PHYSICS (DIV III)
Chair: Professor DAVID TUCKER-SMITH

Professors: D. AALBERTS***, K. JONES*, P. MAJUMDER*, J. STRAIT, D. TUCKER-SMITH, W. WOOTTERS. Associate Professor: F. STRAUCH. Assistant Professors: C. DORET, C. KEALHOFER, S. SINGH. Laboratory Supervisor: K. FORKEY. Assistant Laboratory Instructor: P. WICKRAMARACHCHI.

What is light? How does a laser work? What is a black hole? What are the fundamental building blocks of the universe? Physics majors and Astrophysics majors study these and related questions to understand the physical world around us, from the very small to the very large. A physics student practices the experimental methods used to learn about this world and explores the mathematical techniques and theories developed to explain these physical phenomena. A Physics major or Astrophysics major serves as preparation for further work in physics, astrophysics, applied physics, other sciences, engineering, medical research, science teaching and writing, and other careers involving critical thinking, problem-solving, and insight into the fundamental principles of nature.

ASTROPHYSICS MAJOR
The Physics Department, in cooperation with the Astronomy Department, offers a major in astrophysics consisting of (at least): 6 or 7 courses in Physics, 3 or 4 in Astronomy, and 1 in Mathematics. The core sequence of the Astrophysics major is the same as the Physics major described below (except that Physics 302, although strongly recommended, is not required). Students intending to pursue graduate study in astrophysics will need to take upper-level physics electives beyond the basic requirements for the major. Honors work in Astrophysics may be in either physics or astronomy. Students majoring in Astrophysics are expected to consult early and often with faculty from both departments in determining their course selections. The detailed description of the Astrophysics major is given under "Astronomy," along with a description of the Astronomy major also offered by that department.

PHYSICS MAJOR
Introductory Courses
Students considering a major in physics should take both physics and mathematics as first-year students. A student normally begins with either Physics 131 or Physics 141:

Physics 131 Introduction to Mechanics. This is designed as a first course in physics. It is suitable for students who either have not had physics before or have had some physics but are not comfortable solving "word problems" that require calculus.

Physics 141 Mechanics and Waves. Students in this course should have solid backgrounds in science and calculus, either from high school or college, including at least a year of high school physics.

The Department of Mathematics will place students in the appropriate introductory calculus course. The physics major sequence courses all make use of calculus at increasingly sophisticated levels. Therefore, students considering a Physics major should continue their mathematical preparation without interruption through the introductory calculus sequence (Mathematics 130, 140, and 150 or 151). Students are encouraged to take Physics 210 as early as possible. Physics 210 is cross listed as Mathematics 210 for the benefit of those students who wish to have the course listed with a MATH prefix.

ADVANCED PLACEMENT
Students with unusually strong backgrounds in calculus and physics may place out of Physics 141 and either: 1) begin with the special seminar course Physics 151 in the fall (typically followed by Physics 210 in the spring), or 2) begin with Physics 142 in the spring (possibly along with Physics 210). Students may take either 151 or 142 but not both. On rare occasions a student with an exceptional background will be offered the option of enrolling in Physics 201.
Placement is based on AP scores, consultation with the department, and results of a placement exam administered during First Days. The exam can also be taken later in the year by arrangement with the department chair. The exam covers classical mechanics, basic wave phenomena, and includes some use of calculus techniques.

REQUIREMENTS FOR THE MAJOR
A total of ten courses in physics and mathematics are required to complete the Physics major. Students who place out of both Physics 141 and Physics 142 and begin their studies in Physics 201 are required to take a total of nine courses.

Required Physics Sequence Courses
Physics 141 Mechanics and Waves
or Physics 131 Introduction to Mechanics

Physics 142 Foundations of Modern Physics
or Physics 151 Seminar in Modern Physics

Physics 201 Electricity and Magnetism
Physics 202 Waves and Optics
Physics 210 Mathematical Methods for Scientists
Physics 301 Quantum Physics
Physics 302 Statistical Mechanics and Thermodynamics

Required Mathematics Course
Mathematics 150 *or* 151 (formerly 105 or 106) Multivariable Calculus

Students entering with Advanced Placement in mathematics may obtain credit toward the major for the equivalent Mathematics 150 or 151 taken elsewhere.

At least two more physics courses above the 100 level (or other approved courses as noted below) must be taken, bringing the total number of courses for the major to ten.

Options

Mathematics 140 (formerly 104) may be counted if taken at Williams.

Mathematics 209 may substitute for Physics 210.

Astronomy 111 may count in place of Physics 141 if a student places out of 141 (see "advanced placement" above).

An additional Astronomy or Astrophysics course above the introductory level that is acceptable for the astrophysics major may be counted.

Two approved Division III courses above the introductory level may be substituted for one Physics course. Approval is on an individual basis at the discretion of the department chair.

Honors work is in addition to completion of the basic major so Physics 493 and 494 do not count towards the ten courses in the major.

PREPARATION FOR ADVANCED STUDY

Students who may wish to do graduate work in physics, astrophysics, or engineering should elect courses in both physics and mathematics beyond the minimum major requirements. The first-year graduate school curriculum in physics usually includes courses in quantum mechanics, electromagnetic theory, and classical mechanics that presuppose intermediate level study of these subjects as an undergraduate. Therefore, students planning graduate work in physics should elect all of the following courses:

Physics 402T Applications of Quantum Mechanics
Physics 405T Electromagnetic Theory
Physics 411T Classical Mechanics

ADVISING

Both majors and non-majors are encouraged to consult with the department chair or course instructors about course selections or other matters.

THE DEGREE WITH HONORS IN PHYSICS

The degree with honors in Physics will be awarded on the basis of a senior thesis presenting the results of a substantial experimental or theoretical investigation carried out under the direction of a faculty member in the department. There is no rigid grade point average required for admission to the program or for the awarding of the degree with honors, but it is normally expected that honors students will maintain at least a B average in physics and mathematics. Students will normally apply for admission to the program early in the spring of their junior year and during senior year these students will normally elect Physics 493, W31, and 494 in addition to the usual requirements for the major. At the end of winter study, the department will decide whether the student will be admitted to honors candidacy. Both a written thesis and a colloquium presentation of the results are required. The degree with honors will be awarded to those who meet these requirements with distinction. The degree with highest honors will be awarded to those who fulfill them with unusually high distinction.

Honors candidates will also be required to participate in departmental colloquium talks.

STUDY ABROAD

The physics community is international in scope and a career in physics (or a related field) can provide many opportunities for travel and contact with individuals from outside the United States. The physics major at Williams is a carefully structured four-year program designed to prepare students who are so inclined for graduate study at leading research institutions. While it is possible to complete the major requirements in three years, such a major will not usually not lead to further study in the field. With careful early planning on the part of a student, and close consultation with the department chair, it is possible to complete a strong major and still study abroad provided the foreign institution can provide courses which reasonably substitute or supplement those in the Williams major program. You can find general study away guidelines for Physics here.

OPTIONS FOR NON-MAJORS

Many students want to take a self-contained and rigorous full-year survey of physics. For such students, the most appropriate sequence will be either Physics 131 or Physics 141 followed by Physics 132, depending on the student's background in science and mathematics (see Introductory Courses above). Either of these sequences satisfies the physics requirement for medical school.

The department also offers one semester courses designed for non-majors.

PHYS 107 Spacetime and Quanta (Q)

Quantum mechanics and Einstein's relativity both drastically altered our view of the physical world when they were developed in the early twentieth century. In this course we will learn about the central concepts that define relativity and quantum mechanics, along with some of the diverse phenomena the two theories describe. These investigations will prepare us to discuss recent developments in cosmology, where observations have produced a surprising picture for the make-up of our universe, and particle physics, where the Large Hadron Collider continues to extend our understanding of nature to higher energies and shorter distances. This course is intended for students whose primary interests lie outside of the natural sciences and mathematics. The mathematics used will be algebra and trigonometry.

Class Format: lecture twice a week, except five Thursdays when the class will break into two conference sections

Requirements/Evaluation: evaluation will be based on weekly problem sets, quizzes, two midterms, and a final exam, all with a significant quantitative component

Prerequisites: none
Enrollment Preferences: by seniority
Enrollment Limit: 60 total*
Expected Class Size: 50 total*
Dept. Notes: *20 per conference section
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
SCST Related Courses

Not Offered Academic Year 2017
LEC   Instructor: David Tucker-Smith

PHYS 108(F) Energy Science and Technology (Q)
Crosslistings: PHYS 108/ENVI 108
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, except five Thursdays when the class will break into two conference sections
Requirements/Evaluation: evaluation will be based on weekly assignments, two hour tests, and a final project; all of these will be substantially quantitative
Prerequisites: high school physics, high school chemistry, and mathematics at the level of MATH 130
Enrollment Limit: 40
Expected Class Size: 40
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
ENVI Natural World Electives
SCST Related Courses

Fall 2016
LEC Section: 01 M 01:10 PM 02:25 PM Instructor: Jefferson Strait

CON Section: 02 R 01:10 PM 02:25 PM Instructor: Jefferson Strait

CON Section: 03 R 02:35 PM 03:50 PM Instructor: Jefferson Strait

PHYS 109 Sound, Light, and Perception (Q)
Light and sound allow us to perceive the world around us, from appreciating music and art to learning the details of atomic structure. Because of their importance in human experience, light and sound have long been the subject of scientific inquiry. How are sound and light related? How do physiology and neural processing allow us to hear and see the world around us? What are the origins of color and musical pitch? This course introduces the science and technology of light and sound to students not majoring in physics. We will start with the origins of sound and light as wave phenomena, and go on to topics including color, the optics of vision, the meaning of musical pitch and tone, and the physical basis of hearing. We will also discuss some recent technological applications of light, such as lasers and optical communications. The class will meet for two 75-minute periods each week for a variable mixture of lecture, discussion, and hands-on, interactive experiments.
Class Format: lecture/lab/discussion; each student will attend the Friday lecture plus one conference section weekly
Requirements/Evaluation: evaluation will be based on class participation, problem sets, in-class exams, oral presentations, and a final exam, all with a quantitative component
Prerequisites: none
Enrollment Limit: 40
Expected Class Size: 40
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
LEC   Instructor: Protik Majumder

PHYS 131(F) Introduction to Mechanics (Q)
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
Dept. 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)
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Fall 2016
LEC Section: 01   MWF 11:00 AM 11:50 AM   Instructor: William Wootters

LAB Section: 02   M 01:00 PM 04:00 PM   Instructor: William Wootters

LAB Section: 03   T 01:00 PM 04:00 PM   Instructor: William Wootters

LAB Section: 04   W 01:00 PM 04:00 PM   Instructor: William Wootters

LAB Section: 05   R 01:00 PM 04:00 PM   Instructor: William Wootters

PHYS 132(S) Electromagnetism and the Physics of Matter (Q)
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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Spring 2017
LEC Section: 01   MWF 11:00 AM 11:50 AM   Instructor: Charlie Doret

LAB Section: 02   M 01:00 PM 04:00 PM   Instructor: Charlie Doret

LAB Section: 03   T 01:00 PM 04:00 PM   Instructor: Charlie Doret

LAB Section: 04   W 01:00 PM 04:00 PM   Instructor: Charlie Doret

PHYS 141(F) Mechanics and Waves (Q)
This course 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
Dept. 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)
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Fall 2016
LEC Section: 01   MWF 11:00 AM 11:50 AM   Instructor: David Tucker-Smith

LAB Section: 02   M 01:00 PM 04:00 PM   Instructor: David Tucker-Smith

LAB Section: 03   T 01:00 PM 04:00 PM   Instructor: David Tucker-Smith

LAB Section: 04   W 01:00 PM 04:00 PM   Instructor: David Tucker-Smith

PHYS 142(S) Foundations of Modern Physics (Q)

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 will survey some of these important ideas, and can serve either as a terminal course for those seeking to complete a year of physics or can serve as the basis for more advanced study of these topics.
Class Format: lecture, three hours perweek; laboratory, three hours approximately every other week; conference section 1 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; students may not take both PHYS 142 and PHYS 151; PHYS 131 may substitute for PHYS 141 with the permission of instructor
Enrollment Limit: 22 per lab
Expected Class Size: 30
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Spring 2017
LEC Section: 01   MWF 11:00 AM 11:50 AM   Instructor: Frederick Strauch

LAB Section: 02   T 01:00 PM 04:00 PM   Instructor: Jefferson Strait

LAB Section: 03   W 01:00 PM 04:00 PM   Instructor: Jefferson Strait

PHYS 151(F) Seminar in Modern Physics (Q)

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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Fall 2016
LEC Section: 01   MWF 11:00 AM 11:50 AM   Instructor: Daniel Aalberts

LAB Section: 02   W 01:00 PM 04:00 PM   Instructor: Daniel Aalberts

PHYS 201(F) Electricity and Magnetism (Q)

We study electromagnetic phenomena and their mathematical description. Topics include electrostatics, magnetic fields, and electromagnetic induction, DC and AC circuits, and the electromagnetic properties of matter. We also introduce Maxwell's equations, which express the essence of the theory in remarkably succinct form.
Class Format: lecture, three hours per week; laboratory, three hours per week
Requirements/Evaluation: evaluation will be based on problem sets, labs, two hour tests, and a final exam, all of which have a substantial quantitative component
Prerequisites: PHYS 142 OR 151; MATH 150 or 151
Enrollment Limit: none
Expected Class Size: 25
Distributional Requirements:

Division 3
Quantitative/Formal Reasoning
Other Attributes:
MTSC Related Courses

Fall 2016
LEC Section: 01   MWF 10:00 AM 10:50 AM   Instructor: Catherine Kealhofer

LAB Section: 02   T 01:00 PM 04:00 PM   Instructor: Catherine Kealhofer

LAB Section: 03   W 01:00 PM 04:00 PM   Instructor: Catherine Kealhofer

PHYS 202(S) Vibrations, Waves and Optics (Q)
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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
MTSC Related Courses

Spring 2017
LEC Section: 01   MWF 10:00 AM 10:50 AM   Instructor: David Tucker-Smith

LAB Section: 02   T 01:00 PM 04:00 PM   Instructor: David Tucker-Smith

LAB Section: 03   W 01:00 PM 04:00 PM   Instructor: David Tucker-Smith

PHYS 210(S) Mathematical Methods for Scientists (Q)
Crosslistings: PHYS 210/MATH 210
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 weekly problem sets and several in-class exams, 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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
MTSC Related Courses

Spring 2017
LEC Section: 01   TR 09:55 AM 11:10 AM   Instructor: Frederick Strauch

PHYS 231T Facts of Life (Q)
The cancer death rate scales like $(age)^6$ so it was thought that a proliferating cancer cell must have acquired 6 mutations. The probability of having had N sexual partners scales like $N^{2.4}.$ Body Mass Index = Mass / Length^2. The heart rate is proportional to the organism's mass$^{0.75}$. The number of policemen scales like population$^{1.15}$. Power-law relationships often describe emergent phenomena of self-organizing systems.

In this course we will learn how to obtain data and plot it in an informative way, including estimates of the errors of fits. We will learn how to describe phenomena with differential equations and to find analytic and numerical solutions. With those tools we will study the human experience: births, body size, sex, death rates (by cause, by age, by gender), metrics of cities, distributions of common names, population growth rates, per capita use of energy, the spread of disease, etc. Projects will involve applying the methods to new phenomena.
Class Format: tutorial, plus one lecture per week
Requirements/Evaluation: weekly problem sets, projects
Extra Info: may not be taken on a pass/fail basis
Prerequisites: MATH 150
Enrollment Preferences: maturity, curiosity, diversity
Enrollment Limit: 10
Expected Class Size: 10
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
TUT   Instructor: Daniel Aalberts

PHYS 301(F) Quantum Physics (Q)
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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
MTSC Related Courses

Fall 2016
LEC Section: 01   MWF 09:00 AM 09:50 AM   Instructor: Frederick Strauch

LAB Section: 02   W 01:00 PM 04:00 PM   Instructor: Frederick Strauch

LAB Section: 03   R 01:00 PM 04:00 PM   Instructor: Frederick Strauch

PHYS 302(S) Stat Mechanics & Thermodynamics (Q)
Macroscopic objects are made up of huge numbers of fundamental particles interacting in simple ways—obeying the Schrõdinger 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 gasses, polymers, heat engines, 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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
BGNP Related Courses
MTSC Related Courses

Spring 2017
LEC Section: 01   MWF 10:00 AM 10:50 AM   Instructor: Swati Singh

LAB Section: 02   M 01:00 PM 04:00 PM   Instructor: Swati Singh

LAB Section: 03   T 01:00 PM 04:00 PM   Instructor: Swati Singh

PHYS 308 Energy Science and Technology, Advanced Section (Q)
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.
PHYS 308 is an advanced section of PHYS 108 "Energy Science and Technology" and is intended for students who have substantial background in college-level physics. It will include all of the material in PHYS 108, supplemented with more advanced readings and more challenging assignments.
Class Format: lecture once a week plus weekly confernce section
Requirements/Evaluation: weekly assignments, two hour tests, and a final project; all of these will be substantially quantitative
Prerequisites: PHYS 201 and MATH 150 or 151
Enrollment Limit: 20
Expected Class Size: 10
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
LEC

PHYS 312(S) Philosophical Implications of Modern Physics (Q)
Crosslistings: PHYS 312/PHIL 312
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 philosophy or a 100-level course in physics
Enrollment Preferences: Philosophy majors and Physics majors
Enrollment Limit: 20
Expected Class Size: 20
Distribution Notes: meets the Division 2 requirement if registration is under PHIL; Division 3 requirement if registration under PHYS
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
PHIL Contemp Metaphysics & Epistemology Courses

Spring 2017
LEC Section: 01   TR 11:20 AM 12:35 PM   Instructors: William Wootters, Keith McPartland

PHYS 314T Controlling Quanta: Atoms, Electrons, and Photons (Q)
This course will explore modern developments in the control of individual quantum systems. Topics covered will include basic physical theories of atoms coupled to photons, underlying mathematical tools (including Lie algebras and groups), and computational methods to simulate and analyze quantum systems. Applications to quantum computing, teleportation, and experimental metaphysics (Bell's inequality) will also be discussed.
Class Format: tutorial
Requirements/Evaluation: tutorial preparation and participation, weekly problem sets/papers, and a final project
Extra Info: may not be taken on a pass/fail basis
Prerequisites: PHYS/MATH 210 or MATH 209 or MATH 250
Enrollment Preferences: sophomores and junior Physics majors
Enrollment Limit: 10
Expected Class Size: 10
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
TUT   Instructor: Frederick Strauch

PHYS 315T Computational Biology (Q)
Crosslistings: PHYS 315/CSCI 315

This course will provide an overview of Computational Biology, the application of computational, mathematical, statistical, and physical problem-solving techniques to interpret the rapidly expanding amount of biological data. Topics covered will include database searching, DNA sequence alignment, clustering, RNA structure prediction, protein structural alignment, methods of analyzing gene expression, networks, and genome assembly using techniques such as string matching, dynamic programming, hidden Markov models, and expectation-maximization.
Class Format: lab three hours per week plus weekly tutorial meeting
Requirements/Evaluation: evaluation will be based on weekly programming assignments, problem sets, a few quizzes and a final project
Extra Info: may not be taken on a pass/fail basis, not available for the fifth course option
Prerequisites: programming experience (e.g., CSCI 136), mathematics (PHYS/MATH 210 or MATH 150), and physical science (PHYS 142 or 151, or CHEM 151 or 153 or 155), or permission of instructor
Enrollment Preferences: based on seniority
Enrollment Limit: 10
Expected Class Size: 8
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
BGNP Recommended Courses

Not Offered Academic Year 2017
TUT   Instructor: Daniel Aalberts

PHYS 316(S) Protecting Information: Applications of Abstract Algebra and Quantum Physics (Q)
Crosslistings: MATH 316/PHYS 316
Living in the information age, we find ourselves depending more and more on codes that protect messages against either noise or eavesdropping. This course examines some of the most important codes currently being used to protect information, including linear codes, which in addition to being mathematically elegant are the most practical codes for error correction, and the RSA public key cryptographic scheme, popular nowadays for internet applications. We also study the standard AES system as well as an increasingly popular cryptographic strategy based on elliptic curves. Looking ahead by a decade or more, we show how a quantum computer could crack the RSA scheme in short order, and how quantum cryptographic devices will achieve security through the inherent unpredictability of quantum events.
Class Format: lecture
Requirements/Evaluation: evaluation will be based on homework sets and exams
Prerequisites: PHYS/MATH 210 or MATH 250 (possibly concurrent) or permission of instructors;
Enrollment Preferences: discretion of the instructors
Enrollment Limit: 50
Expected Class Size: 35
Dept. Notes: students not satisfying the course prerequisites but who have completed MATH 200 or MATH 209 are particularly encouraged to ask to be admitted
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Spring 2017
LEC Section: 01   MWF 09:00 AM 09:50 AM   Instructors: Susan Loepp, William Wootters

PHYS 319(F) Integrative Bioinformatics, Genomics, and Proteomics Lab (Q)
Crosslistings: BIOL 319/MATH 319/CHEM 319/PHYS 319/CSCI 319
What can computational biology teach us about cancer? In this capstone experience for the Genomics, Proteomics, and Bioinformatics program, computational analysis and wet-lab investigations will inform each other, as students majoring in biology, chemistry, computer science, mathematics/statistics, and physics contribute their own expertise to explore how ever-growing gene and protein data-sets can provide key insights into human disease. In this course, we will take advantage of one well-studied system, the highly conserved Ras-related family of proteins, which play a central role in numerous fundamental processes within the cell. The course will integrate bioinformatics and molecular biology, using database searching, alignments and pattern matching, phylogenetics, and recombinant DNA techniques to reconstruct the evolution of gene families by focusing on the gene duplication events and gene rearrangements that have occurred over the course of eukaryotic speciation. By utilizing high through-put approaches to investigate genes involved in the MAPK signal transduction pathway in human colon cancer cell lines, students will uncover regulatory mechanisms that are aberrantly altered by siRNA knockdown of putative regulatory components. This functional genomic strategy will be coupled with independent projects using phosphorylation-state specific antisera to test our hypotheses. Proteomic analysis will introduce the students to de novo structural prediction and threading algorithms, as well as data-mining approaches and Bayesian modeling of protein network dynamics in single cells. Flow cytometry and mass spectrometry will be used to study networks of interacting proteins in colon tumor cells.
Class Format: two afternoons of lab, with one hour of lecture, per week
Requirements/Evaluation: lab participation, several short homework assignments, one lab report, a programming project, and a grant proposal
Prerequisites: BIOL 202; students who have not taken BIOL 202 but have taken BIOL 101 and CSCI 315 or PHYS 315, may enroll with permission of instructor. No prior computer programming experience is required.
Enrollment Preferences: seniors, then juniors, then sophomores
Enrollment Limit: 12

Expected Class Size: 12
Dept. Notes: does not satisfy the distribution requirement in the Biology major
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
BGNP Core Courses
BIMO Interdepartmental Electives

Fall 2016
LEC Section: 01   W 12:25 PM 01:00 PM   Instructor: Lois Banta

LAB Section: 02   WR 01:00 PM 04:00 PM   Instructor: Lois Banta

LAB Section: 03   Cancelled

PHYS 321 Introduction to Particle Physics (Q)
The Standard Model of particle physics incorporates special relativity, quantum mechanics, and almost all that we know about elementary particles and their interactions. This course introduces some of the main ideas and phenomena associated with the Standard Model. After a review of relativistic kinematics, we will learn about symmetries in particle physics, Feynman diagrams, and selected applications of quantum electrodynamics, the weak interactions, and quantum chromodynamics. We will conclude with a discussion of spontaneous symmetry breaking and the Higgs mechanism.
Class Format: lecture
Requirements/Evaluation: weekly problem sets, two midterm exams, and a final exam
Prerequisites: PHYS 301, which may be taken concurrently
Enrollment Limit: none
Expected Class Size: 15
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
LEC   Instructor: David Tucker-Smith

PHYS 402T(S) Applications of Quantum Mechanics (Q)
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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Spring 2017
TUT Section: T1   F 01:10 PM 02:25 PM   Instructor: Catherine Kealhofer

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TUT Section: T2   F 01:10 PM 02:25 PM   Instructor: Catherine Kealhofer

PHYS 405T Electromagnetic Theory (Q)
This course builds on the material of Physics 201, and explores the application of Maxwell's Equations to understand a range of topics including electric and magnetic fields in matter, light, and radiation. We begin with electrostatics, developing analytical solutions to Laplace's and Poisson's equations using mathematical tools and approximation techniques. We then move on to magnetic materials, electromagnetic waves, accelerating charges, and relativistic electrodynamics.   In addition to weekly tutorial meetings, the class will meet once a week as a whole to introduce 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, and a final exam or final project, 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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
MTSC Related Courses

Not Offered Academic Year 2017
TUT   Instructor: Charlie Doret

PHYS 411T(F) Classical Mechanics (Q)
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 with 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
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning
Other Attributes:
MTSC Related Courses

Fall 2016
TUT Section: T1   F 01:10 PM 02:25 PM   Instructor: Charlie Doret

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TUT Section: T2   F 01:10 PM 02:35 PM   Instructor: Charlie Doret

PHYS 418T Gravity (Q)
This course is an introduction Einstein's theory of general relativity. We begin with a review of special relativity, emphasizing geometrical aspects of Minkowski spacetime. Working from the equivalence principle, we then motivate gravity as spacetime curvature, and study in detail the Schwarzschild geometry around a spherically symmetric mass. After this application, we use tensors to develop Einstein's equation, which describes how energy density curves spacetime. With this equation in hand we study the Friedmann-Robertson-Walker geometries for an expanding universe, and finally, we linearize Einstein's equation to develop the theory of gravitational waves.
Class Format: tutorial
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 or PHYS 405 or PHYS 411; students with strong math backgrounds are invited to consult with the instructor about a possible waiving of the prerequisites
Enrollment Limit: 10/section
Expected Class Size: 10/section
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
TUT   Instructor: David Tucker-Smith

PHYS 451(S) Condensed Matter Physics (Q)
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, and semiconductors, with particular attention to structure, thermal properties, energy bands, and electronic properties. After developing the appropriate background, we will examine some simple semiconductor devices.
Class Format: seminar
Requirements/Evaluation: weekly readings and problem sets, and a final exam
Prerequisites: PHYS 301; PHYS 302 preferred; or permission of instructor
Enrollment Preferences: Physics majors
Enrollment Limit: 10
Expected Class Size: 4-6
Distributional Requirements:

Division 3
Quantitative/Formal Reasoning

Spring 2017
SEM Section: 01   MR 02:35 PM 03:50 PM   Instructor: Jefferson Strait

PHYS 475 Methods in Mathematical Fluid Dynamics (Q)
Crosslistings: MATH 475/PHYS 475
The mathematical study of fluids is an exciting field with applications in areas such as engineering, physics and biology. The applied nature of the subject has led to important developments in aerodynamics and hydrodynamics. From ocean currents and exploding supernovae to weather prediction and even traffic flow, several partial differential equations (pde) have been proposed as models to study fluid phenomena. This course is designed to both, introduce students to some of the techniques used in mathematical fluid dynamics and lay down a foundation for future research in this and other related areas. Briefly, we start with the method of characteristics, a useful tool in the study of pde. Symmetry and geometrical arguments, special solutions, energy methods, particle trajectories, and techniques from ordinary differential equations (ode) are also discussed. A special focus will be on models from hydrodynamics. These include the KdV and the Camasss Holm equations (and generalizations thereof), and the Euler equations of ideal fluids. Mainly, we will be concerned with models whose solutions depend on time and one spatial variable, although depending on student interest and time, we may also investigate higher-dimensional models.
Class Format: lecture
Requirements/Evaluation: problem sets and final project
Extra Info: may not be taken on a pass/fail basis
Prerequisites: MATH 151, MATH 250, and MATH 350 or 351; some background in pde/ode would be helpful but not required
Enrollment Preferences: senior Mathematics majors
Enrollment Limit: 40
Expected Class Size: 25
Distributional Requirements:
Division 3
Quantitative/Formal Reasoning

Not Offered Academic Year 2017
LEC   Instructor: Alejandro Sarria

PHYS 493(F) Senior Research: Physics
An original experimental or theoretical investigation is carried out under the direction of a faculty member in Physics, as discussed above under the heading of *The Degree with Honors in Physics*.
Class Format: independent study
Prerequisites: permission of department; senior course
Distributional Requirements:
Division 3

Fall 2016
HON Section: 01   TBA   Instructor: David Tucker-Smith

PHYS 494(S) Senior Research: Physics
An original experimental or theoretical investigation is carried out under the direction of a faculty member in Physics, as discussed above under the heading of *The Degree with Honors in Physics*.
Class Format: independent study
Prerequisites: permission of department; senior course
Distributional Requirements:
Division 3

Spring 2017
HON Section: 01   TBA   Instructor: David Tucker-Smith

PHYS 497(F) Independent Study: Physics
Physics independent study.
Class Format: independent study
Distributional Requirements:
Division 3

Fall 2016
IND Section: 01   TBA   Instructor: David Tucker-Smith

PHYS 498(S) Independent Study: Physics
Physics independent study.
Class Format: independent study
Distributional Requirements:
Division 3

Spring 2017
IND Section: 01   TBA   Instructor: David Tucker-Smith

PHYS 499(F,S) Physics and Astronomy Colloquium
Crosslistings: PHYS 499/ASTR 499
Physicists and Astronomers from around the country come to explain their research. Students of Physics and Astronomy at any level are welcome. Registration is not necessary to attend. A non-credit course.
Class Format: colloquium
Requirements/Evaluation: not a for-credit course
Extra Info: registration not necessary to attend
Prerequisites: none
Enrollment Limit: none
Distributional Requirements:
Non-divisional

Fall 2016
LEC Section: 01   F 02:35 PM 03:50 PM   Instructor: David Tucker-Smith

Spring 2017
LEC Section: 01   F 02:35 PM 03:50 PM   Instructor: David Tucker-Smith