry out the statistical analyses.

**Class Format:** lecture

**Requirements/Evaluation:** problem sets, midterm, final exam, project

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** STAT 201, 202, or equivalent

**Enrollment Limit:** 20

**Enrollment Preferences:** Statistics majors, seniors

**Expected Class Size:** 15

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

**Attributes:** COGS Related Courses;

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Fall 2018

LEC Section: 01    TF 2:35 pm - 3:50 pm     Richard D. De Veaux

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STAT 346 (F) Regression and Forecasting (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 standard method for analyzing continuous response data and their relationship with explanatory variables. This course provides both theoretical and practical training in statistical modeling with particular emphasis on simple linear and multiple regression, using R to develop and diagnose models. The course covers the theory of multiple regression and diagnostics from a linear algebra perspective with emphasis on the practical application of the methods to real data sets. The data sets will be taken from a wide variety of disciplines.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on performance on exams, homework, and a project

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** STAT 201 or 202, and MATH 150 and 250; or permission of instructor

**Enrollment Limit:** 22

**Expected Class Size:** 15

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

**Attributes:** EVST Methods Courses;

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Fall 2018

LEC Section: 01    TF 1:10 pm - 2:25 pm     Laurie L. Tupper

Spring 2019

LEC Section: 01    TF 2:35 pm - 3:50 pm     Laurie L. Tupper

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STAT 355 (S) Multivariate Statistical Analysis (QFR)

To better understand complex processes, we study how variables are related to one another, and how they work in combination. Therefore, we want to make inferences about more than one variable at time? Elementary statistical methods might not apply. In this course, we study the tools and the intuition that are necessary to analyze and describe such data sets. Topics covered will include data visualization techniques for high dimensional data sets, parametric and non-parametric techniques to estimate joint distributions, techniques for combining variables, as well as classification and clustering algorithms.

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Class Format: lecture
Requirements/Evaluation: evaluation will be based on homework and exams
Prerequisites: MATH 250, and STAT 346 or permission of instructor
Enrollment Limit: 25
Expected Class Size: 10
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01    MWF 8:30 am - 9:45 am    Xizhen Cai

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: lecture
Requirements/Evaluation: evaluation will be based on problem sets and exams
Extra Info: may not be taken on a pass/fail basis
Prerequisites: MATH 250, STAT 201 or 202, STAT 341
Enrollment Limit: 30
Enrollment Preferences: Statistics majors
Expected Class Size: 30
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01    TR 9:55 am - 11:10 am    Daniel B. Turek

STAT 365 (F) Bayesian Statistics (QFR)
The Bayesian approach to statistical inference represents a reversal of traditional (or frequentist) inference, in which data are viewed as being fixed and model parameters as unknown quantities. Interest and application of Bayesian methods have exploded in recent decades, being facilitated by recent advances in computational power. We begin with an introduction to Bayes' Theorem, the theoretical underpinning of Bayesian statistics which dates back to the 1700's, and the concepts of prior and posterior distributions, conjugacy, and closed-form Bayesian inference. Building on this, we introduce modern computational approaches to Bayesian inference, including Markov chain Monte Carlo (MCMC), Metropolis-Hastings sampling, and the theory underlying these simple and powerful methods. Students will become comfortable with modern software tools for MCMC using a variety of applied hierarchical modeling examples, and will use R for all statistical computing.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on 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: 10
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01    TF 1:10 pm - 2:25 pm    Daniel B. Turek
STAT 372 (S) Longitudinal Data Analysis: Modeling Change over Time (QFR)

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

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on performance on exams, homework, and a project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 201 and STAT 346
Enrollment Limit: 30
Enrollment Preferences: junior and senior Statistics majors
Expected Class Size: 20
Distributions: (D3) (QFR)
Attributes: PHLH Statistics Courses;

Spring 2019
LEC Section: 01   TF 1:10 pm - 2:25 pm   Anna M. Plantinga

STAT 442 (S) Statistical Learning and Data Mining (QFR)

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

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homeworks and projects
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 346 or permission of instructor
Enrollment Limit: 14
Enrollment Preferences: seniors and Statistics Majors
Expected Class Size: 10
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01   TF 2:35 pm - 3:50 pm   Richard D. De Veaux

STAT 458 (F) Spatio-Temporal Data (QFR)

Everything happens somewhere and sometime. But the study of data collected over multiple times and locations requires special methods, due to the dependence structure that relates different observations. In this course, we'll look at exploring, analyzing, and modeling this kind of information--introducing standard methods for purely time-series and purely spatial data, and moving on to methods that incorporate space and time together. Topics will include autocovariance structures, empirical orthogonal functions, and an introduction to Bayesian hierarchical modeling. We'll use R to apply these techniques to real-world datasets.

Class Format: lecture
Requirements/Evaluation: project work, homework, exams, and contribution to discussion.
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 346, or permission of instructor
Enrollment Limit: 14
Enrollment Preferences: Seniors and Statistics majors
Expected Class Size: 10
Distributions: (D3) (QFR)
Distribution Notes: This is an intensive statistics course, involving theoretical and mathematical reasoning as well as the application of mathematical ideas to data using software.

Fall 2018
LEC Section: 01  TF 2:35 pm - 3:50 pm  Laurie L. Tupper

Quantitative and Formal Reasoning

ASTR 111 (F) Introduction to Astrophysics  (QFR)

How do stars work? This course answers that question from start to finish! In this course we undertake a survey of some of the main ideas in modern astrophysics, with an emphasis on the observed properties and evolution of stars; 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 radiation laws and stellar spectra, astronomical instrumentation, physical characteristics of the Sun and other stars, star formation and evolution, nucleosynthesis, white dwarfs and planetary nebulae, pulsars and neutron stars, supernovae, relativity, and black holes. We will also discuss the detections of long-sought gravitational waves’ the first detection generated during the merging of two massive stellar black holes more than a billion light-years away, and, another from the merger of two neutron stars in a galaxy over 100 million light-years distant. Observing sessions include use of the 24-inch and other telescopes for observations of stars, nebulae, planets and galaxies, as well as daytime observations of the Sun.

Class Format: lecture/discussion, observing sessions, and five labs per semester
Requirements/Evaluation: evaluation will be based on weekly problem sets, two hour tests, a final exam, lab reports, and an observing portfolio
Prerequisites: a year of high school Physics, or concurrent college Physics, or permission of instructor, and MATH 140 or equivalent
Enrollment Limit: 28
Expected Class Size: 15
Distributions: (D3) (QFR)

Fall 2018
LAB Section: 02  M 1:00 pm - 4:00 pm  Steven P. Souza, Kevin Flaherty
LEC Section: 01  TR 11:20 am - 12:35 pm  Marek Demianski
LAB Section: 03  R 1:00 pm - 4:00 pm  Steven P. Souza, Kevin Flaherty

BIMO 321 (F) Biochemistry I: Structure and Function of Biological Molecules  (QFR)
Crosslistings: BIOL321 / CHEM321 / BIMO321

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

Class Format: lecture, three hours per week; laboratory, four hours per week
Requirements/Evaluation: evaluation is based on quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports
Extra Info: may not be taken on a pass/fail basis
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: 16/lab

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Fall 2018
LAB Section: 04  W 1:00 pm - 5:00 pm  Amy Gehring
LAB Section: 03  T 1:00 pm - 5:00 pm  Katie M. Hart
LEC Section: 01  MWF 10:00 am - 10:50 am  Katie M. Hart
LAB Section: 02  M 1:00 pm - 5:00 pm  Katie M. Hart

Spring 2019
LAB Section: 02  M 1:00 pm - 5:00 pm  Bob Rawle
LEC Section: 01  MWF 9:00 am - 9:50 am  Bob Rawle
LAB Section: 03  Cancelled

BIMO 322 (S)  Biochemistry II: Metabolism  (QFR)
Crosslistings: CHEM322 / BIMO322 / BIOL322

Primary Crosslisting
This lecture course provides an in-depth presentation of the complex metabolic reactions which 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; laboratory, three hours per week

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 64

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

Expected Class Size: 64

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Spring 2019
LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Janis E. Bravo
LEC Section: 01  MWF 11:00 am - 11:50 am  Pei-Wen Chen
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
Genetics, classically defined as the study of heredity, has evolved into a discipline whose limits are continually expanded by innovative molecular technologies. 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. The laboratory part of the course provides an experimental introduction to modern genetic analysis. Laboratory experiments include linkage analysis, bacterial transformation with plasmids and DNA restriction mapping.

Class Format: lecture/laboratory, six hours per week

Requirements/Evaluation: evaluation will be based on bi-weekly problem sets, weekly laboratory exercises and laboratory reports, and examinations

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 101 and 102

Enrollment Limit: none

Expected Class Size: 84

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses; BIMO Required Courses;

Fall 2018
LAB Section: 03  T 1:00 pm - 4:00 pm  Derek Dean
LAB Section: 02  M 1:00 pm - 4:00 pm  Derek Dean
LAB Section: 05  R 1:00 pm - 4:00 pm  Derek Dean
LAB Section: 04  W 1:00 pm - 4:00 pm  Derek Dean
LEC Section: 01  MWF 11:00 am - 11:50 am  David W. Loehlin

BIOL 203 (F) Ecology (QFR)

Crosslistings: BIOL203 / ENVI203

Primary Crosslisting

This course combines lectures 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 overall view of global patterns and then builds from the population to the ecosystem level. An emphasis is given to basic ecological principles and relates them to 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).

Class Format: lecture/laboratory, six hours per week

Requirements/Evaluation: evaluation will be based on problem sets, lab reports, hour exams, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 101 and 102, or ENVI 101 or 102, or permission of instructor

Enrollment Limit: none

Expected Class Size: 35

Department Notes: satisfies the living system course requirement for the major in Environmental Studies; satisfies the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: ENVI Natural World Electives; EVST Environmental Science; EVST Living Systems Courses;

Fall 2018
LAB Section: 02  T 1:00 pm - 4:00 pm  Ron D. Bassar
LEC Section: 01  MWF 10:00 am - 10:50 am  Ron D. Bassar
BIOL 210 (S) Mathematical Biology (QFR)
Crosslistings: MATH310 / BIOL210

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

Class Format: tutorial
Requirements/Evaluation: problem sets, weekly meetings, final project and paper
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: MATH 250, MATH 209 or 309, permission of instructor
Enrollment Limit: 10
Enrollment Preferences: if over-enrolled, will have students submit reasons for taking class; preference to those with interest in both subjects
Expected Class Size: 10
Distributions: (D3) (QFR)
Distribution Notes: QFR: The course will introduce methods for developing and analyzing mathematical models.
Attributes: PHLH Methods in Public Health;

Spring 2019
TUT Section: T1 TBA Julie C. Blackwood

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: lecture/discussion/laboratory, six hours per week
Requirements/Evaluation: regular quizzes, final exam, writing assignments (including problem sets), and lab assignments
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: BIOL 101 and CHEM 156; not open to students who have taken BIOL 321 or BIOL 322
Enrollment Limit: 24
Enrollment Preferences: seniors who need to fulfill the biochemistry requirement for premedical school
Expected Class Size: 24
Department Notes: does not satisfy the distribution requirement for the 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)
Distribution Notes: QFR: The laboratory program is quantitative covering data analyses, numerical transformations, graphical displays.

Spring 2019
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 the emergence of diversity). Topics include micro-evolutionary models, natural selection and adaptation, sexual selection, speciation, the inference of evolutionary history among others.

Class Format: lecture/discussion/laboratory, six hours per week
Requirements/Evaluation: evaluation will be based on independent research project, problem sets, participation in discussions and exams
Prerequisites: BIOL 202
Enrollment Limit: 24
Enrollment Preferences: Seniors and biology majors
Expected Class Size: 24
Department Notes: satisfies the distribution requirement in the Biology major
Distributions: (D3) (QFR)
Attributes: BGNP Recommended Courses; BIMO Interdepartmental Electives; COGS Related Courses;

Spring 2019
LAB Section: 03  R 1:00 pm - 4:00 pm  Luana S. Maroja
LAB Section: 02  W 1:00 pm - 4:00 pm  Luana S. Maroja
LEC Section: 01  MWF 10:00 am - 10:50 am  Luana S. Maroja

BIOL 321 (F)  Biochemistry I: Structure and Function of Biological Molecules  (QFR)
Crosslistings: BIOL321 / CHEM321 / BIMO321
Secondary Crosslisting
This course introduces the basic concepts of biochemistry with an emphasis on the structure and function of biological macromolecules. Specifically, the structure of proteins and nucleic acids are examined in detail in order to determine how their chemical properties and their biological behavior result from those structures. Other topics covered include catalysis, enzyme kinetics, mechanism and regulation; the molecular organization of biomembranes; and the flow of information from nucleic acids to proteins. In addition, the principles and applications of the methods used to characterize macromolecules in solution and the interactions between macromolecules are discussed. The laboratory provides a hands-on opportunity to study macromolecules and to learn the fundamental experimental techniques of biochemistry including electrophoresis, chromatography, and principles of enzymatic assays.

Class Format: lecture, three hours per week; laboratory, four hours per week
Requirements/Evaluation: evaluation is based on quizzes, a midterm exam, a final exam, problem sets and performance in the laboratories including lab reports
Extra Info: may not be taken on a pass/fail basis
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: 16/lab
Department Notes: does not satisfy the distribution requirement in the Biology major
Distributions: (D3) (QFR)
Attributes: BGNP Related Courses; BIMO Required Courses;
BIOL 322 (S)  Biochemistry II: Metabolism  (QFR)
Crosslistings: CHEM322 / BIMO322 / BIOL322

Secondary Crosslisting
This lecture course provides an in-depth presentation of the complex metabolic reactions which 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; laboratory, three hours per week
Requirements/Evaluation: evaluation is based on several exams and performance in the laboratories including lab reports that emphasize conceptual and quantitative and/or graphic analysis of the data generated
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites:  BIOL 101 and CHEM 251/255 or permission of instructor
Enrollment Limit:  64
Enrollment Preferences:  junior and senior Biology and Chemistry majors and BIMO concentrators
Expected Class Size:  64
Department Notes:  does not satisfy the distribution requirement in the Biology major
Distributions:  (D3) (QFR)
Attributes:  BGNP Related Courses;  BIMO Required Courses;

BIOL 329 (F)  Conservation Biology  (QFR)
Crosslistings: BIOL329 / ENVI339

Primary Crosslisting
Conservation biology is an interdisciplinary field that develops scientific and technical means for the protection, maintenance, and restoration of diversity at all levels of biological organization. This course provides an overview of the discipline including the causes and consequences of biodiversity loss as well as approaches and strategies used to combat biodiversity threats such as climate change, habitat fragmentation, and invasive species. Particular emphasis is placed on the ecological dimension of conservation and the application of biological principles (derived from physiological and behavioral ecology, population genetics, population ecology, community ecology, and systematics) to the conservation of biodiversity. The course combines lectures, readings, in-class discussion, and a laboratory that includes both field and lab projects.
Class Format: lecture and discussion three hours per week; lab three hours per week

Requirements/Evaluation: lab assignments, two exams, and discussion participation

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 203, or BIOL 202, or permission of instructor

Enrollment Limit: 24

Enrollment Preferences: biology majors, seniors, and juniors

Expected Class Size: 24

Department Notes: satisfies the distribution requirement for the Biology major

Distributions: (D3) (QFR)

Distribution Notes: QFR: This course uses quantitative and statistical analyses in both the laboratory and lecture portion of the course. In lectures mathematical models will be covered to understand conservation dynamics. In lab, students will collect and analyze data and present results in graphical and statistical forms.

Attributes: ENVI Natural World Electives;

Fall 2018

LAB Section: 02  M 1:00 pm - 4:00 pm  Sonya K. Auer
LAB Section: 03  W 1:00 pm - 4:00 pm  Sonya K. Auer
LEC Section: 01  TR 11:20 am - 12:35 pm  Sonya K. Auer

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.

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

Requirements/Evaluation: evaluation is based on frequent electronic and quantitative written weekly problem set assignments, laboratory work and reports, quizzes, two tests, and a final exam

Extra Info: information about the Chemistry Placement Test can be found at http://chemistry.williams.edu/placement/

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: all students planning to enroll are required to take the online Chemistry Placement Test prior to registering for the course (and incoming first year students are required to meet with a faculty member during First Days);

Enrollment Limit: 16/lab

Enrollment Preferences: incoming first year students are required to meet with a faculty member during First Days;

Expected Class Size: 48

Department Notes: CHEM 151 may be taken concurrently with MATH 102--see under Mathematics; CHEM 151 or its equivalent is prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Distribution Notes: students who have studied chemistry for one or more years are directed to CHEM 153 or 155

Attributes: BIMO Required Courses;

Fall 2018

LAB Section: 03  Cancelled
LAB Section: 02  M 1:00 pm - 5:00 pm  Laura R. Strauch
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 work includes synthesis, qualitative and quantitative chemical analysis, and molecular modeling. 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 fundamental ideas of chemistry as part of their general education.

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

Requirements/Evaluation: evaluation is based on quantitative weekly problem set assignments, laboratory work and reports, hour tests, and a final exam

Extra Info: information about the Chemistry Placement Test can be found at http://chemistry.williams.edu/placement/

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: all students are required to take the online Chemistry Placement Test prior to registering for the course (and incoming first year students are required to meet with a faculty member during First Days)

Enrollment Limit: 16/lab

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

Expected Class Size: 70

Department Notes: one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Attributes: BIMO Required Courses;

CHEM 155 (F) Principles of Modern Chemistry (QFR)

This course is designed for students with strong preparation in secondary school chemistry, including a laboratory experience, such as provided by an Advanced Placement chemistry course (or equivalent) with a corresponding score of 5 of the AP Chemistry Exam (or a 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, industrial, environmental, biological, and medicinal chemistry. Laboratory work includes synthesis, characterization, and reactivity of coordination complexes, electrochemical analysis, materials chemistry, qualitative analysis, and molecular modeling. This course is of interest for students who are anticipating professional 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 hours per week; laboratory, four hours per week

Requirements/Evaluation: evaluation is based on weekly problem sets, laboratory work and reports, an hour test, and a final exam

Extra Info: information about the Chemistry Placement Test can be found at http://chemistry.williams.edu/placement/

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: students planning to enroll are required to take the Chemistry Placement Survey prior to registering; incoming first year students are required to meet with faculty during First Days; for more information go to http://chemistry.williams.edu/placement/

Enrollment Limit: 16/lab

Enrollment Preferences: CHEM 151 is an introductory course for students with no or little chemistry background. Students who have studied chemistry for one or more years are directed to CHEM 153 or 155

Expected Class Size: 36

Department Notes: CHEM 151 may be taken concurrently with MATH 102--see under Mathematics; CHEM 151 or its equivalent is prerequisite to CHEM 156; one of CHEM 151 or 153 or 155 required for the BIMO concentration

Distributions: (D3) (QFR)

Attributes: BIMO Required Courses;

CHEM 151 (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 and elimination reactions, and the addition reactions of alkenes and alkynes. 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 hours per week; laboratory, four hours per week

Requirements/Evaluation: evaluation will be based on quantitative problem sets, laboratory performance, including written lab reports, three midterm exams, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 16/lab

Expected Class Size: 120

Distributions: (D3) (QFR)

Attributes: BIMO Required Courses;

CHEM 321 (F) Biochemistry I: Structure and Function of Biological Molecules (QFR)
Crosslistings: BIOL321 / CHEM321 / BIMO321

Secondary Crosslisting

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

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

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

Extra Info: may not be taken on a pass/fail basis

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: 16/lab

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Fall 2018
LAB Section: 04  W 1:00 pm - 5:00 pm  Amy Gehring
LAB Section: 03  T 1:00 pm - 5:00 pm  Katie M. Hart
LEC Section: 01  MWF 10:00 am - 10:50 am  Katie M. Hart
LAB Section: 02  M 1:00 pm - 5:00 pm  Katie M. Hart

Spring 2019
LAB Section: 03  Cancelled
LAB Section: 02  M 1:00 pm - 5:00 pm  Bob Rawle
LEC Section: 01  MWF 9:00 am - 9:50 am  Bob Rawle

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

Crosslistings: CHEM322 / BIMO322 / BIOL322

Secondary Crosslisting

This lecture course provides an in-depth presentation of the complex metabolic reactions which 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; laboratory, three hours per week

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 64
Enrollment Preferences: junior and senior Biology and Chemistry majors and BIMO concentrators

Expected Class Size: 64

Department Notes: does not satisfy the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: BGNP Related Courses; BIMO Required Courses;

Spring 2019

LAB Section: 04  R 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 03  W 1:00 pm - 4:00 pm  Janis E. Bravo
LAB Section: 02  T 1:00 pm - 4:00 pm  Janis E. Bravo
LEC Section: 01  MWF 11:00 am - 11:50 am  Pei-Wen Chen

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 the laboratory session 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.

Class Format: tutorial, meeting time to be determined

Requirements/Evaluation: evaluation is based on tutorial participation, presentations, and submitted papers

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: CHEM 361 or equivalent background in Physics

Enrollment Limit: 10

Expected Class Size: 10

Distributions: (D3) (QFR)

Spring 2019

TUT Section: T1  Cancelled

CSCI 134 (F)  Introduction to Computer Science: Diving into the Deluge of Data  (QFR)
We are surrounded by information: weather forecasts, twitter feeds, restaurant reviews, stock market tickers, music recommendations, among others. This course introduces fundamental computational concepts for representing and manipulating data. Using the programming language Python, this course explores effective ways to organize and transform information in order to solve problems. Students will learn to design algorithms to search, sort, and manipulate data in application areas like text and image processing, social networks, scientific computing, databases, and the World Wide Web. Programming topics covered include object-oriented and functional programming, control structures, types, recursion, arrays, lists, streams, and dictionaries. This course is appropriate for all students who want to create software and learn computational techniques for manipulating and analyzing data. More details are available on the department website, http://www.cs.williams.edu

Class Format: lecture/laboratory

Requirements/Evaluation: evaluation will be based on weekly assignments, programming projects, and examinations

Prerequisites: none, except for the standard prerequisites for a (Q) course; previous programming experience is not required

Enrollment Limit: 75

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

Expected Class Size: 75

Department Notes: students with prior experience with object-oriented programming should discuss appropriate course placement with members of the department

Distributions: (D3) (QFR)
CSCI 136 (F) 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.

Class Format: lecture/laboratory

Requirements/Evaluation: evaluation will be based on programming assignments, homework and/or examinations

Prerequisites: CSCI 134 or equivalent; fulfilling the Discrete Mathematics Proficiency requirement is recommended, but not required

Enrollment Limit: 60

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

Expected Class Size: 60

Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses;
CSCI 237 (F) 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.

Class Format: lecture/laboratory
Requirements/Evaluation: evaluation will be based primarily on projects, and one or more exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 134, or both experience in programming and permission of instructor
Enrollment Limit: 30
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 30
Distributions: (D3) (QFR)

Fall 2018
LAB Section: 02  W 12:00 pm - 2:00 pm  Daniel W. Barowy
LAB Section: 05  W 2:00 pm - 4:00 pm  Bill K. Jannen

Spring 2019
LAB Section: 02  R 1:00 pm - 2:25 pm  Duane A. Bailey
LAB Section: 03  R 2:35 pm - 4:00 pm  Duane A. Bailey

CSCI 256 (F) 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 induction, divide-and-conquer, dynamic programming, and greedy algorithms. Additional topics of study include algorithms on graphs and strategies for handling potentially intractable problems.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on problem sets and programming assignments, and midterm and final examinations
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136 and fulfillment of the Discrete Mathematics Proficiency requirement
Enrollment Limit: 30
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 30
Distributions: (D3) (QFR)
Attributes: BGNP Recommended Courses;

Fall 2018
LEC Section: 01  MWF 11:00 am - 11:50 am  William J. Lenhart
CSCI 326 (F)  Software Methods  (QFR)
Sophisticated software systems play a prominent role in many aspects of our lives, and while programming can be a very creative and exciting process, building a reliable software system of any size is no easy feat. Moreover, the ultimate outcome of any programming endeavor is likely to be incomplete, unreliable, and unmaintainable unless principled methods for software construction are followed. This course explores those methods. Specific topics include: software processes; specifying requirements and verifying correctness; abstractions; design principles; software architectures; concurrent and scalable systems design; testing and debugging; and performance evaluation.

Class Format: lecture/lab
Requirements/Evaluation: homework, programming assignments, group work, presentations, exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136, and at least one of CSCI 237, 256, or 334
Enrollment Limit: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Distributions: (D3) (QFR)

CSCI 333 (S)  Storage Systems  (QFR)
This course will examine topics in the design, implementation, and evaluation of storage systems. Topics include the memory hierarchy; ways that data is organized (both logically and physically); storage hardware and its influence on storage software designs; data structures; performance models; and system measurement/evaluation. Readings will be taken from recent technical literature, and an emphasis will be placed on identifying and evaluating design trade-offs.

Class Format: lecture/lab
Requirements/Evaluation: problem sets, programming assignments, and midterm and final examinations
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136; CSCI 237 or permission of instructor
Enrollment Limit: 24
Enrollment Preferences: current Computer Science majors, students with research experience or interest
Expected Class Size: 24
Distributions: (D3) (QFR)
Distribution Notes: QFR: This course will have students develop quantitative/formal reasoning skills through problem sets and programming assignments.

CSCI 334 (F)  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.
CSCI 336 (F) Computer Networks (QFR)
This course explores the design and implementation of computer networks. Topics include wired and wireless networks; techniques for efficient and reliable encoding and transmission of data; addressing schemes and routing mechanisms; resource allocation for bandwidth sharing; and security issues. An important unifying theme is the distributed nature of all network problems. We will examine the ways in which these issues are addressed by current protocols such as TCP/IP and 802.11 WiFi.

Class Format: This class will follow the meeting structure of a tutorial, with groups of three or four
Requirements/Evaluation: evaluation will be based on problem sets, programming assignments, and midterm and final examinations
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 136 and 237
Enrollment Limit: 18
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 18
Distributions: (D3) (QFR)

Fall 2018
LEC Section: T1 Cancelled

CSCI 361 (F) Theory of Computation (QFR)
Crosslistings: CSCI361 / MATH361

Primary Crosslisting
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
Requirements/Evaluation: evaluation will be based on problem sets, a midterm examination, and a final examination
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 256 or both a 300-level MATH course and permission of instructor
Enrollment Limit: 34
Enrollment Preferences: current or expected Computer Science majors
CSCI 432 (F) 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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on several implementation projects that will include significant programming, as well as written homework and exams
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: CSCI 237 and either CSCI 256 or 334
Enrollment Limit: 24
Enrollment Preferences: current or expected Computer Science majors
Expected Class Size: 24
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01 MWF 12:00 pm - 12:50 pm Thomas P. Murtagh
LEC Section: 02 MWF 11:00 am - 11:50 am Thomas P. Murtagh

Spring 2019
LEC Section: 01 MR 1:10 pm - 2:25 pm Jeannie R Albrecht
ECON 110 (F) 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.

Class Format: lecture/discussion

Requirements/Evaluation: problem sets, quizzes, short essays, two midterms (one for Bradburd's sections), final exam

Extra Info: 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

Extra Info 2: not available for the fifth course option

Prerequisites: none

Enrollment Limit: 40

Expected Class Size: 40

Department 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)

Distribution Notes: Prof. Bradburd's section ONLY; intends to use the issue of environmental protection in general, and climate change in particular, as the vehicle for presenting and applying many, though not all, of the economic concepts and tools developed in the course

Attributes: POEC Required Courses;

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ECON 120 (F) 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.

Class Format: lecture/discussion

Requirements/Evaluation: problem sets, short essays, midterm, final exam

Prerequisites: ECON 110

Enrollment Limit: 40

Expected Class Size: 40

Distributions: (D2) (QFR)

Attributes: POEC Required Courses;
ECON 213 (S) Introduction to Environmental and Natural Resource Economics (QFR)

Crosslistings: ECON213 / ENVI213

Primary Crosslisting

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

Class Format: lecture

Requirements/Evaluation: problem sets, short essays, paper(s); exam(s) are possible

Prerequisites: ECON 110

Enrollment Limit: 30

Enrollment Preferences: first-year and sophomore students

Expected Class Size: 30

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

Distributions: (D2) (QFR)

Attributes: ENVI Environmental Policy; POEC Comparative POEC/Public Policy Courses;

Spring 2019

LEC Section: 01 MW 11:00 am - 12:15 pm  Sarah A. Jacobson

ECON 229 (S) Law and Economics (QFR)

This course applies the tools of microeconomic analysis to private (i.e., civil) law. This analysis has both positive and normative aspects. The positive aspects deal with how individuals respond to the incentives created by the legal system. Examples include: how intellectual property law encourages the creation of knowledge while simultaneously restricting the dissemination of intellectual property; how tort law motivates doctors to avoid malpractice suits; and how contract law facilitates agreements. The normative aspects of the analysis ask whether legal rules enhance economic efficiency (or, more broadly, social welfare). Examples include: what legal rules are most appropriate for mitigating pollution, ensuring safe driving, and guaranteeing workplace safety? The course will also cover the economics of legal systems; for example, what are the incentives for plaintiffs to initiate lawsuits and what role do lawyers play in determining outcomes. The course will also consider potential reforms of the legal system.

Class Format: lecture/discussion

Requirements/Evaluation: evaluation will be based on class participation, problem sets, short papers based on actual court cases and possible legal reforms, a midterm exam, and a final exam

Prerequisites: ECON 110

Enrollment Limit: 35

Enrollment Preferences: Open; prefer a mix of student backgrounds

Expected Class Size: 25

Distributions: (D2) (QFR)
British colonial rule in South Asia shaped economy and society in fundamental ways. As resistance to colonial rule emerged in the late nineteenth century, "nationalist" writers developed a critique of its economic impact via taxation, fiscal policy, trade, and many other policies. In their turn, supporters of British rule, "apologists," argued that British rule had laid the foundations of economic growth by securing property rights, enforcing contracts, and developing infrastructure. The debate between "nationalists" and "apologists" has never quite ended, but after the recent growth of the Indian economy it has lost some of its emotional charge. We will use this opportunity to revisit the controversy.

Class Format: tutorial

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: one course in ECON

Enrollment Limit: 10

Enrollment Preferences: Economics major, prior course on South Asia

Expected Class Size: 10

Distributions: (D2) (DPE) (WI) (QFR)

Distribution Notes: DPE: Issues of difference, power, and equity are at the heart of any analysis of colonialism, hence the DPE designation. QFR and WI: Students will write six essays, in which they will employ economic models and engage with quantitative evidence, so the course satisfies both the WI and QFR requirement.

Attributes: GBST South + Southeast Asia Studies Electives; POEC Comparative POEC/Public Policy Courses;
ECON 252 (F) 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.

Class Format: lecture/discussion

Requirements/Evaluation: problem sets and/or written assignments, midterm(s), and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 30

Expected Class Size: 25

Distributions: (D2) (QFR)

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ECON 255 (F) 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. 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.

Class Format: lecture

Requirements/Evaluation: problem sets, two midterms, group presentations, and possible additional assignments Swamy: problem sets, one midterm, final exam and a group project Gentry: problem sets, one midterm, final exam, a group project, and possible additional assignments

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Expected Class Size: 30

Department Notes: students may substitute the combination of STAT 201 and 346 for ECON 255

Distributions: (D2) (QFR)

Attributes: EVST Methods Courses; PHLH Statistics Courses; POEC Required Courses;
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 discussed include: What causes inflation? What are the channels through which monetary policy affects the economy? Why should central banks commit to policy rules? How do exchange rates respond to monetary policy? How did the gold standard work? And will cryptocurrencies replace the dollar? In addition, we will develop and learn how to simulate the "New Keynesian" macroeconomic model, which has become the standard framework for monetary policy analysis for central banks around the world.

Class Format: lecture

Requirements/Evaluation: at least one exam, a research paper and a class presentation

Extra Info: not available for the fifth course option

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

Enrollment Limit: 25

Enrollment Preferences: junior and senior Economics majors

Expected Class Size: 25

Distributions: (D2) (QFR)

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

Spring 2019

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

ECON 364 (F) Theory of Asset Pricing  (QFR)
What is the price of time? What is the price of risk? How do markets allocate resources across time and uncertain states of the world? This course theoretically studies how markets allocate scarce resource across time and when outcomes are risky. The "goods" in such markets are called "assets" and the prices of "assets" determine the cost of trading resources across time and across uncertain states of the world. We theoretically investigate how equilibrium determines the price of time, then asset price implications; then asset allocations and prices in the presence of risk; finally, implications for new assets.

Class Format: lecture

Requirements/Evaluation: problem sets and exams

Extra Info: may not be taken on a pass/fail basis

Prerequisites: ECON 251 or ECON 252; and ECON 255 or STAT 201

Enrollment Limit: 25

Expected Class Size: 25

Distributions: (D2) (QFR)

Fall 2018

LEC Section: 01  TR 8:30 am - 9:45 am  Greg Phelan

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

Class Format: seminar
Requirements/Evaluation: term paper and regular homework assignments
Extra Info: may not be taken on a pass/fail basis
Prerequisites: ECON 252 and either ECON 255 or STATS 346
Enrollment Limit: 19
Enrollment Preferences: students wishing to write an honors thesis, and students with strong MATH/STAT/CSCI backgrounds
Expected Class Size: 19
Distributions: (D2) (QFR)
Distribution Notes: QFR: Uses quantitative/formal reasoning intensively in the form of mathematical and statistical arguments, as well as computer programming.

Fall 2018
SEM Section: 01 TF 1:10 pm - 2:25 pm Peter L. Pedroni

ECON 378 (F) Long-Run Perspectives on Economic Growth (QFR)
The world today is marred by vast differences in the standard of living, with about a 30-fold difference in per-capita incomes between the poorest country and the most affluent. What explanations do long-run growth economists have to offer for these differences in levels of prosperity across nations? Are the explanations to be found in underlying differences between countries over the past few decades, the past few centuries, or the past few millennia? If contemporary differences in living standards have "deep" historically-rooted origins, what scope exists for policies to reduce global inequality today? Can we expect global inequality to be reduced gradually over time, through natural processes of economic development, or are they likely to persist unless action is taken to reduce them? 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 long-lasting effects of geography on comparative development, through its impact on the emergence of agriculture in early human societies and its influence in shaping the genetic composition of human populations across the globe.

Class Format: lecture/discussion
Requirements/Evaluation: at least one exam, a research paper and a class presentation
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
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
Distributions: (D2) (QFR)
Attributes: POEC Comparative POEC/Public Policy Courses;

Fall 2018
LEC Section: 01 TR 11:20 am - 12:35 pm Quamrul H. Ashraf
Development organizations face strict competition for scarce resources. Both public and private organizations are under increasing pressure to use rigorous program evaluation in order to justify funding for their programs and to design more effective programs. This course is an introduction to evaluation methodology and the tools available to development practitioners, drawing on examples from developing countries. It will cover a wide range of evaluation techniques and discuss the advantages and disadvantages of each. The course is a mix of applied econometrics and practical applications covering implementation, analysis, and interpretation. You will learn to be a critical reader of evaluations, and to develop your own plan to evaluate an existing program of your choice.

Class Format: seminar

Requirements/Evaluation: problem sets, midterm exam and one 7- to 10-page essay

Extra Info: may not be taken on a pass/fail basis

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)

Enrollment Limit: 20

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

Expected Class Size: 20

Distributions: (D2) (QFR)

Attributes: PHLH Methods in Public Health; POEC Comparative POEC/Public Policy Courses;

Spring 2019

SEM Section: 01 TR 11:20 am - 12:35 pm Susan Godlonton

Taxes are half of what government does. So if you are interested in what government policy can do to promote efficiency, equity, and economic development, you should be interested in tax policy. Governments must raise tax revenue to finance critical public goods, address other market failures and distributional issues, and to avoid problems with debt and inflation. Taxes typically take up anywhere from ten to fifty percent of a country's income, they profoundly affect the incentives to undertake all varieties of economic activity, and the government expenditures that they finance have potentially large consequences for human welfare. So the stakes involved in improving tax policy are quite large. This class provides an in-depth exploration of tax policy, from a global and comparative perspective. Because most students in this class will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are most pertinent to developing countries, but we will also learn something about tax systems in the U.S. and other industrialized nations. Topics addressed in this class include: how basic economic principles can be applied to help one think about 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 reforms of these taxes; theory and evidence in the debate over progressive taxes versus "flat" taxes; how various elements of tax design affect incentives to save and invest; how market failures and administrative problems may influence the optimality of different tax policies; the implications of global capital flows and corporate tax avoidance for the design of tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on economic growth, 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.

Class Format: seminar

Requirements/Evaluation: midterm exam, 4 problem sets, two 8-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
ECON 453 (S) Research in Labor Economics and Policy (QFR)
The labor market plays a crucial role in people's lives worldwide. In industrialized countries, most households contain at least one wage earner, and income from working represents the largest component of total income. Thus analyses of the labor market are fundamentally relevant to both public policy and private decision-making. This seminar will explore the structure and functioning of the labor market using theoretical and empirical tools. Topics to be covered include labor supply and demand, minimum wages, labor market effects of social insurance and welfare programs, the collective bargaining relationship, discrimination, human capital, immigration, wage distribution, and unemployment. As labor economics is an intensely empirical subfield, students will be expected to analyze data as well as study the empirical work of others.

Class Format: seminar
Requirements/Evaluation: a series of short papers and empirical exercises, constructive contributions to class discussion, class presentations, and a 15- to 20-page original empirical research paper (written in stages)
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: ECON 251 and ECON 255 or POEC 253
Enrollment Limit: 19
Enrollment Preferences: senior Economics majors
Expected Class Size: 19
Distributions: (D2) (QFR)
Attributes: POEC Comparative POEC/Public Policy Courses;

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

Class Format: seminar
Requirements/Evaluation: periodic homework assignments, term paper
Extra Info: not available for the fifth course option
Prerequisites: ECON 371
Enrollment Limit: 10
Enrollment Preferences: students with strong quantitative backgrounds, and to students intending to write an honors thesis
Expected Class Size: 10
Distributions: (D2) (QFR)
**ECON 472 (F) Macroeconomic Instability and Financial Markets (QFR)**
This advanced course in macroeconomics and financial theory attempts to explain the role and the importance of the financial system in the global economy. The course will provide an understanding of why there is financial intermediation, how financial markets differ from other markets, and the equilibrium consequences of financial activities. Rather than separating off the financial world from the rest of the economy, we will study financial equilibrium as a critical element of economic equilibrium. An important topic in the course will be studying how financial market imperfections amplify and propagate shocks to the aggregate economy. The course may cover the following topics: the determination of asset prices in general equilibrium; consequences of limited asset markets for economic efficiency; theoretical foundations of financial contracts and justifications for the existence of financial intermediaries; the roles of financial frictions in magnifying aggregate fluctuations and creating persistence and instability; the role of leverage and financial innovation in fueling financial crises.

Class Format: seminar

Requirements/Evaluation: evaluation will be based on problem sets, exams, and potentially student presentations

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: ECON 251 and ECON 252

Enrollment Limit: 19

Enrollment Preferences: Economics majors

Expected Class Size: 15

Distributions: (D2) (QFR)

Fall 2018

SEM Section: 01 MWF 8:30 am - 9:45 am Greg Phelan

**ECON 477 (S) Economics of Environmental Behavior (QFR)**
Crosslistings: ENV376 / ECON477

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

Class Format: seminar

Requirements/Evaluation: short essays and empirical exercises, class participation, oral presentation(s), and a final original research paper using an experiment, existing data, or theory

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

Enrollment Limit: 19

Enrollment Preferences: senior Economics majors

Expected Class Size: 15

Distributions: (D2) (QFR)

Attributes: MAST Interdepartmental Electives; POEC Comparative POEC/Public Policy Courses;

Spring 2019

SEM Section: 01 MWF 8:30 am - 9:45 am Sarah A. Jacobson

**ECON 514 (S) Tax Policy in Global Perspective (QFR)**
Crosslistings: ECON514 / ECON389

Primary Crosslisting
Taxes are half of what government does. So if you are interested in what government policy can do to promote efficiency, equity, and economic
development, you should be interested in tax policy. Governments must raise tax revenue to finance critical public goods, address other market failures and distributional issues, and to avoid problems with debt and inflation. Taxes typically take up anywhere from ten to fifty percent of a country’s income, they profoundly affect the incentives to undertake all varieties of economic activity, and the government expenditures that they finance have potentially large consequences for human welfare. So the stakes involved in improving tax policy are quite large. This class provides an in-depth exploration of tax policy, from a global and comparative perspective. Because most students in this class will be CDE fellows, we will emphasize tax policy issues, examples, and evidence that are most pertinent to developing countries, but we will also learn something about tax systems in the U.S. and other industrialized nations. Topics addressed in this class include: how basic economic principles can be applied to help one think about 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 reforms of these taxes; theory and evidence in the debate over progressive taxes versus "flat" taxes; how various elements of tax design affect incentives to save and invest; how market failures and administrative problems may influence the optimality of different tax policies; the implications of global capital flows and corporate tax avoidance for the design of tax policy; tax holidays and other special tax incentives for investment; empirical evidence on the influence of taxes on economic growth, 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.

Class Format: seminar

Requirements/Evaluation: midterm exam, 4 problem sets, two 8-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

Distributions: (D2) (QFR)

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

Spring 2019

SEM Section: 01    TR 8:30 am - 9:45 am     Jon M. Bakija

ECON 523 (S) Program Evaluation for International Development  (QFR)

Crosslistings: ECON379 / ECON523

Primary Crosslisting

Development organizations face strict competition for scarce resources. Both public and private organizations are under increasing pressure to use rigorous program evaluation in order to justify funding for their programs and to design more effective programs. This course is an introduction to evaluation methodology and the tools available to development practitioners, drawing on examples from developing countries. It will cover a wide range of evaluation techniques and discuss the advantages and disadvantages of each. The course is a mix of applied econometrics and practical applications covering implementation, analysis, and interpretation. You will learn to be a critical reader of evaluations, and to develop your own plan to evaluate an existing program of your choice.

Class Format: seminar

Requirements/Evaluation: problem sets, midterm exam and one 7- to 10-page essay

Extra Info: may not be taken on a pass/fail basis

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)

Enrollment Limit: 20

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

Expected Class Size: 20

Distributions: (D2) (QFR)

Attributes: PHLH Methods in Public Health; POEC Comparative POEC/Public Policy Courses;
ENVI 108 (F) Energy Science and Technology (QFR)

Crosslistings: ENVI108 / PHYS108

Secondary Crosslisting

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

Requirements/Evaluation: evaluation will be based on 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

Distributions: (D3) (QFR)

Attributes: ENVI Natural World Electives; SCST Related Courses

Fall 2018

ENVI 203 (F) Ecology (QFR)

Crosslistings: BIOL203 / ENVI203

Secondary Crosslisting

This course combines lectures 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 overall view of global patterns and then builds from the population to the ecosystem level. An emphasis is given to basic ecological principles and relates them to 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).

Class Format: lecture/laboratory, six hours per week

Requirements/Evaluation: evaluation will be based on problem sets, lab reports, hour exams, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: BIOL 101 and 102, or ENVI 101 or 102, or permission of instructor

Enrollment Limit: none

Expected Class Size: 35

Department Notes: satisfies the living system course requirement for the major in Environmental Studies; satisfies the distribution requirement in the Biology major

Distributions: (D3) (QFR)

Attributes: ENVI Natural World Electives; EVST Environmental Science; EVST Living Systems Courses;
ENVI 213 (S) Introduction to Environmental and Natural Resource Economics (QFR)

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

Class Format: lecture
Requirements/Evaluation: problem sets, short essays, paper(s); exam(s) are possible
Prerequisites: ECON 110
Enrollment Limit: 30
Enrollment Preferences: first-year and sophomore students
Expected Class Size: 30
Department Notes: this course will count toward both the Environmental Studies major and concentration
Distributions: (D2) (QFR)
Attributes: ENVI Environmental Policy; POEC Comparative POEC/Public Policy Courses;

Spring 2019
LEC Section: 01    MW 11:00 am - 12:15 pm     Sarah A. Jacobson

ENVI 339 (F) Conservation Biology (QFR)

Secondary Crosslisting
Conservation biology is an interdisciplinary field that develops scientific and technical means for the protection, maintenance, and restoration of diversity at all levels of biological organization. This course provides an overview of the discipline including the causes and consequences of biodiversity loss as well as approaches and strategies used to combat biodiversity threats such climate change, habitat fragmentation, and invasive species. Particular emphasis is placed on the ecological dimension of conservation and the application of biological principles (derived from physiological and behavioral ecology, population genetics, population ecology, community ecology, and systematics) to the conservation of biodiversity. The course combines lectures, readings, in-class discussion, and a laboratory that includes both field and lab projects.

Class Format: lecture and discussion three hours per week; lab three hours per week
Requirements/Evaluation: lab assignments, two exams, and discussion participation
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: BIOL 203, or BIOL 202, or permission of instructor
Enrollment Limit: 24
Enrollment Preferences: biology majors, seniors, and juniors
Expected Class Size: 24
Department Notes: satisfies the distribution requirement for the Biology major
Distributions: (D3) (QFR)
Distribution Notes: QFR: This course uses quantitative and statistical analyses in both the laboratory and lecture portion of the course. In lectures mathematical models will be covered to understand conservation dynamics. In lab, students will collect and analyze data and present results in graphical and statistical forms.
Attributes: ENVI Natural World Electives;

Fall 2018
ENVI 376 (S) Economics of Environmental Behavior (QFR)

Crosslistings: ENVI376 / ECON477

Secondary Crosslisting

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

Class Format: seminar

Requirements/Evaluation: short essays and empirical exercises, class participation, oral presentation(s), and a final original research paper using an experiment, existing data, or theory

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

Enrollment Limit: 19

Enrollment Preferences: senior Economics majors

Expected Class Size: 15

Distributions: (D2) (QFR)

Attributes: MAST Interdepartmental Electives; POEC Comparative POEC/Public Policy Courses;

Spring 2019

SEM Section: 01 MWF 8:30 am - 9:45 am Sarah A. Jacobson

ENVI 404 (S) Coastal Processes and Geomorphology (QFR)

Crosslistings: ENVI404 / MAST404 / GEOS404

Secondary Crosslisting

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: GEOS 104 or permission of instructor

Enrollment Limit: none

Expected Class Size: 10
GEOS 301 (F) Structural Geology (QFR)
The structure of the Earth's crust is constantly changing and the rocks making up the crust must deform to accommodate these changes. Rock deformation occurs over many scales ranging from individual mineral grains to mountain belts. This course deals with the geometric description of structures, stress and strain analysis, deformation mechanisms in rocks, and the large scale forces responsible for crustal deformation. The laboratories cover geologic maps and cross sections, folds and faults, stereonet analysis, field techniques, strain, and stress.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week

Requirements/Evaluation: evaluation will be based on weekly laboratory exercises, problem sets, a midterm exam, and a final exam; many of the labs and problem sets use geometry, algebra, and several projection techniques to solve common problems in structural geology

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: GEOS 101 or 102, or permission of instructor

Enrollment Limit: 16

Enrollment Preferences: Geosciences majors

Expected Class Size: 12

Distributions: (D3) (QFR)

Fall 2018

LEC Section: 01  MW 11:00 am - 12:15 pm  Paul M. Karabinos

LAB Section: 02  M 1:00 pm - 4:00 pm  Paul M. Karabinos

GEOS 404 (S) Coastal Processes and Geomorphology (QFR)
Crosslistings: ENVI404 / MAST404 / GEOS404

Primary Crosslisting

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: GEOS 104 or permission of instructor

Enrollment Limit: none
**Expected Class Size:** 10

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

**Attributes:** ENVI Natural World Electives;

Spring 2019

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

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

**MATH 110 (F) Logic and Likelihood (QFR)**

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

**Class Format:** lecture

**Requirements/Evaluation:** homework, essays, presentations, exams, and participation

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** none

**Enrollment Limit:** 25

**Enrollment Preferences:** first-year students

**Expected Class Size:** 25

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

**Distribution Notes:** QFR: This course will be covering formal logic and probability theory at sufficient depth to place this course on level with other QFR designated courses.

Fall 2018

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

**MATH 130 (F) 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.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on exams, homework and quizzes

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

**Enrollment Limit:** 50

**Enrollment Preferences:** Professor's discretion

**Expected Class Size:** 30

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

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

Fall 2018

LEC Section: 02  TR 9:55 am - 11:10 am  Pamela E. Harris

LEC Section: 01  TR 8:30 am - 9:45 am  Pamela E. Harris
MATH 140 (F) Calculus II (QFR)
Mastery of calculus requires understanding how integration computes areas and business profit and acquiring a stock of techniques. Further methods solve equations involving derivatives ("differential equations") for population growth or pollution levels. Exponential and logarithmic functions and trigonometric and inverse functions play an important role. This course is the right starting point for students who have seen derivatives, but not necessarily integrals, before.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on 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
Expected Class Size: 30
Department Notes: students who have higher advanced placement must enroll in MATH 150 or above
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01 MWF 10:00 am - 10:50 am Cesar E. Silva
LEC Section: 02 MWF 11:00 am - 11:50 am Cesar E. Silva

Spring 2019
LEC Section: 01 MWF 9:00 am - 9:50 am Susan R. Loepp

MATH 150 (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, multiple integrals. There is also a unit on infinite series, sometimes with applications to differential equations.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homework, quizzes, and/or exams
Prerequisites: MATH 140 or equivalent, such as satisfactory performance on an Advanced Placement Examination
Enrollment Limit: 50
Expected Class Size: 50
Department Notes: this course is the right starting point for students who have seen differentiation and integration before; students with the equivalent of advanced placement of AB 4, BC 3 or above should enroll in MATH 150
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01 MWF 9:00 am - 9:50 am Julie C. Blackwood
LEC Section: 03 MWF 11:00 am - 11:50 am Julie C. Blackwood
LEC Section: 02 MWF 10:00 am - 10:50 am Julie C. Blackwood

Spring 2019
LEC Section: 02 MWF 10:00 am - 10:50 am Stewart D. Johnson
LEC Section: 01 MWF 9:00 am - 9:50 am Stewart D. Johnson

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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homework, quizzes, and/or exams
Prerequisites: AP BC 3 or higher or integral calculus with infinite series
Enrollment Limit: 50
Expected Class Size: 50
Department Notes: MATH 151 satisfies any MATH 150 prerequisite; credit will not be given for both MATH 150 and MATH 151
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01 MWF 9:00 am - 9:50 am Colin C. Adams
LEC Section: 03 MWF 11:00 am - 11:50 am Colin C. Adams
LEC Section: 02 MWF 10:00 am - 10:50 am Colin C. Adams

MATH 200 (F) Discrete Mathematics (QFR)
Course Description: In contrast to calculus, which is the study of continuous processes, this course examines the structure and properties of finite sets. Topics to be covered include mathematical logic, elementary number theory, mathematical induction, set theory, functions, relations, elementary combinatorics and probability, graphs and trees, and algorithms. Emphasis will be given on the methods and styles of mathematical proofs, in order to prepare the students for more advanced math courses.
Class Format: lecture/discussion
Requirements/Evaluation: evaluation will be based primarily on homework and exams
Prerequisites: MATH 140 or MATH 130 with CSCI 134 or 135; or one year of high school calculus with permission of instructor; students who have taken a 300-level math course should obtain permission of the instructor before enrolling
Enrollment Limit: 40
Expected Class Size: 25
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 02 MWF 10:00 am - 10:50 am Ralph E. Morrison
LEC Section: 01 MWF 9:00 am - 9:50 am Ralph E. Morrison

Spring 2019
LEC Section: 01 MWF 10:00 am - 10:50 am Leo Goldmakher
LEC Section: 02 MWF 11:00 am - 11:50 am Leo Goldmakher

MATH 210 (S) Mathematical Methods for Scientists (QFR)
Crosslistings: PHYS210 / MATH210
Secondary Crosslisting
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:** lecture, three hours per week

**Requirements/Evaluation:** evaluation will be based on 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

**Expected Class Size:** 30

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

Spring 2019

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

**MATH 250 (F) 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.

**Class Format:** lecture

**Requirements/Evaluation:** evaluation will be based primarily on homework and exams

**Prerequisites:** MATH 150/151 or MATH 200

**Enrollment Limit:** 45

**Expected Class Size:** 35

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

**Attributes:** COGS Related Courses;

Fall 2018

LEC Section: 01    TF 1:10 pm - 2:25 pm    Haydee M. A. Lindo

LEC Section: 02    TF 2:35 pm - 3:50 pm    Haydee M. A. Lindo

Spring 2019

LEC Section: 01    MWF 10:00 am - 10:50 am    Thomas A. Garrity

LEC Section: 02    MWF 11:00 am - 11:50 am    Thomas A. Garrity

**MATH 307 (F) 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; and Monte Carlo techniques. This course could also be considered a course in numerical analysis or computational science.

**Class Format:** lecture

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

**Extra Info:** may not be taken on a pass/fail basis

**Prerequisites:** Math 250, some elementary computer programming experience is strongly recommended

**Enrollment Limit:** 30

**Enrollment Preferences:** Professor's discretion
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 include numerical solutions, separation of variables, integrating factors, constant coefficient linear equations, and power series solutions. Later, we focus on nonlinear ODE, for which it is usually impossible to find analytical solutions. Tools from dynamical systems allows us to obtain some information about the behavior of the ODE without explicitly knowing the solution.

Class Format: lecture, discussion, interactive activities
Requirements/Evaluation: quizzes/exams, problem sets, activities
Extra Info: may not be taken on a pass/fail basis
Prerequisites: MATH 150/151 and MATH 250
Enrollment Limit: 30
Enrollment Preferences: Professor's discretion
Expected Class Size: 30
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01    TR 11:20 am - 12:35 pm    Chad M. Topaz

MATH 310 (S)  Mathematical Biology  (QFR)
Crosslistings: MATH310 / BIOL210
Primary Crosslisting
This course will provide an introduction to the many ways in which mathematics can be used to understand, analyze, and predict biological dynamics. We will learn how to construct mathematical models that capture essential properties of biological processes while maintaining analytic tractability. Analytic techniques, such as stability and bifurcation analysis, will be introduced in the context of both continuous and discrete time models. Additionally, students will couple these analytic tools with numerical simulation to gain a more global picture of the biological dynamics. Possible biological applications include, but are not limited to, single and multi-species population dynamics, neural and biological oscillators, tumor cell growth, and infectious disease dynamics.

Class Format: tutorial
Requirements/Evaluation: problem sets, weekly meetings, final project and paper
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: MATH 250, MATH 209 or 309, permission of instructor
Enrollment Limit: 10
Enrollment Preferences: if over-enrolled, will have students submit reasons for taking class; preference to those with interest in both subjects
Expected Class Size: 10
Distributions: (D3) (QFR)
Distribution Notes: QFR: The course will introduce methods for developing and analyzing mathematical models.
Attributes: PHLH Methods in Public Health;

Spring 2019
TUT Section: T1    TBA    Julie C. Blackwood
MATH 313 (F) Introduction to Number Theory (QFR)
The study of numbers dates back thousands of years, and is fundamental in mathematics. In this course, we will investigate both classical and modern questions about numbers. In particular, we will explore the integers, and examine issues involving primes, divisibility, and congruences. We will also look at the ideas of number and prime in more general settings, and consider fascinating questions that are simple to understand, but can be quite difficult to answer.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on performance on homework, projects, and examinations
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 40
Expected Class Size: 25
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01  MR 2:35 pm - 3:50 pm  Leo Goldmakher

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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based on problem sets, midterms, a paper and a final exam
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Expected Class Size: 25
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01  MWF 8:30 am - 9:45 am  Colin C. Adams

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

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homework, classwork, and exams
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30

Enrollment Preferences: members or alternates of the Putnam team, Mathematics, Physics or Computer Science majors
Expected Class Size: 25
Department Notes: http://web.williams.edu/Mathematics/sjmiller/public_html/331/
Distributions: (D3) (QFR)
MATH 334 (S) Graph Theory (QFR)

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

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on problem sets and exams
Prerequisites: MATH 200 or MATH 250
Enrollment Limit: 35
Enrollment Preferences: Math majors
Expected Class Size: 20
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01 TR 9:55 am - 11:10 am Ralph E. Morrison

MATH 341 (F) Probability (QFR)
Crosslistings: STAT341 / MATH341

Primary Crosslisting

While probability began with a study of games, it has grown to become a discipline with numerous applications throughout mathematics and the sciences. Drawing on gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables, expectation, independence, laws of large numbers, and the Central Limit Theorem. Many interesting and important applications will also be presented, potentially including some from coding theory, number theory and nuclear physics.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homework, classwork, and exams
Prerequisites: MATH 250 or permission of the instructor
Enrollment Limit: 40
Expected Class Size: 20
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01 MWF 11:00 am - 11:50 am Steven J. Miller

Spring 2019
LEC Section: 01 MWF 9:00 am - 9:50 am Thomas A. Garrity

MATH 350 (F) Real Analysis (QFR)

Real analysis is the theory behind calculus. It is based on a precise understanding of the real numbers, elementary topology, and limits. Topologically, nice sets are either closed (contain their limit points) or open (complement closed). You also need limits to define continuity, derivatives, integrals, and to understand sequences of functions.

Class Format: lecture/discussion
Requirements/Evaluation: evaluation will be based on homework, classwork, and exams
Prerequisites: MATH 150 or MATH 151 and MATH 250, or permission of instructor
Enrollment Limit: 40
Expected Class Size: 30
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01  TF 2:35 pm - 3:50 pm  Leo Goldmakher

Spring 2019
LEC Section: 01  MWF 10:00 am - 10:50 am  Cesar E. Silva

**MATH 351 (F) Applied Real Analysis**  (QFR)
Real analysis or the theory of calculus—derivatives, integrals, continuity, convergence—starts with a deeper understanding of real numbers, limits, and some topology. Applications of Real Analysis involve questions of existence and uniqueness of solutions, implicit definition of functions, infinite dimensional function spaces, and tools from calculus of variations to construct optimal controls and minimizing curves and surfaces.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on exams, homework and quizzes
Prerequisites: MATH 150 and MATH 250, or permission of instructor
Enrollment Limit: 50
Expected Class Size: 20
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01  MWF 9:00 am - 9:50 am  Stewart D. Johnson

**MATH 355 (F) 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.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on problem sets and exams
Prerequisites: MATH 250 or permission of instructor
Enrollment Limit: 30
Expected Class Size: 25
Distributions: (D3) (QFR)

Fall 2018
LEC Section: 01  MWF 10:00 am - 10:50 am  Susan R. Loepp

Spring 2019
LEC Section: 01  TR 9:55 am - 11:10 am  Allison Pacelli
LEC Section: 02  TR 11:20 am - 12:35 pm  Allison Pacelli

**MATH 361 (F) Theory of Computation**  (QFR)
Crosslistings: CSCI361 / MATH361
Secondary Crosslisting
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

**Requirements/Evaluation:** evaluation will be based on problem sets, a midterm examination, and a final examination

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

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

**Enrollment Limit:** 34

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

**Expected Class Size:** 34

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

**Attributes:** COGS Interdepartmental Electives;

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Fall 2018

LEC Section: 01  MWF 12:00 pm - 12:50 pm  Thomas P. Murtagh

LEC Section: 02  MWF 11:00 am - 11:50 am  Thomas P. Murtagh

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**MATH 374 (F) Topology** (QFR)

Topology is the study of when one geometric object can be continuously deformed and twisted into another object. Determining when two objects are topologically the same is incredibly difficult and is still the subject of a tremendous amount of research, including recent work on the Poincaré Conjecture, one of the million-dollar millennium-prize problems. The main part of the course on point-set topology establishes a framework based on "open sets" for studying continuity and compactness in very general spaces. The second part on homotopy theory develops refined methods for determining when objects are the same. We will prove for example that you cannot twist a basketball into a doughnut.

**Class Format:** lecture

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

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** MATH 350 or 351; not open to students who have taken MATH 323

**Enrollment Limit:** 30

**Expected Class Size:** 10

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

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Fall 2018

LEC Section: 01  MWF 10:00 am - 10:50 am  Andrew Bydlon

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**MATH 402 (S) Measure Theory and Probability** (QFR)

The study of measure theory arose from the study of stochastic (probabilistic) systems. Applications of measure theory lie in biology, chemistry, physics as well as in economics. In this course, we develop the abstract concepts of measure theory and ground them in probability spaces. Included will be Lebesgue and Borel measures, measurable functions (random variables). Lebesgue integration, distributions, independence, convergence and limit theorems. This material provides good preparation for graduate studies in mathematics, statistics and economics.

**Class Format:** lecture/discussion

**Requirements/Evaluation:** evaluation will be based primarily on performance on homework assignments and exams

**Prerequisites:** MATH 350 or MATH 351 or permission of instructor

**Enrollment Limit:** 40

**Expected Class Size:** 30

**Distributions:** (D3) (QFR)
MATH 403 (S) Measure and Ergodic Theory (QFR)
An introduction to measure theory and ergodic theory. Measure theory is a generalization of the notion of length and area, has been used in the study of stochastic (probabilistic) systems. The course covers the construction of Lebesque and Borel measures, measurable functions, and Lebesque integration. Ergodic theory studies the probabilistic behavior of dynamical systems as they evolve through time, and is based on measure theory. The course will cover basic notions, such as ergodic transformations, weak mixing, mixing, and Bernoulli transformations, and transformations admitting and not admitting an invariant measure. There will be an emphasis on specific examples such as group rotations, the binary odometer transformations, and rank-one constructions. The Ergodic Theorem will also be covered, and will be used to illustrate notions and theorems from measure theory.

Class Format: lecture
Requirements/Evaluation: homework and exams
Prerequisites: MATH 350 or MATH 351 or permission of instructor
Enrollment Limit: 25
Enrollment Preferences: Mathematics majors
Expected Class Size: 15-20
Department Notes: senior major course
Distributions: (D3) (QFR)

MATH 407 (F) Dance of the Primes (QFR)
Prime numbers are the building blocks for all numbers and hence for most of mathematics. Though there are an infinite number of them, how they are spread out among the integers is still quite a mystery. Even more mysterious and surprising is that the current tools for investigating prime numbers involve the study of infinite series. Function theory tells us about the primes. We will be studying one of the most amazing functions known: the Riemann Zeta Function. Finding where this function is equal to zero is the Riemann Hypothesis and is one of the great, if not greatest, open problems in mathematics. Somehow where these zeros occur is linked to the distribution of primes. We will be concerned with why anyone would care about this conjecture. More crassly, why should solving the Riemann Hypothesis be worth one million dollars? (Which is what you will get if you solve it, beyond the eternal fame and glory.)

Class Format: lecture
Requirements/Evaluation: exams and weekly homework assignments
Prerequisites: MATH 350 or MATH 351, and MATH 355
Enrollment Limit: 30
Enrollment Preferences: seniors
Expected Class Size: 10
Distributions: (D3) (QFR)
Distribution Notes: QFR: It is a math course

MATH 411 (S) 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. Possible topics include Noetherian rings, primary
decomposition, localizations and quotients, height, dimension, basic module theory, and the Krull Altitude Theorem.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on homework and exams

Prerequisites: MATH 355 or permission of instructor

Enrollment Limit: 30

Expected Class Size: 15

Distributions: (D3) (QFR)

Spring 2019

LEC Section: 01    MWF 10:00 am - 10:50 am     Andrew Bydlon

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

Class Format: discussion, research

Requirements/Evaluation: writing assignments, modeling activities, presentations, research project

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Enrollment Limit: 24

Enrollment Preferences: Professor's discretion

Expected Class Size: 20

Distributions: (D3) (QFR)

Fall 2018

LEC Section: 01    TR 11:20 am - 12:35 pm     Chad M. Topaz

MATH 458 (S) Algebraic Combinatorics (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. This course will focus on the study of symmetric functions, young tableaux, matroids, graph theory, and other related topics.

Class Format: seminar

Requirements/Evaluation: homework assignments, proof portfolio, individual and group projects

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: MATH 200 and MATH 355

Enrollment Limit: 25

Enrollment Preferences: seniors

Expected Class Size: 20

Distributions: (D3) (QFR)

Distribution Notes: QFR: Mathematics course in the area of algebraic combinatorics

Spring 2019

SEM Section: 01    TR 8:30 am - 9:45 am     Pamela E. Harris
MATH 459 (S)  Applied Partial Differential Equations  (QFR)

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

Class Format: tutorial
Requirements/Evaluation: participation, problem sets, oral presentations, oral exams, and a final project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: MATH 209 or MATH/PHYS 210 or MATH 309 or permission of instructor
Enrollment Limit: 10
Enrollment Preferences: students with an interest in applied mathematics, selected to create a diverse set of tutorial participants
Expected Class Size: 10
Department Notes: students who have taken MATH 453 may not enroll in MATH 458T without permission of the instructor
Distributions: (D3) (QFR)
Distribution Notes: QFR: This tutorial involves regular and substantial problem sets in which quantitative/formal reasoning skills are practiced and evaluated.

Spring 2019
TUT Section: T1    TBA    Chad M. Topaz

MATH 487 (S)  Computational Algebraic Geometry  (QFR)

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

Class Format: lecture
Requirements/Evaluation: evaluation will be based on homework, exams, and final project
Extra Info: may not be taken on a pass/fail basis
Prerequisites: MATH 355
Enrollment Limit: 40
Enrollment Preferences: instructor decision
Expected Class Size: 15
Department Notes: This course is not a senior seminar, and so it does not fulfill the senior seminar requirement for the math major
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01    TR 8:30 am - 9:45 am    Ralph E. Morrison

PHIL 203 (S)  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: lecture/discussion
Requirements/Evaluation: a midterm, a final, frequent homework and problem sets
Prerequisites: none
Enrollment Limit: none
Expected Class Size: 50-80
Distributions: (D2) (QFR)
Attributes: Linguistics; PHIL Contemp Metaphysics & Epistemology Courses;

Spring 2019
LEC Section: 01 MWF 10:00 am - 10:50 am Steven B. Gerrard

PHIL 312 (S) Philosophical Implications of Modern Physics (QFR)
Crosslistings: PHIL312 / SCST312 / PHYS312
Secondary Crosslisting
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.
Class Format: lecture
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
Distributions: (D2) (QFR)
Distribution Notes: meets the Division 2 requirement if registration is under PHIL or SCST; Division 3 requirement if registration under PHYS
Attributes: PHIL Contemp Metaphysics & Epistemology Courses;

Spring 2019
LEC Section: 01 TR 11:20 am - 12:35 pm Frederick W. Strauch, Keith E. McPartland

PHYS 108 (F) Energy Science and Technology (QFR)
Crosslistings: ENVI108 / PHYS108
Primary Crosslisting
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: lecture twice a week, occasional lab exercises, and a field trip to the college heating plant, all during class hours
Requirements/Evaluation: evaluation will be based on 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
Fall 2018

LEC Section: 01    MR 1:10 pm - 2:25 pm    Kevin M. Jones

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.

Class Format: lecture, three hours per week; laboratory, three hours approximately every other week

Requirements/Evaluation: evaluation will be based on 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: 24/lab

Department 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)

Spring 2019

LEC Section: 01    MWF 11:00 am - 11:50 am    Savan Kharel

LAB Section: 03    T 1:00 pm - 4:00 pm    Savan Kharel

LAB Section: 02    M 1:00 pm - 4:00 pm    Savan Kharel

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; conference section 1 hour approximately every other week

Requirements/Evaluation: evaluation will be based on 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

Expected Class Size: 60

Distributions:  (D3) (QFR)
PHYS 141 (F) Mechanics and Waves  (QFR)
This is the typical first course for a prospective physics major. It covers 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: evaluation will be based on weekly problem sets, labs, 2 one-hour tests, and a final exam, all of which have a substantial quantitative component

Prerequisites: high school physics and MATH 130 or equivalent placement

Enrollment Limit: 22 per lab

Expected Class Size: 50

Department 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)

Fall 2018
LEC Section: 01  MWF 11:00 am - 11:50 am  Katharine E. Jensen
LAB Section: 04  W 1:00 pm - 4:00 pm  Katharine E. Jensen
LAB Section: 02  M 1:00 pm - 4:00 pm  Katharine E. Jensen
LAB Section: 03  T 1:00 pm - 4:00 pm  Katharine E. Jensen

PHYS 142 (S) Foundations of Modern Physics  (QFR)
Newtonian Mechanics, spectacular as it is in describing planetary motion and a wide range of other phenomena, only hints at the richness of behaviors seen in the universe. Special relativity, which extends physics into the realm of high speeds and high energies, requires 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, alternating between three hours and one hour approximately every other week

Requirements/Evaluation: evaluation will be based on weekly homework, labs, two hour tests, and a final exam, all of which have a substantial quantitative component

Prerequisites: PHYS 141 and MATH 130 (formerly 103), 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: 18 per CON

Expected Class Size: 30

Department Notes: Limit: 22 per lab, 18 per conference section

Distributions: (D3) (QFR)

Spring 2019
CON Section: 02  F 11:00 am - 11:50 am  Charlie Doret
CON Section: 03  F 12:00 pm - 12:50 pm  Charlie Doret
LAB Section: 04  M 1:00 pm - 4:00 pm  Charlie Doret
LEC Section: 01  MW 11:00 am - 11:50 am  Charlie Doret
LAB Section: 05  T 1:00 pm - 4:00 pm  Charlie Doret
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 basic material as PHYS 142 but in a small seminar format for students with strong prior preparation in physics.

**Class Format:** lecture/discussion, three hours per week; laboratory, 3 hours approximately every other week; conference section 1 hour approximately every other week

**Requirements/Evaluation:** evaluation will be based on class participation, labs, weekly problem sets, an oral presentation, two hour-exams and a final exam, all of which have a substantial quantitative component

**Extra Info:** this is a small seminar designed for first-year students who have placed out of PHYS 141

**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

**Expected Class Size:** 18

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

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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:** evaluation will be based on problem sets, labs, 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:** 20 per lab

**Expected Class Size:** 25

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

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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:** evaluation will be based on problem sets, labs, two one-hour 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:** none

**Expected Class Size:** 20

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

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

Crosslistings: PHYS210 / MATH210

**Primary Crosslisting**

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:** lecture, three hours per week

**Requirements/Evaluation:** evaluation will be based on 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

**Expected Class Size:** 30

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

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

This course serves as a one-semester introduction to the history, formalism, and phenomenology of quantum mechanics. We begin with a discussion of the historical origins of the quantum theory, and the Schroedinger wave equation. The concepts of matter waves and wave-packets are introduced. Solutions to one-dimensional problems will be treated prior to introducing the system which serves as a hallmark of the success of quantum theory, the three-dimensional hydrogen atom. In the second half of the course, we will develop the important connection between the underlying mathematical formalism and the physical predictions of the quantum theory and introduce the Heisenberg formalism. We then go on to apply this knowledge to several important problems within the realm of atomic and nuclear physics concentrating on applications involving angular momentum and spins.

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

**Requirements/Evaluation:** evaluation will be based on weekly problem sets, labs, a midterm exam, and final exam, all of which have a substantial quantitative component
**Prerequisites:** PHYS 202 and PHYS/MATH 210 or MATH 209

**Enrollment Limit:** none

**Expected Class Size:** 15

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

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**PHYS 302 (S) Stat 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; laboratory, three hours per week

**Requirements/Evaluation:** evaluation will be based on weekly problem sets, exams, and labs, all of which have a substantial quantitative component

**Prerequisites:** required: PHYS 201, PHYS/MATH 210 or MATH 209; recommended: PHYS 202, PHYS 301

**Enrollment Limit:** 24

**Expected Class Size:** 15

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

**Attributes:** BGNP Related Courses;

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

Crosslistings: PHIL312 / SCST312 / PHYS312

**Primary Crosslisting**

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.

**Class Format:** lecture

**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

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

**Distribution Notes:** meets the Division 2 requirement if registration is under PHIL or SCST; Division 3 requirement if registration under PHYS

**Attributes:** PHIL Contemp Metaphysics & Epistemology Courses;
PHYS 402 (S) Applications of Quantum Mechanics (QFR)
This course will explore a number of important topics in the application of quantum mechanics to physical systems, including perturbation theory, the variational principle and the semiclassical interaction of atoms and radiation. The course will finish up with three weeks on quantum optics including an experimental project on non-classical interference phenomena. Applications and examples will be taken mostly from atomic physics with some discussion of solid state systems.
Class Format: tutorial, 1 and 1/4 hours per week; lecture, one hour per week
Requirements/Evaluation: evaluation will be based on weekly problem sets, tutorial participation, presentations, and a final exam, all of which have a substantial quantitative component
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: PHYS 301
Enrollment Limit: 10 per sec
Expected Class Size: 16
Distributions: (D3) (QFR)

Spring 2019
TUT Section: T1  F 1:10 pm - 2:25 pm  Catherine Kealhofer
TUT Section: T2  F 1:10 pm - 2:25 pm  Catherine Kealhofer

PHYS 411 (F) Classical Mechanics (QFR)
This course will explore advanced topics in classical mechanics including the calculus of variations, the Lagrangian and Hamiltonian formulations of mechanics, phase space, non-linear dynamics and chaos, central-force motion, non-inertial reference frames (including implications for physics on a rotating Earth), and rigid-body rotations. Numerical and perturbative techniques will be developed and used extensively. We will also examine the ways in which classical mechanics informs other fields of physics. In addition to weekly tutorial meetings the class will meet once a week as a whole to discuss new material.
Class Format: tutorial, 1 and 1/4 hours per week; lecture, one hour per week
Requirements/Evaluation: evaluation will be based on weekly problem sets, tutorial participation, presentations, a final project, and a final exam, all of which have a substantial quantitative component
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: PHYS 202 and PHYS/MATH 210 or MATH 209
Enrollment Limit: 10/section
Expected Class Size: 25
Distributions: (D3) (QFR)

Fall 2018
TUT Section: T1  F 1:10 pm - 2:25 pm  Daniel P. Aalberts
TUT Section: T2  F 1:10 pm - 2:25 pm  Daniel P. Aalberts

PHYS 451 (S) Condensed Matter Physics (QFR)
Condensed matter physics is an important area of current research and serves as the basis for modern electronic technology. We plan to explore the physics of metals, insulators, semiconductors, superconductors, and photonic crystals, with particular attention to structure, thermal properties, energy bands, and electronic properties.
Class Format: seminar
Requirements/Evaluation: weekly readings and problem sets, and exams
**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.

**Class Format:** lecture/discussion

**Requirements/Evaluation:** problem sets, group projects, and three exams

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

**Enrollment Limit:** 25

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

**Expected Class Size:** 15

**Department 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)

**Attributes:** EVST Methods Courses; PHLH Statistics Courses; POEC Required Courses;

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**PSYC 201 (F) 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.

**Class Format:** lecture/lab

**Requirements/Evaluation:** papers, exams, and problem sets

**Extra Info:** two sections; must register for the lab and lecture with the same instructor

**Extra Info 2:** may not be taken on a pass/fail basis

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

**Enrollment Limit:** 22

**Enrollment Preferences:** Psychology majors

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

**Attributes:** COGS Related Courses; PHLH Statistics Courses;
SCST 312 (S) Philosophical Implications of Modern Physics  (QFR)

Crosslistings: PHIL312 / SCST312 / PHYS312

Secondary Crosslisting

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.

Class Format: lecture

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

Distributions: (D2) (QFR)

Distribution Notes: meets the Division 2 requirement if registration is under PHIL or SCST; Division 3 requirement if registration under PHYS

Attributes: PHIL Contemp Metaphysics & Epistemology Courses;

Spring 2019

LEC Section: 01  TR 11:20 am - 12:35 pm  Frederick W. Strauch,  Keith E. McPartland

STAT 101 (F)  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.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on performances on quizzes and exams

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: MATH 102 (or demonstrated proficiency on a diagnostic test)

Enrollment Limit: 50

Expected Class Size: 40

Department Notes: Students with calculus background and social science interest should consider STAT 161. Students with MATH 150 should enroll in STAT 201. Students with a 5 on AP Stats should enroll in STAT 202. Students with a 4 on AP Stat should consult the department.
Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses; COGS Related Courses; PHLH Statistics Courses;

Fall 2018
LEC Section: 02    MWF 10:00 am - 10:50 am     Xizhen Cai
LEC Section: 01    MWF 9:00 am - 9:50 am     Xizhen Cai

Spring 2019
LEC Section: 01    MWF 11:00 am - 11:50 am     Xizhen Cai

STAT 161 (F) 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.

Class Format: lecture

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

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

Department Notes: Students with MATH 150 should consider STAT 201. Students with a 5 on AP Stats should enroll in STAT 202. Students with a 4 on AP Stats should consult the department. Students without any calculus background should consider STAT 101.

Distributions: (D3) (QFR)

Distribution Notes: QFR: It is a quantitative course

Fall 2018
LEC Section: 01    TF 1:10 pm - 2:25 pm     Richard D. De Veaux

Spring 2019
LEC Section: 01    TF 1:10 pm - 2:25 pm     Richard D. De Veaux

STAT 201 (F) 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.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on performance on quizzes and exams

Prerequisites: MATH 150 or equivalent. Not open to students who have completed STAT 101 or STAT 161 or equivalent.

Enrollment Limit: 40

Expected Class Size: 40

Department Notes: Students with a 5 on AP Stats should enroll in STAT 202. Students with a 4 on AP Stats should consult the department. Students with MATH 130/140 background should consider STAT 161. Students with no calc. should consider STAT 101.

Distributions: (D3) (QFR)

Attributes: BGNP Recommended Courses; COGS Related Courses; EVST Methods Courses; PHLH Statistics Courses;
STAT 202 (F) Introduction to Statistical Modeling  (QFR)

Data come from a variety of sources sometimes from planned experiments or designed surveys, but also arise by much 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 as well as its limits to answer questions about the world. We'll emphasize applications over theory and analyze real data sets throughout the course.

Class Format: lecture

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

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: AP Statistics 5 or STAT 101, 161 or 201 or permission of instructor

Enrollment Limit: 25

Expected Class Size: 20

Department Notes: Students with a 4 on the AP Stats exam should contact the department for proper placement.

Distributions: (D3) (QFR)

Attributes: EVST Methods Courses; PHLH Statistics Courses;

STAT 341 (F) Probability  (QFR)

Crosslistings: STAT341 / MATH341

Secondary Crosslisting

While probability began with a study of games, it has grown to become a discipline with numerous applications throughout mathematics and the sciences. Drawing on gaming examples for motivation, this course will present axiomatic and mathematical aspects of probability. Included will be discussions of random variables, expectation, independence, laws of large numbers, and the Central Limit Theorem. Many interesting and important applications will also be presented, potentially including some from coding theory, number theory and nuclear physics.

Class Format: lecture

Requirements/Evaluation: evaluation will be based primarily on homework, classwork, and exams

Prerequisites: MATH 250 or permission of the instructor

Enrollment Limit: 40

Expected Class Size: 20

Distributions: (D3) (QFR)
STAT 344 (F)  Statistical Design of Experiments  (QFR)
What does statistics have to do with designing and carrying out experiments? The answer is, surprisingly perhaps, a great deal. In this course, we will study how to design experiments with the fewest number of observations possible that are still capable of understanding which factors influence the results. After reviewing basic statistical theory and two sample comparisons, we cover one and two-way ANOVA and (fractional) factorial designs extensively. The culmination of the course will be a project where each student designs, carries out, analyzes, and presents an experiment of interest to him or her. Throughout the course, we will use both the statistics program R and the package JMP to carry out the statistical analyses.

Class Format: lecture
Requirements/Evaluation: problem sets, midterm, final exam, project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 201, 202, or equivalent
Enrollment Limit: 20
Enrollment Preferences: Statistics majors, seniors
Expected Class Size: 15
Distributions: (D3) (QFR)
Attributes: COGS Related Courses;

Fall 2018
LEC Section: 01  TF 2:35 pm - 3:50 pm  Richard D. De Veaux

STAT 346 (F)  Regression and Forecasting  (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 standard method for analyzing continuous response data and their relationship with explanatory variables. This course provides both theoretical and practical training in statistical modeling with particular emphasis on simple linear and multiple regression, using R to develop and diagnose models. The course covers the theory of multiple regression and diagnostics from a linear algebra perspective with emphasis on the practical application of the methods to real data sets. The data sets will be taken from a wide variety of disciplines.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on performance on exams, homework, and a project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 201 or 202, and MATH 150 and 250; or permission of instructor
Enrollment Limit: 22
Expected Class Size: 15
Distributions: (D3) (QFR)
Attributes: EVST Methods Courses;

Fall 2018
LEC Section: 01  TF 1:10 pm - 2:25 pm  Laurie L. Tupper

Spring 2019
LEC Section: 01  TF 2:35 pm - 3:50 pm  Laurie L. Tupper

STAT 355 (S)  Multivariate Statistical Analysis  (QFR)
To better understand complex processes, we study how variables are related to one another, and how they work in combination. Therefore, we want to make inferences about more than one variable at time? Elementary statistical methods might not apply. In this course, we study the tools and the intuition that are necessary to analyze and describe such data sets. Topics covered will include data visualization techniques for high dimensional data sets, parametric and non-parametric techniques to estimate joint distributions, techniques for combining variables, as well as classification and clustering algorithms.
Class Format: lecture  
Requirements/Evaluation: evaluation will be based on homework and exams  
Prerequisites: MATH 250, and STAT 346 or permission of instructor  
Enrollment Limit: 25  
Expected Class Size: 10  
Distributions: (D3) (QFR)

Spring 2019  
LEC Section: 01  MWF 8:30 am - 9:45 am  Xizhen Cai

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: lecture  
Requirements/Evaluation: evaluation will be based on problem sets and exams  
Extra Info: may not be taken on a pass/fail basis  
Prerequisites: MATH 250, STAT 201 or 202, STAT 341  
Enrollment Limit: 30  
Enrollment Preferences: Statistics majors  
Expected Class Size: 30  
Distributions: (D3) (QFR)

Spring 2019  
LEC Section: 01  TR 9:55 am - 11:10 am  Daniel B. Turek

STAT 365 (F) Bayesian Statistics (QFR)  
The Bayesian approach to statistical inference represents a reversal of traditional (or frequentist) inference, in which data are viewed as being fixed and model parameters as unknown quantities. Interest and application of Bayesian methods have exploded in recent decades, being facilitated by recent advances in computational power. We begin with an introduction to Bayes' Theorem, the theoretical underpinning of Bayesian statistics which dates back to the 1700's, and the concepts of prior and posterior distributions, conjugacy, and closed-form Bayesian inference. Building on this, we introduce modern computational approaches to Bayesian inference, including Markov chain Monte Carlo (MCMC), Metropolis-Hastings sampling, and the theory underlying these simple and powerful methods. Students will become comfortable with modern software tools for MCMC using a variety of applied hierarchical modeling examples, and will use R for all statistical computing.  
Class Format: lecture  
Requirements/Evaluation: evaluation will be based on 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: 10  
Distributions: (D3) (QFR)

Fall 2018  
LEC Section: 01  TF 1:10 pm - 2:25 pm  Daniel B. Turek
STAT 372 (S) Longitudinal Data Analysis: Modeling Change over Time (QFR)
This course explores modern statistical methods for drawing scientific inferences from longitudinal data, i.e., data collected repeatedly on experimental units over time. The independence assumption made for most classical statistical methods does not hold with this data structure because we have multiple measurements on each individual. Topics will include linear and generalized linear models for correlated data, including marginal and random effect models, as well as computational issues and methods for fitting these models. We will consider many applications in the social and biological sciences.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on performance on exams, homework, and a project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 201 and STAT 346
Enrollment Limit: 30
Enrollment Preferences: junior and senior Statistics majors
Expected Class Size: 20
Distributions: (D3) (QFR)
Attributes: PHLH Statistics Courses;

Spring 2019
LEC Section: 01 TF 1:10 pm - 2:25 pm Anna M. Plantinga

STAT 442 (S) Statistical Learning and Data Mining (QFR)
In both science and industry today, the ability to collect and store data can outpace our ability to analyze it. Traditional techniques in statistics are often unable to cope with the size and complexity of today's data bases and data warehouses. New methodologies in Statistics have recently been developed, designed to address these inadequacies, emphasizing visualization, exploration and empirical model building at the expense of traditional hypothesis testing. In this course we will examine these new techniques and apply them to a variety of real data sets.

Class Format: lecture
Requirements/Evaluation: evaluation will be based primarily on homeworks and projects
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 346 or permission of instructor
Enrollment Limit: 14
Enrollment Preferences: seniors and Statistics Majors
Expected Class Size: 10
Distributions: (D3) (QFR)

Spring 2019
LEC Section: 01 TF 2:35 pm - 3:50 pm Richard D. De Veaux

STAT 458 (F) Spatio-Temporal Data (QFR)
Everything happens somewhere and sometime. But the study of data collected over multiple times and locations requires special methods, due to the dependence structure that relates different observations. In this course, we'll look at exploring, analyzing, and modeling this kind of information--introducing standard methods for purely time-series and purely spatial data, and moving on to methods that incorporate space and time together. Topics will include autocovariance structures, empirical orthogonal functions, and an introduction to Bayesian hierarchical modeling. We'll use R to apply these techniques to real-world datasets.

Class Format: lecture
Requirements/Evaluation: project work, homework, exams, and contribution to discussion.
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: STAT 346, or permission of instructor
Enrollment Limit: 14

Enrollment Preferences: Seniors and Statistics majors

Expected Class Size: 10

Distributions: (D3) (QFR)

Distribution Notes: This is an intensive statistics course, involving theoretical and mathematical reasoning as well as the application of mathematical ideas to data using software.

Fall 2018
LEC Section: 01   TF 2:35 pm - 3:50 pm   Laurie L. Tupper

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