PHYS 1000. Physics at Northeastern. 1 Hour.
Intended for freshmen in the College of Science. Introduces freshmen to the liberal arts in general; familiarizes them with their major; helps them develop the academic skills necessary to succeed (analytical ability and critical thinking); provides grounding in the culture and values of the University community; and helps them develop interpersonal skills—in short, familiarizes students with all skills needed to become a successful university student.

PHYS 1111. Astronomy. 4 Hours.
Introduces modern astronomical ideas designed for nonscience majors. Topics include an introduction to the cosmos, Earth and its relation to the universe, our solar system (planets, moons, asteroids, and comets), the sun and how it works, stars and their classification, and the life and death of stars. Introduces various tools of the astronomer (the nature of light and radiation, telescopes, the types of spectra, and what they tell us).

PHYS 1121. Introduction to Science. 4 Hours.
Provides nonscience majors with an interdisciplinary treatment of the basic ideas of the natural sciences. Discusses concepts such as particles and waves, heat, optics, energy, gravity, and the atom, followed by a consideration of the ways in which atoms combine to form the substances that compose matter.

PHYS 1122. Modern Science: A Voyage into Matter, Life, and Mind. 4 Hours.
Offers an intellectual voyage into matter, life, and mind—the three pillars of modern science. It is a mosaic of different themes that offer a concise overview of science's greatest minds, ideas, questions, discoveries, theories, and methods while placing all of them within their historical contexts. Emphasizes the profound scientific revolutions of the 20th century—quantum mechanics, biogenetics, and artificial intelligence—that unlocked the secrets of the atom, unraveled the molecule of life, and created the electronic computer. Recognizes significant trends across a wide range of subjects, including medicine, biotechnology, computing and communicating, artificial intelligence and artificial life, and robotics. Discusses the synergism of science, technology, and business on future scientific development.

PHYS 1123. Physics for Future Leaders. 4 Hours.
Introduces basic concepts in physics and other sciences in a manner accessible to nonscience majors. Offers students an opportunity to learn to think scientifically about issues in the realm of public policy and current events. Topics may include fossil fuels and the energy economy, nuclear energy and nuclear weapons, radiation safety, alternative fuels and transportation, space exploration, climate change, and the greenhouse effect.

PHYS 1125. Introduction to Network Science: From the Human Cell to Facebook. 4 Hours.
Introduces network science as a way to understand complex patterns of connections and relationships in increasingly complex social, infrastructure, transportation, information, and biological networks, as well as business and consumer networks. Describes basic conceptual and computational tools to model networks and discusses applications of those tools through a wide range of examples from the World Wide Web to protein and gene networks to massive social networks such as Twitter and Facebook. Discusses both network structures and dynamical phenomena on networks, such as spreading of information, rumors, gossip, and epidemics.

PHYS 1130. Computing, Data, and Science. 4 Hours.
Introduces how to deal with data and computation problems through the use of computer languages commonly used in the sciences. Focuses on manipulating data, but symbolic calculations are also covered. Intended for science majors during the first summer, when such a course can act as a foundation for later work.

PHYS 1132. Energy, Environment, and Society. 4 Hours.
Seeks to provide nonscience students with a practical knowledge of our present use of the Earth's energy resources and the environmental consequences. Topics include fossil fuels for transportation and electrical power, global warming, nuclear energy, solar energy, wind power, biomass, electric and hybrid vehicles, and air pollution. No previous knowledge of physics is assumed; nevertheless, because of the nature of the subject, a significant part of the course includes simple quantitative reasoning.

PHYS 1141. General Physics. 4 Hours.
Covers mechanics, fluids, and vibrations and waves. Emphasizes the application of physics to a variety of problems in structural engineering. Mechanics topics include one-dimensional motion, forces, vectors, Newton's laws, equilibrium, work, energy, and power. Fluids topics include density, pressure, buoyancy, and fluids in motion. Vibrations and waves topics include mechanical vibrations and sound. Requires knowledge of algebra.

PHYS 1145. Physics for Life Sciences 1. 4 Hours.
Covers mechanics, fluids, and temperature and kinetic theory. The application of physics to a variety of problems in the life and health sciences is emphasized. Mechanics topics include one-dimensional motion, forces, vectors, Newton's laws, equilibrium, work, energy, and power. Fluids topics include density, pressure, buoyancy, fluids in motion, viscosity, and surface tension. Temperature and kinetic theory topics include temperature, thermal equilibrium, gas laws, ideal gas law, kinetic theory, vapor pressure, and diffusion. A laboratory is included.

PHYS 1146. Lab for PHYS 1145. 1 Hour.
Accompanies PHYS 1145. Covers topics from the course through various experiments.

PHYS 1147. Physics for Life Sciences 2. 4 Hours.
Continues PHYS 1145. Covers heat, electricity, vibrations and waves, sound, geometrical optics, and nuclear physics and radioactivity. The application of physics to a variety of problems in the life and health sciences is emphasized. Electricity topics include electrostatics, capacitance, resistivity, direct-current circuits, and RC circuits. Vibrations and waves topics include simple harmonic motion and wave motion. Sound topics include wave characteristics, the ear, Doppler effect, shock waves, and ultrasound. Optics topics include reflection, mirrors, refraction, total internal reflection, fiber optics, lenses, the eye, telescopes, and microscopes. Nuclear physics and radioactivity topics include atomic nucleus, radioactivity, half-life, radioactive dating, detectors, nuclear reaction, fission, fusion, radiation damage, radiation therapy, PET, and MRI. A laboratory is included.

PHYS 1148. Lab for PHYS 1147. 1 Hour.
Accompanies PHYS 1147. Covers topics from the course through various experiments.

PHYS 1149. Physics for Pharmacy. 4 Hours.
Offers an integrated lecture and laboratory course for pharmacy students.
PHYS 1150. Lab for PHYS 1149. 1 Hour.
Accompanies PHYS 1149. Covers topics from the course through various experiments.

PHYS 1151. Physics for Engineering 1. 3 Hours.
Covers calculus-based physics. Offers the first semester of a two-semester integrated lecture and laboratory sequence intended primarily for engineering students. Covers Newtonian mechanics and fluids. Stresses the balance between understanding the basic concepts and solving specific problems. Includes topics such as one-dimensional and three-dimensional motion, Newton's laws, dynamics friction, drag, work, energy and power, momentum and collisions, rotational dynamics, forces, torque and static equilibrium, pressure, fluids, and gravity.

PHYS 1152. Lab for PHYS 1151. 1 Hour.
Accompanies PHYS 1151. Covers topics from the course through various experiments. Requires concurrent registration in PHYS 1151 and PHYS 1153.

PHYS 1153. Interactive Learning Seminar for PHYS 1151. 1 Hour.
Offers interactive problem solving for PHYS 1151. Emphasizes organized approaches and use of mathematical techniques, including calculus, to solve a wide range of problems in mechanics. Topics include static equilibrium, applications of Newton's laws and conservation principles, rotational dynamics, and fluids. Requires concurrent registration in PHYS 1151 and PHYS 1152.

PHYS 1155. Physics for Engineering 2. 3 Hours.
Continues PHYS 1151. Offers integrated lecture and laboratory. Covers electrodynamics; capacitors; resistors and direct-current circuits; magnetism and magnetic induction; RC, LR, and LRC circuits; waves; electromagnetic waves; and radiation.

PHYS 1156. Lab for PHYS 1155. 1 Hour.
Accompanies PHYS 1155. Covers topics from the course through various experiments. Requires concurrent registration in PHYS 1155 and PHYS 1157.

PHYS 1157. Interactive Learning Seminar for PHYS 1155. 1 Hour.
Offers interactive problem solving for PHYS 1155. Emphasizes organized approaches to solve a wide range of problems in electricity, magnetism, and waves. Requires concurrent registration in PHYS 1155 and PHYS 1156.

PHYS 1161. Physics 1. 4 Hours.
Covers calculus-based physics. Offers the first semester of a two-semester integrated lecture and laboratory sequence intended primarily for science students. Covers Newtonian mechanics and fluids. Emphasizes the underlying concepts and principles. Takes applications from a wide variety of fields, such as life sciences and medicine, astrophysics, and planetary physics, and so on. Includes topics such as forces, torque and static equilibrium, one-dimensional and three-dimensional motion, Newton's laws, dynamics friction, drag, work, energy and power, momentum and collisions, rotational dynamics, oscillations, pressure, fluids, and gravity.

PHYS 1162. Lab for PHYS 1161. 1 Hour.
Accompanies PHYS 1161. Covers topics from the course through various experiments.

PHYS 1163. Recitation for PHYS 1161. 0 Hours.
Accompanies PHYS 1161. Offers an opportunity for interactive problem solving.

PHYS 1165. Physics 2. 4 Hours.
Continues PHYS 1161. Offers the second semester of a two-semester integrated lecture and laboratory sequence intended primarily for science students. Includes topics such as electrodynamics; capacitors; resistors and direct-current circuits; magnetism and magnetic induction; RC, LR, and LRC circuits; waves; electromagnetic waves; and fluids.

PHYS 1166. Lab for PHYS 1165. 1 Hour.
Accompanies PHYS 1165. Covers topics from the course through various experiments.

PHYS 1167. Recitation for PHYS 1165. 0 Hours.
Accompanies PHYS 1165. Offers an opportunity for interactive problem solving.

PHYS 1171. Physics 1 for Bioscience and Bioengineering. 3 Hours.
Designed for students in engineering and science majors with a biologically related curriculum. Studies the fundamentals of calculus-based physics through a relationship with living systems. Includes topics such as kinematics of living systems, stress/strain/strength of biomaterials, fluid flow and boundary layers, aspiration and circulatory models, diffusion and random motion, and thermodynamics with examples from living systems.

PHYS 1172. Lab for PHYS 1171. 1 Hour.
Accompanies PHYS 1171. Experiments include measurement and error, forces in one dimension, work and energy on an air track, fluid flow, Brownian diffusion, uniform circular motion, and ideal gas laws. Requires concurrent registration in PHYS 1171 and PHYS 1173.

PHYS 1173. Interactive Learning Seminar for PHYS 1171. 1 Hour.
Offers interactive problem solving for PHYS 1171. Emphasizes organized approaches to solve a wide range of problems in the course. Requires concurrent registration in PHYS 1171 and PHYS 1172.

PHYS 1175. Physics 2 for Bioscience and Bioengineering. 3 Hours.
Continues PHYS 1171. Includes topics such as wave motion and hearing; electric fields (including application to biological membranes); direct current electrical circuits (including biological circuits); RC circuit models of ion channels; bioelectricity in marine organisms; electromagnetic waves and optics; modern physics (including radioactive decay, applications of radioactivity in nuclear medicine, and carbon 14 dating).

PHYS 1176. Lab for PHYS 1175. 1 Hour.
Accompanies PHYS 1175. Experiments include standing waves, electric charge/field, DC circuits, gel electrophoresis, geometric optics, light spectroscopy, and radioactive decay. Requires concurrent registration in PHYS 1175 and PHYS 1177.

PHYS 1177. Interactive Learning Seminar for PHYS 1175. 1 Hour.
Offers interactive problem solving for PHYS 1175. Emphasizes organized approaches to solve a wide range of problems in the course. Requires concurrent registration in PHYS 1175 and PHYS 1176.

PHYS 1211. Computational Problem Solving in Physics. 4 Hours.
Introduces students to computational problem-solving techniques with common computer languages used in the physical sciences. Begins with programming basics of data handling, visualization tools, random number generators, functions, and control statements and expands to more advanced topics of interpolation, numeric integration, numeric derivatives, ordinary differential equations, and some Monte Carlo techniques. Explores topics contextually using physical models and problems.

PHYS 1990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
PHYS 2303. Modern Physics. 4 Hours.
Reviews experiments demonstrating the atomic nature of matter, the properties of the electron, the nuclear atom, the wave-particle duality, spin, and the properties of elementary particles. Discusses, mostly on a phenomenological level, such subjects as atomic and nuclear structure, properties of the solid state, and elementary particles. Introduces the special theory of relativity.

PHYS 2305. Thermodynamics and Statistical Mechanics. 4 Hours.
Focuses on first and second laws of thermodynamics, entropy and equilibrium, thermodynamic potentials, elementary kinetic theory, statistical mechanics, and the statistical interpretation of entropy.

PHYS 2371. Electronics. 3 Hours.
Covers the physics underlying computers and our modern electronic world. Focuses on principles of semiconductor devices (diodes, transistors, integrated circuits, LEDs, photovoltaics); analog techniques (amplification, AC circuits, resonance); digital techniques (binary numbers, NANDs, logic gates, and circuits); electronic subsystems (operational amplifiers, magnetoelectronics, optoelectronics); and understanding commercial electronic equipment. Lab experiments are designed to investigate the properties of discrete and integrated devices and use them to design and build circuits.

PHYS 2372. Lab for PHYS 2371. 1 Hour.
Accompanies PHYS 2371. Illustrates topics from the lecture course through various hands-on experimental projects. Covers the process of electronics design from a goal-oriented perspective. Students are expected to consider their own electronics design project and build a prototype device that accomplishes a specific purpose.

PHYS 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

PHYS 3600. Advanced Physics Laboratory. 4 Hours.
Introduces research through experiments that go beyond the simple demonstration of basic physical principles found in introductory physics courses. Data are taken to higher precision and the analysis is more in-depth. Experiments focus on lasers, fiber-optic communication, spectroscopy, Faraday rotation, speed of light, semiconductor physics, Hall effect, fuel cells, and Fourier analysis of music and sound. Lab reports are assessed on organization, format, grammar, and style. Offers students an opportunity to significantly improve their abilities in written scientific communication.

PHYS 3601. Classical Dynamics. 4 Hours.
Covers advanced topics in classical mechanics including vector kinematics, harmonic oscillator and resonance, generalized coordinates, Lagrange's equations, central forces and the Kepler problem, rigid body motion, and mathematical methods in physics.

PHYS 3602. Electricity and Magnetism. 4 Hours.
Covers electrostatics and dielectric materials, magnetostatics and magnetic materials, currents in conductors, induction, displacement currents, computer solutions of EM problems, and Maxwell's equations.

PHYS 3603. Electromagnetic Waves and Optics. 4 Hours.
Focusses on electromagnetic waves in vacua and matter, electrodynamics and radiation, and computer visualization of electromagnetic fields. Also considers special relativity.

PHYS 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

PHYS 4621. Biological Physics 1. 4 Hours.
Offers an introduction to biophysics focusing on development and implementation of physical models for various biophysical processes that occur in living organisms and in living cells. Topics covered, some of which are explored through computational examples, include thermodynamics of solutions and cells, randomness, diffusion, entropy, membranes, electrostatics, and electricity in cells.

PHYS 4623. Medical Physics. 4 Hours.
Introduces the physical principles and basic mathematical methods underlying the various modalities of medical imaging. These include computed tomography (CT), magnetic resonance (MRI), positron emission tomography (PET), single-photon emission tomography (SPECT), and ultrasound. Covers nuclear physics and the interaction of radiation with biological matter with application to radiation therapy.

PHYS 4651. Medical Physics Seminar 1. 4 Hours.
Offers the first part of a seminar series conducted by expert practitioners from Boston-area hospitals. Examines the clinical applications of medical imaging methods (CT, MRI, and PET), the clinical applications of radiation therapy, and the clinical applications of lasers and optical techniques. Includes site visits to local hospitals and medical instrumentation companies.

PHYS 4652. Medical Physics Seminar 2. 4 Hours.
Continues PHYS 4651. Further examines the clinical applications of medical imaging methods (CT, MRI, and PET), the clinical applications of radiation therapy, and the clinical applications of lasers and optical techniques.

PHYS 4970. Junior/Senior Honors Project 1. 4 Hours.
Focuses on in-depth project in which a student conducts research or produces a product related to the student's major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8-credit honors project. May be repeated without limit.

PHYS 4980. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

PHYS 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

PHYS 4991. Research. 4 Hours.
Offers an opportunity to conduct research under faculty supervision.

PHYS 4992. Directed Study. 1-4 Hours.
Offers independent work under the direction of a member of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

PHYS 4996. Experiential Education Directed Study. 4 Hours.
Draws upon the student's approved experiential activity and integrates it with study in the academic major. Restricted to those students who are using it to fulfill their experiential education requirement. May be repeated without limit.
PHYS 5113. Introduction to Particle and Nuclear Physics. 4 Hours.
Introduces the physics of atomic nuclei and elementary particles. Topics include classification of nuclei, strong and weak nuclear forces, mesons and nucleons, quarks and gluons, and unified theories of elementary particle interactions.

PHYS 5115. Quantum Mechanics. 4 Hours.
Focuses on observations of macroscopic and microscopic bodies. Covers the uncertainty principle and wave-particle duality; probability amplitudes; Schrödinger wave theory and one-dimensional problems; Schrödinger equation in three dimensions; and angular momentum and the hydrogen atom.

PHYS 5116. Complex Networks and Applications. 4 Hours.
Introduces network science and the set of analytical, numerical, and modeling tools used to understand complex networks emerging in nature and technology. Focuses on the empirical study of real networks, with examples coming from biology (metabolic, protein interaction networks), computer science (World Wide Web, Internet), or social systems (e-mail, friendship networks). Shows the organizing principles that govern the emergence of networks and the set of tools necessary to characterize and model them. Covers elements of graph theory, statistical physics, biology, and social science as they pertain to the understanding of complex systems.

PHYS 5117. Astrophysics. 4 Hours.
Applies physics concepts to processes in celestial objects, particularly stars. Topics include tools of the astronomer (telescopes, spectroscopy, and methods of distance measurement); stellar properties; nuclear fusion reactions; hydrostatic equilibrium and stellar models; stellar evolution and the Hertzsprung-Russell diagram; morphology and dynamics of galaxies; and high-energy astrophysical phenomena. Not open to students who have completed PHYS 5111.

PHYS 5118. General Relativity and Cosmology. 4 Hours.
Introduces basic concepts in the general theory of relativity, including Riemannian geometry and Einstein’s field equations. These concepts are applied in studying the standard model of cosmology. Topics include thermodynamics in an expanding universe, dark matter and dark energy, and modern theories of cosmology. Not open to students who have completed PHYS 5111.

PHYS 5260. Introduction to Nanoscience and Nanotechnology. 4 Hours.
Focuses on reviewing the basic scientific concepts relevant to this field and also gives a broad overview of the current state-of-the-art in research and technology. Nanotechnology promises to transform twenty-first century technology by exploiting phenomena exhibited by nanoscaled materials. This technology is expected to have significant impact in diverse areas such as computers, electronics, health, etc. Successful technological advancement of this field requires that we have a fundamental understanding of the “science” of these materials. This course comprises a series of lectures on various topics: development of nanofabrication methods, advanced microscopy techniques, fabrication of novel nanomaterials, investigation of their fundamental properties and device applications. Provides a strong introduction for students interested in nanoscience and technology.

PHYS 5318. Principles of Experimental Physics. 4 Hours.
Designed to introduce students to the techniques of modern experimental physics. Topics include communication and information physics, signal processing and noise physics, applied relativity physics, detector techniques, semiconductor and superconductor physics, nanoscale microscopy and manipulation, and lasers and quantum optics.

PHYS 6962. Elective. 1–4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

PHYS 7200. Methods of Advanced Problem Solving. 4 Hours.
Designed to improve the ability of students to solve physics problems, which are of the same degree of difficulty as problems that often appear on the qualifying exam.

PHYS 7210. Introduction to Research in Physics. 0 Hours.
Offers a weekly seminar to introduce first- and second-year physics graduate students to research being done in the Physics department by advanced physics graduate students and faculty. May be repeated without limit.

PHYS 7301. Classical Mechanics/Math Methods. 4 Hours.
Covers mathematical methods of physics and classical mechanics. Topics include differential equations, boundary value problems, functions of a complex variable, linear vector spaces, Green’s functions, Lagrangian and Hamiltonian mechanics, linear oscillators, and scattering. May include additional topics as time permits.

PHYS 7302. Electromagnetic Theory. 4 Hours.
Explores Maxwell’s equations in vacuum and special relativity. Topics include electric and magnetic fields due to known sources with boundary conditions, radiation fields, bremsstrahlung, synchrotron radiation, the energy-momentum tensor for the electromagnetic field, fields in material media, boundary conditions at the interface between two media, and scattering of radiation. May include additional topics as time permits.

PHYS 7305. Statistical Physics. 4 Hours.
Briefly reviews thermodynamics. Topics include the principles of statistical mechanics and statistical thermodynamics; density matrix; theory of ensembles; Fermi-Dirac and Bose-Einstein statistics, application to gases, liquids, and solids; theory of phase transitions; and thermodynamics of electric and magnetic systems, transport phenomena, random walks, and cooperative phenomena.

PHYS 7315. Quantum Theory 1. 4 Hours.
Continues PHYS 7315. Topics include quantum theory of scattering; Born approximation; phase-shift analysis; introduction to S-matrix theory; general formulation quantum mechanics in Hilbert space; spin; identical particles and symmetrization principle; time-independent and time-dependent perturbation theory; semiclassical theory of radiation and atomic spectra; addition of angular momentum; Wigner-Eckart theorem; quantum theory of radiation; and absorption, emission, and scattering of photons. Also introduces free particle Dirac equation.

PHYS 7321. Computational Physics. 4 Hours.
Covers basic numerical methods for differentiation, integration, and matrix operations used in linear algebra problems, discrete Fourier transforms, and standard and stochastic ordinary and partial differential equations. Specific applications of these methods may include classical chaos, computation of eigenstates of simple quantum systems, classical phase transitions, boundary value problems, pattern formation, and molecular dynamics and classical/quantum Monte Carlo methods to simulate the equilibrium and nonequilibrium properties of condensed phases.
PHYS 7323. Elementary Particle Physics. 4 Hours.

Presents a survey of the present state of elementary particle physics, suitable for all graduate students. Topics include overview of strong interactions and their applications to nuclear physics; nonrelativistic quark structure of strongly interacting particles (hadrons); color and the SU(3) Yang-Mills theory of strong interactions; coupling constant renormalization and asymptotic freedom; and the parton model of scattering. Covers weak interactions including phenomenology of the Fermi V-A theory; universality; and neutrino scattering. Studies the Glashow-Weinberg-Salam theory including unification of weak and electromagnetic interaction, neutral currents, the Higgs mechanism, quark masses and mixing, neutrino masses, and neutrino oscillation. Offers experimental support for the standard model. Also examines supersymmetry including the hierarchy problem and broken supersymmetry; role of supersymmetry in cosmology.

PHYS 7324. Condensed Matter Physics. 4 Hours.

Explores condensed matter physics. Topics include Drude and Sommerfeld models of electrons in metals, crystal structure, one-electron states in crystal lattices, Bloch's theorem, semiclassical theory of conduction, semiconductors and semiconducting devices, effects of electron-electron interactions, lattice vibrations and the classical and quantum theories of specific heat, optical properties of solids, investigation of crystal structure and excited states of crystals by x-ray and neutron scattering, simple transport theory based on the Boltzmann equation, and magnetic properties of solids.

PHYS 7325. Quantum Field Theory 1. 4 Hours.

Introduces the principles of quantum field theory. Topics include canonical quantization of scalar and spinor fields, functional integral methods, perturbation theory, regularization and renormalization, and symmetry breaking. Emphasizes applications to particle physics and condensed matter phenomena.

PHYS 7326. Quantum Field Theory 2. 4 Hours.

Presents the quantum theory of gauge fields and their interactions, as well as advanced topics in quantum field theory. Additional topics covered may include Lie groups and Yang-Mills theory, asymptotic freedom, perturbation theory anomalies, and applications to phase transitions.

PHYS 7331. Biological Physics 1. 4 Hours.

Introduces the major classes of biological macromolecules and the physics underlying their structure, interaction, and biological function. Emphasis is on physical techniques for characterizing the structure and dynamics of proteins. Students are required to present a written and oral report on a focused research topic in molecular biophysics, based on a critical review of current scientific literature. Topics may include introduction to biomolecular structure, aqueous solution physics and hydrophobic interactions, chemical thermodynamics and reaction dynamics, spectroscopic techniques, molecular force measurements, and protein dynamics.

PHYS 7332. Condensed Matter Physics. 4 Hours.

Covers selected advanced topics in the theory of solids to be chosen each time by the interested students and instructor. Topics may include theory of normal metals, Hartree-Fock and random phase approximations, optical and transport properties, solid-state plasmas, Raman spectroscopy, quasiparticles and collective excitations, quantum solids, and amorphous solids. May be repeated without limit.

PHYS 7333. Elementary Particle Physics and Cosmology. 4 Hours.

Covers unified theories including evidence for supersymmetric SU(5) unification of couplings, and the grand unified scale and proton decay. Discusses particle physics and cosmology including a brief introduction to Einstein's theory of general relativity, candidates for dark matter, inflation and the primordial fluctuations, and the problem of the cosmological constant. Examines developments leading to string theory including normal mode expansion; open and closed strings; deduction of D-26 for bosonic and D-10 for superstrings; scattering amplitudes in strings; heterotic string; compactifications on the torus, orbifolds, and Calabi-Yau manifolds; 4-D strings; and superstring phenomenology. Explores physics with extra dimensions including gravity at small distances, branes, and new approaches to the hierachy problem. May be repeated without limit.

PHYS 7334. Topics: Condensed Matter Physics. 4 Hours.

Covers selected advanced topics in the theory of solids to be chosen each time by the interested students and instructor. Topics may include theory of normal metals, Hartree-Fock and random phase approximations, optical and transport properties, solid-state plasmas, Raman spectroscopy, quasiparticles and collective excitations, quantum solids, and amorphous solids. May be repeated without limit.
PHYS 7741. Biological Physics 2. 4 Hours.
Continues PHYS 7731. The first part of the course provides a foundation necessary to construct and implement models of neurons and networks of neurons. Topics include Hodgkin-Huxley form of the kinetical equations, single neuron models, dynamics of synapses, plasticity of synaptic strength, and neuromodulators. The second part covers nonlinear time series analysis and nonlinear dynamics in neuroscience. The goal is to provide a set of tools to analyze and model large multidimensional data sets encountered in many biological/neuroscience experiments. Topics include data testing of nonlinearity construction of linear and nonlinear models; spike sorting using independent component analysis and clustering algorithms; and analysis of continuous time series.

PHYS 7962. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

PHYS 7976. Directed Study. 1-4 Hours.
Offers independent work under the direction of a member of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

PHYS 7990. Thesis. 1-4 Hours.
Undertakes a master's thesis in a selected topic in experimental or theoretical physics. Written thesis required. May be repeated without limit.

PHYS 9984. Advanced Research. 1-8 Hours.
Provides an opportunity for advanced students to work with an individual instructor on a topic related to current research. The instructor and student negotiate a written agreement as to what topic(s) are covered and what written or laboratory work forms the basis for the grade. Viewed as a lead-in to thesis research. May be repeated without limit.

PHYS 9986. Research. 0 Hours.
Offers an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

PHYS 9990. Dissertation. 0 Hours.
Offers experimental and theoretical work for PhD candidates. Requires written thesis and final oral exam. May be repeated once.

PHYS 9996. Dissertation Continuation. 0 Hours.
Offers experimental and theoretical work for PhD candidates. Requires written thesis and final oral exam. May be repeated without limit.