Physics (PHYS)

PHYS 1000 Thriving as a Physics Major 1 Credit
This course will help you maximize your experience as a Georgetown physics major in order for you to achieve your goals. We will provide you with resources regarding profession skills development (e.g., resume/cover letter assistance, graduate school preparation and research opportunities) and pair you with student physics mentors.
Level: Undergraduate
Grading: Pass/Fail Default

PHYS 1001 Basic Physics 3 Credits
In this 3-credit, algebra based course, we will study the basic principles used to describe and explain physical phenomena. We will cover topics in Classical Physics, which include Mechanics, Waves, Sound, Heat, Electricity, Magnetism, Light Waves, basic ideas in Quantum Physics, and time permitting, a brief introduction to Special Theory of Relativity. This course is appropriate for nonscience majors and for those who desire a more conceptual and less mathematical introduction to physics before taking a two semester physics course required for science majors, and for those interested in gaining insight into the physical laws that governs observed phenomena. We will emphasize the conceptual understanding of the laws of nature and their applications in explaining and predicting the way matter and energy interact.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1101 Science of Sound and Sight 3 Credits
The nature of sound and light is addressed in the context of our auditory and visual senses. Physics of sound, anatomy and physiology of the ear and the pathway to the cerebral cortex, and the psychology of perception are drawn upon to understand musical instruments as well as our perception of music. The richness of color sensation in nature and art is addressed by similarly drawing on the physics of light, as well as the anatomy, physiology and psychology of vision. Technological approaches to correcting ocular and auditory defects are addressed as well as means of enhancing or extending the senses of sight and hearing. This course, in conjunction with a core math/science course, may be used to satisfy the College math/science requirement.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1102 The Way Things Work 3 Credits
This is a conceptual science course, meaning that the emphasis will be on understanding, rather than calculating. Many natural phenomena and the technologies of our modern world can be understood through verbal descriptions, rather than calculations. Equations will be presented in the course, but they will be minimal and relatively straight forward. Given the qualitative, rather than quantitative, nature of this course, the focus will be on seeing and understanding the “science” in everyday life. Most science courses start by presenting abstract theory and then treating applications of it. This course takes the opposite approach. We start with a well known phenomenon, e.g., the blue sky or the fact that microwave ovens make things hot, and then address the question: “Why is this so?” or “How does this happen?” A broad range of topics will be covered, including bicycles, roller coasters, clocks, rockets, ovens, refrigerators and air conditioners, copy machines, lasers, CD, DVD and Blu-ray players, nuclear weapons and reactors, cell phones, medical imaging, and trains that float. Classroom discussions will be augmented with a number of in-class demonstrations and video clips. This course serves as a core course for completion of the University’s mathematics/science curriculum requirement.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1103 Physics for Future Leaders 3 Credits
Every leader would like to save the world, but an understanding of how things work -both natural and man-made - is the first step towards achieving that goal. The focus of this course is to help students begin to become knowledgeable and articulate about the physics and technological aspects of important issues. We will emphasize a conceptual understanding of the physical principles that underlie many technological advances and natural phenomena. The topics covered may vary but may include the physics behind the smartphone and the MRI, as well as the physics that underlies natural phenomena, such as the greenhouse effect and global climate change. This course has no prerequisites.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1201 Earth's Energy Bal Clim Chng 1.5 Credits
Do you have a favorite renewable energy source? Can it really make a major contribution to global energy needs? How can you estimate its environmental impact as compared to the use of fossil fuels? We will distinguish the two forms of Earth’s energy sources: the fixed energy stores that, once used cannot be replenished and the sources of energy that flows to or around the Earth’s surface that we can harness at will. We will discuss the physics of climate. How do we articulate Earth’s energy balance and the radiative forcing that perturbs this balance? Moreover, the Earth is a complex system with many interacting parts. How does feedback – positive or negative – impact the energy balance? What is the role of modelling in climate physics and how are such models validated? This course does not require any math beyond high school algebra. Potential quantitative exercises will only consist of approximations in the spirit of “back of the envelope” calculations as well as extractions of quantitative information from graphs. Such skills will contribute to any argument that supports whether – or to what extent – a particular renewable source can truly serve the needs of humanity. The ability to communicate scientific findings to the society at large is a vital skill. To this end, assignments will consist of writing in a variety of forms that will be suitable to the intended audience.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1202 Energy DisastersPossible Solu 3 Credits
Access to energy resources is crucial for sustained economic development. However, every form of energy-generation affects the environment, health and security of the immediate state in which a plant is localized but also the state's neighbors and even the global community. For an informed assessment of the social and political impact of different methods of energy generation, it is crucial to have a thorough understanding of the underlying technologies. This course is a problem-based survey on energy-generating technology. Failed energy projects in the areas of water, fossil fuels, and nuclear energy generation will be presented and the underlying technology explained. This enables students to discuss and present possible solutions to the issues that take into account the historical limitations but that also incorporate current alternatives. Additionally an overview on solar energy will be included in this course. An on-site excursion to an energy generating plant will connect the theoretical content to the current situation. Students will be assessed by quizzes as well as their proposals for alternative solutions to the discussed energy disasters.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1203 Physics of Climate Change 3 Credits
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1205 The Physics of the Atomic Bomb 3 Credits
This is a single semester non-lab based 3 credit hour course that is designed to provide students with a broad understanding of the twentieth century physics that defined our modern world. This course will focus on the revolution of relativistic, quantum and nuclear physics that took place in the 50 years between 1895 and 1945. The course will explore how the early discoveries of the age, in particular Planck's quantization of energy, Einstein's theory of relativity, Rutherford's discovery of the atom's nucleus, Bohr's theoretical model of the atomic structure, and Chadwick's discovery of the neutron provided a prelude to the eventual use of the atom beyond of the laboratories of Europe. The textbook will be the Pulitzer Prize winning book, “Making of the Atomic Bomb”, by Richard Rhodes. There will also be use of other media such as the recent film “Oppenheimer”, directed by Christopher Nolan.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1302 Innovating with Modern Physics 3 Credits
What does modern physics do for you? What possibilities has it opened up for us? What limits does it constrain us to? While physicists continue to develop our understanding of general relativity and quantum mechanics, the ideas presented in these two areas inspire many. Science fiction creators imagine worlds based on our current understanding and gaps in that understanding. Engineers and innovators are provided with the seeds to develop new technologies. In this course, we will examine the fundamentals of both relativity and quantum mechanics and how this science has led to the development of technologies like GPS and MRI. Our first exploration will be into Einstein's theory of relativity. We will pay particular attention to how motion and gravity alter time and its role in GPS. We will look at some of the ways that science fiction has presented time travel and discuss both the alignment with general relativity and the constraints physics places on travel in space and time. Our second exploration in quantum mechanics will examine the properties of magnets, how atomic nuclei behave in magnetic fields and how that behavior is utilized in magnetic resonance imaging. We will connect physics and philosophy to discuss quantum interpretations and their possible implications. This course will provide opportunities to practice science process skills (e.g. by engaging in hands-on experiments and reading scientific articles), to learn about the nature of science, and to connect physics ideas to your life. The course assumes no prior experience with physics and will be conceptually focused.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1304 Physics Tech Of Your Future 1.5 Credits
In this course we will explore two areas of modern physics in order to describe the workings of two technological innovations that have a major influence on our everyday lives: GPS and MRI. Not only will we build an understanding of the fundamental physics behind these technologies, but we will also discuss the process of development from understanding to innovation and future possibilities based on current research surrounding those foundations and technologies. Our first exploration will be into Einstein's theory of relativity, with particular attention to how motion and gravity alter time and its role in GPS. We will also consider the possibilities and constraints this physics provides us for innovations related to travel in space and time. For the second area we will examine the properties of magnets, how atomic nuclei behave in magnetic fields and how that behavior is utilized in magnetic resonance imaging. We can then discuss how ongoing research with fMRI machines might eventually be capable of mind-reading and the ethical implications of such an endeavor. You will have opportunities to practice science process skills (e.g. engaging in hands-on experiments and reading scientific articles), to learn about the nature of science, and to connect physics ideas to areas that are of most interest to you.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 1501 The Universe: Startling Truths 3 Credits

In the 20th century the scientific community transformed human understanding of the natural world. We now know that matter, space, and time follow rules that appear to contradict our everyday experience and in fact profoundly challenge our intuitive sense of physical reality. What are these revolutionary concepts, and how did they come to be accepted truths? We will start with the Theory of Relativity, which describes how motion and mass warp time and space, and how it sprang from Einstein's genius, building on the careful experiments of a handful of scientists. Next we will look at some of the principles of Quantum Mechanics, with a particular focus on the description of a world where the outcome of a measurement is necessarily uncertain, and seek to understand how a small group of scientists worked collectively to come to these realizations. More recently, the scientific community has found that the Theory of Chaos introduces fundamental unpredictability of an entirely different origin. Finally, we will see how these ideas come together in our modern description of the Cosmos, including our detailed understanding of the origin of the Universe 14 Billion years ago, and realization that the stuff of our universe is mostly "dark", invisible to our most powerful telescopes. Chaos Theory and our modern view of the Cosmos emerged from the collective work of a vast network of scientists, sharing ideas, fighting against uncertainty (and sometimes each other), and applying rigorous empirical tests to collectively determine how to most accurately describe how our world works, and therefore they provide examples of how the process of scientific discovery has changed over the course of the last century from a primarily individual pursuit to a fully communal endeavor.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Undergraduate level students.

PHYS 1801 Modern Astronomy 3 Credits

The aim of this course is to present a primarily descriptive introduction to modern astronomy, which is surely one of the most profound accomplishments of humanity and is of intellectual interest to people in all walks of life. No previous background in astronomy (or physics) is presumed. The mathematics employed will, for the most part, be limited to algebra and trigonometry. The topics to be covered will be chosen from: the appearance of the sky; an introduction to the physics underlying astronomy; instruments used by astronomers; formation and structure of our solar system; the nature of extrasolar planets and planetary systems; structure and properties of stars; structure and properties of galaxies; an introduction to cosmology; the possibility of life elsewhere in the universe. Students will be asked to take advantage of local resources, such as the Georgetown Observatory, the Naval Observatory, and the Smithsonian Institution for three self-guided field trips. Students will also carry out a modest hands-on observing project. There will be three exams that will not be explicitly cumulative. They will be written as hour exams and given during a two-hour period in the late afternoon or early evening, except for the third exam which will be given at the time designated for the final exam. During non-exam weeks there will usually be a homework assignment and a 10-minute in-class quiz. Some tutorial activities will be incorporated into class periods. This course serves as a core course for completion of the math/science requirement in the College. Textbook: Astronomy Today, Seventh Edition, by Eric Chaisson and Steve McMillan (with some ancillary materials to be decided upon). For further information, please contact the instructor.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 2002 Shaping National Science Polic 3 Credits

This class introduces students to science policy while emphasizing how to bring about change. Students will work on one project throughout the semester. They will break into teams, identify a politically hot science-issue, develop a lobbying strategy, and take their issue to Capitol Hill. The class is three credits and will meet once a week. The course is intended for science majors, but is open to non-science majors who have a working knowledge of government or marketing. Cross-listed as BIOL-262/562.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 2003 Science/Society:Global Challng 3 Credits

This seminar introduces students to some of the most significant and complex science and public interest challenges of our time including: managing a global pandemic, reducing carbon emissions, meeting growing global energy demand, and containing weapons of mass destruction. Guest speakers - including scientists, venture capitalists, congressional staff, and journalists - will examine the science, politics and public perceptions surrounding these challenges. Throughout the semester, students will break into groups and develop a report on one "Grand Challenge" that covers: the science, pending legislation, any Administration initiatives, relevant activity in the private sector, and the various policy options and barriers for solving the problem. The class, which meets once a week, is open to sophomores through seniors and is three credits. Biology students may count one credit towards a degree. Physics students count the class as a restricted elective towards a degree. This course does not satisfy the General Education Requirements for science.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 2020 Astronomy and Astrophysics 3 Credits
This course will cover Solar System, Interstellar medium, formation of stars and planets, Exoplanets, Milky Way / Galaxies, Black holes, Big Bang / Cosmology. It will also cover Astronomical Observatories / Science Policy / Science Funding and Career Paths in astronomy.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 2051 Principles of Physics 0-5 Credits
PHYS-101 and 102 constitute a year-long comprehensive calculus-based introduction to physics, particularly suited to the needs and interests of pre-medical students. Topics covered are Newton's laws, linear, planar, and rotational motions, work, energy, momentum, gravitation, periodic motion and waves, fluid mechanics, acoustics, thermodynamics, electric fields, electric potential, dielectrics, magnetic fields, induction, DC circuits, electromagnetic waves and light, interference and diffraction of light, geometric optics, atomic, quantum, nuclear, and condensed matter physics, and cosmology. Important note: Familiarity with calculus is assumed. Three lecture hours, one recitation hour, and two laboratory hours.
Level: Undergraduate
Prerequisites: MATH 035 or MATH 1350 (may be taken concurrently)
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Students cannot enroll who have a major in Post Baccalaureate Pre-Medical, Post Baccalaureate Pre-Medical, Post Baccalaureate Pre-Medical or Post Baccalaureate Pre-Medical.

PHYS 2052 Principles of Physics II 0-5 Credits
PHYS-101 and 102 constitute a year-long comprehensive calculus-based introduction to physics, particularly suited to the needs and interests of pre-medical students. Topics covered are Newton's laws, linear, planar, and rotational motions, work, energy, momentum, gravitation, periodic motion and waves, fluid mechanics, acoustics, thermodynamics, electric fields, electric potential, dielectrics, magnetic fields, induction, DC circuits, electromagnetic waves and light, interference and diffraction of light, geometric optics, atomic, quantum, nuclear, and condensed matter physics, and cosmology. Important note: Familiarity with calculus is assumed. Three lecture hours, one recitation hour, and two laboratory hours.
Level: Undergraduate
Prerequisites: (PHYS 2051 or PHYS 101) or (PHYS 2101 or PHYS 151)
Grading: Main Campus (UGrad, Grad)

PHYS 2056 Prin of Physics I Lab 1 Credit
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 2057 Prin of Physics Lab II 1 Credit
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 2101 Mechanics 5 Credits
This is the first semester of a calculus-based introduction to physics, particularly suited to the needs of majors in physics and other sciences. The course deals with the nature of matter and its interactions, with a particular emphasis on the small set of laws that govern all mechanical interactions. The course will focus on the atomic nature of matter, connections between microscopic and macroscopic viewpoints, and on fundamental principles such as the momentum principle and the energy principle. These ideas will be used to describe a variety of phenomena, including the speed of sound in a solid and the orbital motion of gravitating bodies. Facility with calculus is assumed. Three lecture hours, one tutorial hour, and two laboratory hours.
Level: Undergraduate
Prerequisites: MATH 1350 (may be taken concurrently)
Grading: Main Campus (UGrad, Grad)

PHYS 2102 Electromagnetic Phenomena 5 Credits
This is the second semester of a calculus-based introduction to physics, particularly suited to the needs of majors in physics and other sciences. This course will deal mainly with electric and magnetic interactions. The focus of the course will be on electric and magnetic fields and their effect on matter, building to the development of Maxwell’s equations and a description of electromagnetic radiation. Connections between macroscopic and microscopic viewpoints will be emphasized. Facility with calculus is assumed. Three lecture hours, one tutorial hour, and two laboratory hours.
Level: Undergraduate
Prerequisites: (PHYS 151 or PHYS 2101 or PHYS 2051 or PHYS 101) and (MATH 035 or MATH 1350 or MATH 036 or MATH 1360 (may be taken concurrently))
Corequisites:
Grading: Main Campus (UGrad, Grad)

PHYS 2103 Relativity Quantum Physics 5 Credits
Relativity and quantum mechanics are the cornerstones of modern physics and deal with some of the most bizarre and paradoxical behavior seen in the physical world. In this course, we will show how to systematically build a theory based on the fact that the speed of light is a constant in any inertial reference frame, which leads to time dilation, length contraction, and a number of surprising paradoxes. We will then note how Einstein's principle of equivalence leads to a reformulation of our understanding of gravity, namely general relativity. Next we will introduce the quantum-mechanical world and see how wave-particle duality leads to a probabilistic interpretation of physical reality. We will employ the two-slit experiment to understand the bizarre predictions of quantum mechanics. We will use Schroedinger's equation to model simple quantum systems, culminating in a description of the hydrogen atom. The emphasis of the course will be on conceptual ideas and theory building, with support through quantitative problem solving. Weekly tutorials and laboratories supplement the lectures. Three lecture hours, one tutorial hour, and two laboratory hours.
Level: Undergraduate
Prerequisites: (PHYS 151 or PHYS 2101 or PHYS 101 or PHYS 2051) and (PHYS 152 or PHYS 2102 or PHYS 102 or PHYS 2052) and (MATH 2370 (may be taken concurrently) or MATH 137)
Grading: Main Campus (UGrad, Grad)

PHYS 2104 Modern Physics and its Exp Met 4 Credits
This course continues the exploration of modern physics begun in Physics 153, combined with hands-on experience with a variety of modern measurement techniques. The goals for the semester are: • Apply the principles of quantum mechanics, statistical mechanics, and relativity to a wide range of physical phenomena including some aspects atomic and molecular structure, solid state materials and semiconductor devices, and nuclear and particle physics. • Learn to use many of the common tools and techniques of experimental physics. • Acquire general lab skills and experience with communicating scientific results in a variety of formats. • Learn to analyze uncertainty and errors in experimental data. The lecture and lab components of the course will be roughly balanced, with three lecture hours per week and two scheduled laboratory hours, with substantial additional independent lab work
Level: Undergraduate
Prerequisites: (PHYS 153 or PHYS 2103)
Grading: Main Campus (UGrad, Grad)

PHYS 2105 Math/Computational Methods 4 Credits
The goals for this course are to help the student learn enough about the mathematical and computational methods used in physics to serve as a foundation for advanced study in physics (and other fields), develop problem-solving skills, and apply those problem-solving skills to simple but realistic situations. It is intended that the depth of coverage of each topic be sufficient to allow the use of the basics of that topic in subsequent study of physics and the acquisition of a more thorough and deeper understanding of that topic should need and/or desire so dictate. In other words, rather than providing exhaustive coverage, this course is intended to get the student up and running. Topics covered will be chosen from ordinary and partial differential equations, complex variables, linear algebra, vector algebra and calculus, partial differentiation, multiple integrals, Fourier series, integral transforms, calculus of variations, and probability. Numerical computation employing Python will be used throughout the class.
Level: Undergraduate
Prerequisites: (PHYS 153 or PHYS 2103) and (MATH 137 or MATH 2370)
Grading: Main Campus (UGrad, Grad)

PHYS 3101 Intermediate Mechanics 4 Credits
The focus of this course is on the review of Newtonian mechanics, development of the Lagrange formulation of classical mechanics, and applications to one- and two-dimensional motion, central forces, collisions, and oscillations. Accelerated coordinate systems, geometrical phases, and rigid-body rotations will also be covered. Throughout the course, there will be emphasis on developing problem-solving techniques and applications to the real world.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 3102 Int. Electricity Magnetism 4 Credits
In the introductory part of this course, vector functions and electrostatics are covered, followed by reacquaintance of the students with the concepts of surface integrals (divergence), line integrals (curl), and gradients. The manifestation of the magnetic field is treated from a relativistic point of view, including transformations of electric fields, magnetic fields, and forces into inertial frames of reference. This background leads to the development of Maxwell's equations and the ideas of electromagnetic wave theory. Three lecture hours and one tutorial hour.
Level: Undergraduate
Prerequisites: (PHYS 155 or PHYS 2105)
Grading: Main Campus (UGrad, Grad)

PHYS 3103 Quantum Mechanics 4 Credits
This course is an intermediate level treatment of quantum mechanics covering wave mechanics of a free particle, particles in potentials, Dirac notation, axiomatic formulation of quantum mechanics, spin-1/2 systems, time evolution of quantum systems, quantum harmonic oscillators, angular momentum, central potentials, the Hydrogen atom, and perturbation theory.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 3104 Statistical Physics 4 Credits
The objective of this course is to introduce the student to today’s understanding of statistical physics. The course begins with a review of thermodynamics. Next comes a brief introduction to probability and statistics. This is followed by the heart of the course, equilibrium statistical mechanics. The microcanonical, canonical, and grand canonical ensembles will be considered and some other ensembles will be noted. Both classical and quantum systems will be investigated. Most applications will focus on systems of non-interacting particles, although some of the techniques for dealing with classical interacting systems will be noted and one or two selected interacting quantum systems will be briefly considered. The first applications will be to a system of localized spins, vacancies in a solid, and a rubber band. Then, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics will be discussed and applied to the classical gas, electrons in a metal, blackbody radiation (photons), lattice vibrations (phonons), the ideal Bose-Einstein gas, and the Ising model. The last portion of the course will be principally concerned with phase transitions, specifically first order phase transitions, phase separation, continuous phase transitions, and the Landau theory of phase transitions. As time allows and where appropriate, second quantization will be introduced and applied to one or two systems, the Ginzburg-Landau theory of inhomogeneous phase transitions will be considered, and some of the ideas and applications of non-equilibrium statistical physics will be entertained.
Level: Undergraduate
Prerequisites: (PHYS 155 or PHYS 2105)
Grading: Main Campus (UGrad, Grad)

PHYS 3106 Quantum Physics II 3 Credits
This course will cover in depth treatment of topics introduced in Phys 3103 as well as advanced topics, including perturbation theory and identical particles.
Level: Undergraduate
Prerequisites: PHYS 3103
Grading: Main Campus (UGrad, Grad)

PHYS 3150 Special Topics:Physics 1-6 Credits
This course may be offered depending on student interest and faculty availability. It will cover advanced topics that are not part of the regular curriculum, such as nuclear physics, elementary particle physics, nonlinear dynamics, general relativity, and astrophysics.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 3201 Dyn Proc in Biological Physics 3 Credits
The class combines basic knowledge of thermodynamics/statistical physics, nonlinear dynamics and biology to highlight physical processes that govern the dynamics of biological systems. The class will concentrate on dynamical aspects emerging on different temporal and spatial scales, random processes, Brownian motion and diffusion, thermodynamics of biological processes and the generation of membrane potentials.
Level: Undergraduate
Prerequisites: (PHYS 151 or PHYS 2101 or PHYS 101 or PHYS 2051) and (PHYS 2102 or PHYS 152 or PHYS 102 or PHYS 2052)
Grading: Main Campus (UGrad, Grad)

PHYS 3701 Sensors Digital Electronics 4 Credits
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 3998 Independent Research Intro 1 3-6 Credits
The focus of this course is independent research carried out under the close supervision of a member of the faculty.
Level: Undergraduate
Grading: Pass/Fail Default

PHYS 3999 Independent Research Intro 2 3-6 Credits
The focus of this course is independent research carried out under the close supervision of a member of the faculty.
Level: Undergraduate
Grading: Pass/Fail Default

PHYS 4202 Biological Physics II 4 Credits
This course will focus on how a wide variety of biological and biochemical systems are modeled using discrete dynamical models and ordinary and partial differential equations. The students will learn how to study the dynamics of these systems using techniques from statistical mechanics and nonlinear dynamics and will learn how to simulate and analyze the systems using computational techniques.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 155 or PHYS 2105) and (PHYS 235 or PHYS 3201)
Corequisites:
Grading: Main Campus (UGrad, Grad)

PHYS 4251 Soft Condensed Matter 3 Credits
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Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 4401 Computational Techniques 4 Credits
Topics will include classical Monte Carlo methods, multidimensional quadrature, Metropolis algorithms, and molecular dynamics. Visualization techniques and parallel computing may also be explored.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 4501 Solid State Physics I 3 Credits
This course is an introduction to fundamental phenomena in solid state and condensed matter physics. Topics will include crystal lattices, reciprocal lattices, phonons, thermal properties of solids, electronic transport, energy bands, semiconductors, and superconductors. There will be a focus on materials that are nanometer size in one or more dimensions and the exploration of properties that are quantum confined in two, one, or zero dimensions.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 253 or PHYS 3103)
Grading: Main Campus (UGrad, Grad)

PHYS 4652 Electrodynamics Optics 4 Credits
This course will concentrate on further development of topics in electrodynamics and on applications to reflection and refraction, interference, geometrical optics, dispersion, coherence, Fraunhofer and Fresnel diffraction, and lasers.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 154 or PHYS 2104) and (PHYS 252 or PHYS 3102)
Grading: Main Campus (UGrad, Grad)

PHYS 4751 FabricationChar:Nanomaterials 3 Credits
Full Title of Class: Title: Fabrication and Characterization of Nanomaterials This experimental course is intended to introduce graduate students as well as advanced undergraduate students to state-of-the-art nanofabrication techniques and physical properties of nanostructured materials. Main topics include vacuum basics, various types of advanced nanofabrication and nanopatterning techniques, common methods for structural, chemical, and magnetic characterizations, and physical properties of nanostructured materials. If health conditions and campus guidance permit, some lab demonstrations will be included; and in the last month of the semester, students will carry out a small research project, utilizing what they have learned in the course, and present their findings. If in-person components are still not possible, additional topics will be covered in class, and students will perform literature study and present a "journal club" type of presentation.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 4801 Introduction to Astrophysics 3 Credits
This course is a broad introduction to the observational data and theoretical concepts underlying modern astronomy and astrophysics. Topics include stellar physics, stellar evolution and remnants (white dwarves, neutron stars, pulsars, black holes), star formation, extrasolar planets, the Milky Way and other galaxies, and selections from cosmology. Students should have a mathematics background at the level of PHYS-155 (Mathematical Methods).
Level: Graduate, Undergraduate
Prerequisites: (PHYS 155 or PHYS 2105)
Grading: Main Campus (UGrad, Grad)

PHYS 4851 Particle Physics and Cosmology 3 Credits
This course is an introduction for advanced undergraduate physics majors to two of the major fields of physics. The first half of the course introduces the phenomenology of particle physics as well as its mathematical description. Topics will include fundamental and composite particles, forces, fields, symmetries, and conservation laws of The Standard Model. Students will also learn Feynman calculus and use it to make simple calculations in quantum electrodynamics. The second half of the course will tackle some areas of cosmology, including expansion of the universe, gravitational phenomena, cosmological models, cosmic inflation, and other topics as time allows. Students will also learn the background of general relativity and apply it to simple situations.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 253 or PHYS 3103)
Grading: Main Campus (UGrad, Grad)

PHYS 4853 Particle Physics 3 Credits
This course is an introduction for advanced undergraduate physics majors to the field of particle physics. Topics will include relativistic collisions, symmetries of elementary particles, quantum mechanical description of scattering processes, a survey of fundamental particles, and the history of their discovery. Students will learn the Feynman rules for quantum electrodynamics, as well as the main ingredients of the Standard Model: electroweak theory and quantum chromodynamics. Along the way, basics of classical and quantum field theory will be discussed.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 2104 or PHYS 154) and (PHYS 3103 (may be taken concurrently) or PHYS 253)
Grading: Main Campus (UGrad, Grad)

PHYS 4871 Introduction to String Theory 3 Credits
This course introduces the basic concepts and methods of string theory, which is a theoretical framework that attempts to unify quantum mechanics and general relativity by describing the fundamental particles and forces of nature as vibrations of one-dimensional strings. This course assumes knowledge of classical mechanics at the intermediate level, as well as basic knowledge of special relativity and quantum physics.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 153 or PHYS 2103) and (PHYS 251 or PHYS 3101)
Grading: Pass/Fail Default

PHYS 4949 Tutorial: Physics 0-5 Credits
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 4998 Independent Research (1st Sem) 3-6 Credits
The focus of this course is independent research carried out under the close supervision of a member of the faculty. A substantial written final report and a brief oral report on the term's work will be required. A list of advisers and possible research projects, together with departmental guidelines for work in this course, is available on the Physics Department website.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 4999 Independent Research (2nd Sem) 3-6 Credits
The focus of this course is independent research carried out under the close supervision of a member of the faculty. A substantial written final report and a brief oral report on the term's work will be required. A list of advisers and possible research projects, together with departmental guidelines for work in this course, is available on the Physics Department website.
Level: Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 5001 Quantum Mechanics I 3 Credits
Beginning with the Dirac formalism, the basic concepts of quantum mechanics will be developed in one-dimension, including the eigenvalue problem and quantum dynamics. The semiclassical formalism of coherent states and the WKB approximation will be discussed. Applications will be made to the simplest lattice model for describing solid state materials properties, the Kronig-Penney model. The one-dimensional formalism will be extended to three dimensions. Topics will include spin, angular momentum, central potentials, time independent perturbation theory, identical particles, symmetries and conservation laws. Applications will be made to atomic systems
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5002 Quantum Mechanics II 3 Credits
This course is an introduction to the more advanced ideas of quantum mechanics. The learning goals are for the student to be able to perform advanced quantum mechanics calculations and to acquire the minimum set of tools needed for independent research. In addition, this course will help develop a better understanding of what quantum mechanics means and how one interprets experiments with quantum understanding. We will begin with the development of degenerate perturbation theory with application to the atomic fine structure. Next we talk about scattering and describe the phenomena of a Feshbach resonance. We then describe time-dependent phenomena in quantum mechanics, including time-ordered products, evolution operators, and perturbation theory. We also briefly describe Fermi's golden rule, the sudden approximation, and the creation of light from atomic hydrogen. Next we will describe the interaction of atoms with lasers and magnetic fields including trapping atoms and the Jaynes-Cummings model. Then we move onto Fermionic problems, starting with the creation and annihilation operators and how they apply to simple models of interacting particle, followed by a thorough discussion of the Hubbard model, which illustrates many different correlated phenomena ranging from antiferromagnetism to ferromagnetism.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5301 Statistical Mechanics 3 Credits
The objective of this course is to introduce the student to today's understanding of statistical physics and statistical mechanics. The course begins with a review of thermodynamics. Next comes a brief introduction to probability and statistics. This is followed by the heart of the course, equilibrium statistical mechanics. The microcanonical, canonical, and grand canonical ensembles will be considered and some other ensembles will be noted. Both classical and quantum systems will be investigated. Most applications will focus on systems of non-interacting particles, although some of the techniques for dealing with classical interacting systems will be noted and one or two selected interacting quantum systems will be briefly considered. The first applications will be to a system of localized spins, vacancies in a solid, and a rubber band. Then, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics will be discussed and applied to the classical gas, electrons in a metal, blackbody radiation (photons), lattice vibrations (phonons), the ideal Bose-Einstein gas, and the Ising model. If time allows, second quantization will be introduced and applied to one or two of these systems. The last portion of the course will be principally concerned with phase transitions, specifically first order phase transitions, phase separation, continuous phase transitions, and the Landau theory of phase transitions. As time allows and where appropriate, the Ginzburg-Landau theory of inhomogeneous phase transitions and some of the ideas and applications of non-equilibrium statistical physics will be entertained.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5401 Computational Techniques 4 Credits
Topics will include classical Monte Carlo methods, multidimensional quadrature, Metropolis algorithms, and molecular dynamics. Visualization techniques and parallel computing may also be explored.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5501 Solid State Physics I 3 Credits
This course is an introduction to fundamental phenomena in solid state and condensed matter physics. Topics will include crystal lattices, reciprocal lattices, phonons, thermal properties of solids, electronic transport, energy bands, semiconductors, and superconductors. There will be a focus on materials that are nanometer size in one or more dimensions and the exploration of properties that are quantum confined in two, one, or zero dimensions.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5502 Solid State Physics II 3 Credits
This course will teach many body physics from a modern perspective. We will begin with a discussion of equilibrium Green's functions for noninteracting models, followed by interacting models, using concrete examples from the dynamical mean-field theory solution to the Falicov-Kimball model. We will cover charge and heat transport, and ordered phase transitions. Next we will describe the theory of superconductivity, leading up to the strong-coupling theory for the transition temperature and for the tunneling conductance. We end with a discussion of path integrals and functional methods, leading up to a description of the Hirsch-Fye algorithm for quantum Monte Carlo. Our learning goals are for you to become proficient in using many-body physics techniques to the point where you can immediately engage in work at the research level upon completing the class.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)

PHYS 5503 Many-Body Theory 3 Credits
This course will teach many body physics from a modern perspective. We will begin with a discussion of equilibrium Green's functions for noninteracting models, followed by interacting models, using concrete examples from the dynamical mean-field theory solution to the Falicov-Kimball model. We will cover charge and heat transport, and ordered phase transitions. Next we will describe the theory of superconductivity, leading up to the strong-coupling theory for the transition temperature and for the tunneling conductance. We end with a discussion of path integrals and functional methods, leading up to a description of the Hirsch-Fye algorithm for quantum Monte Carlo. Our learning goals are for you to become proficient in using many-body physics techniques to the point where you can immediately engage in work at the research level upon completing the class. In addition, another goal is to make you practitioners of computational methods.
Level: Graduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

Enrollment limited to students in the Physics department.

PHYS 5511 Phase Trans Non-Eqm St Mech 4 Credits
The course will focus on consequences of fluctuations and correlations in statistical mechanics, in and out of equilibrium. Topics will include spatial and temporal fluctuations and correlation functions; phase transitions in interacting systems (magnets, liquids, liquid crystals); scaling and critical exponents in phase transitions; the renormalization group; dynamical linear response theory and Fluctuation-Dissipation relations; stochastic dynamics; dissipative processes; Jarzynski and work relations; non-equilibrium thermodynamics and fluctuating hydrodynamics; Green-Kubo formalism; applications such as the time-dependent Ginzburg Landau equation, Models A, B, H, coarsening during phase separation, and active matter.
Level: Graduate, Undergraduate
Prerequisites: (PHYS 507 or PHYS 5301)
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5601 Electricity Magnetism 3 Credits
Electricity and Magnetism covers the basic principles of electromagnetism and their theoretical description: electrostatics, steady currents and magnetostatics, time varying fields, Maxwell's equations, propagation and radiation of electromagnetic waves, electric and magnetic properties of matter, and the unity of the electricity and magnetic phenomena. The appropriate mathematics is incorporated in the context of physics.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 5701 Sensors Digital Electronics 4 Credits
During the sensors half of this course, the basics of sensors and instrumentation will be covered, including sensor properties, precision and accuracy, and control and interfacing . The physical principles of electrical, mechanical, optical, magnetic, and chemical sensing will be reviewed. Applications to the measurement of position, velocity, acceleration, force, strain, pressure, flow, electrical and thermal transport, electromagnetic radiation, and temperature will be discussed. The digital electronics half will be a combination of lecture and laboratory work which will focus on combinational and sequential logic networks, counters and shift registers, and interfacing to computer hardware.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 6000 Colloquium: Physics 1.5 Credits
Guest speakers introduce current research topics in physics and present their contributions to the field. Faculty hosts lead follow-up discussion sessions.
Level: Graduate, Undergraduate
Grading: Pass/Fail Default
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 6001 Physics Colloquium 1.5 Credits
Level: Graduate
Grading: Pass/Fail Default

PHYS 6010 Intellectual Property Course
Level: Graduate
Grading: Pass/Fail Default
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 6012 Entrepreneurship in Physics 2 Credits
Level: Graduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 7000 Physics Lab Rotation 3 Credits
Students engage in an eight-week lab rotation in a selected research group to gain research skills and to learn about on-going research in the group. Typically, students complete two lab rotations per semester. This requires enrolling in one section each of PHYS-535 and 537 in the Fall, or one section each of PHYS-536 and 538 in the Spring.
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to students with a major in Physics, Physics, Physics or Physics.

Enrollment is limited to Graduate level students.

PHYS 7001 Physics Lab Rotation II 1.5 Credits
Students engage in an eight-week lab rotation in a selected research group to gain research skills and to learn about on-going research in the group. Typically, students complete two lab rotations per semester. This requires enrolling in one section each of PHYS-7000 and PHYS-7001. Registration in this class requires instructor approval. Restrictions: Restricted to physics graduate students
Level: Graduate
Grading: Main Campus (UGrad, Grad)
Equivalent to PHYS 537

PHYS 9991 Continuous Registration
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 9992 Continuous Registration
Level: Graduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 9993 Continuous Registration
Level: Graduate, Undergraduate
Grading: Main Campus (UGrad, Grad)
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 9994 Continuous Registration
Level: Graduate
Grading: No Grade
Course registration restrictions:
Enrollment is limited to Graduate level students.

PHYS 9999 Thesis Research
Level: Graduate, Undergraduate
Grading: No Grade
Course registration restrictions:
Enrollment is limited to Graduate level students.