

# PHYSICS (PHY)

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## **PHY SCE Senior Capstone Experience 2 Credits**

The Senior Capstone Experience is required of all majors in Physics. It consists of an experimental, theoretical, or computational investigation of a current topic in physics under the guidance of a faculty mentor. Results of these investigations will be presented in the weekly Physics Seminar and may also result in conference posters or publication in professional journals. Academic credit equivalent to one semester course (four credits) is granted upon successful completion of the Senior Capstone Experience, and a grade of Honors, Pass or Fail will be recorded on the student's transcript along with the title of the investigation.

**Term(s) Offered:** All Terms, All Years

## **PHY 100 Concepts in Contemporary Physics W/ Lab 4 Credits**

This course traces the evolving concepts of space, time, and motion through the main contributions of Galileo, Newton, Einstein, and Bohr. Topics include sizing up the universe surrounding us, the kinematics and dynamics of motion, the great conservation laws, the unification of space-time and gravity in theories of special and general relativity, the physics of black-holes, and the quantum structure of matter.

**Term(s) Offered:** Other, Non Conforming

## **PHY 101 College Physics I with Lab 4 Credits**

[Students interested in pursuing Physics or Engineering studies must take PHY 111.] An algebra-based introduction to physics for students interested in life sciences or healthcare professions. Kinematics in one and two dimensions, Newton's laws of motion, work-energy theorem, conservation of energy, conservation of linear momentum, collisions, rotational kinematics and dynamics, simple harmonic motion, Newton's law of gravitation, fluid mechanics, temperature, heat, kinetic theory, and thermodynamics. Prerequisite: High school algebra and trigonometry, or permission of the instructor.

**Term(s) Offered:** Fall, All Years

## **PHY 102 College Physics II with Lab 4 Credits**

[Students interested in pursuing Physics or Engineering studies must take PHY 112.] Second part of two-semester algebra-based introduction to physics for students interested in life sciences or healthcare professions. Electric charge, electric field and potential, conductors, dielectrics, capacitors, electric circuits and power; magnetic fields, forces on moving charges and on current-carrying wires, fields of current-carrying wires, electromagnetic induction; wave motion, superposition, physical and ray optics; quantum physics of atoms and atomic nuclei.

**Requisites:** Pre-req: PHY 101 or PHY 111

**Term(s) Offered:** Spring, All Years

## **PHY 105 Astronomy with Lab 4 Credits**

A survey of the universe, beginning with the Earth, Moon, the planets, and the Sun, and continuing outwards to distant stars, galaxies, galactic clusters, superclusters, and large-scale structure. The emphasis is on the interplay between physical theory and observation that leads to the modern astrophysical perspective of the universe. Topics include the origin and evolution of stars, formation of red giants, planetary nebulae, white dwarfs, neutron stars, supernovae, and black holes. We explore the present state of our knowledge of these objects and how this knowledge is acquired. The course concludes with a discussion of quasars and the past, present, and future of the universe according to the Big Bang cosmology.

**Term(s) Offered:** Fall, All Years

## **PHY 111 General Physics I with Lab 4 Credits**

A calculus-based introduction to physics for further study in the physical sciences and engineering. Mechanics: kinematics and dynamics of particles, conservation of momentum and energy, the law of universal gravitation, oscillations, and fluids.

**Requisites:** Pre or co-req: MAT 111 or MAT 106 and MAT 107

**Term(s) Offered:** Fall, All Years

## **PHY 112 General Physics II with Lab 4 Credits**

Second part of two-semester calculus-based introduction to physics. Thermodynamics: internal energy, heat, work, entropy, and their statistical foundations. Waves: wave propagation, superposition, interference, and physical and ray optics. Electric and magnetic fields: Coulomb's law, Gauss's law, electric potential, steady currents, magnetic forces, Ampere's and Faraday's laws.

**Requisites:** Pre-req: PHY 111 ; Pre or co-req: MAT 112

**Term(s) Offered:** Spring, All Years

## **PHY 194 Special Topics 4 Credits**

Topics not regularly offered in a department's normal course offerings, chosen based on current student interest and faculty expertise. Special topic courses can only be offered 3 times; after this, the course must be approved as a regular course. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

## **PHY 195 On-Campus Research 4 Credits**

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted on campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 196 Off-Campus Research 4 Credits**

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted off-campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 197 Physics Independent Study 4 Credits**

The study of areas of physics not covered in other courses. Instructor and student meet weekly to discuss any progress. Designed for students interested in pursuing a professional career in physics or engineering. Available to physics majors and others by agreement of instructor. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 211 Modern Physics with Lab 4 Credits**

The first part of the course will explain the special theory of relativity: simultaneity, time dilation, length contraction, Lorentz's transformations, and relativistic dynamics. The second part of the course will introduce the fundamental ideas of quantum physics: Planck's hypothesis, Bohr's model of the hydrogen atom, wave-particle duality, Schrödinger's equation, and basic applications of the formalism to atomic and molecular physics.

**Requisites:** Pre-req: PHY 112 ; Pre or co-req: MAT 210

**Term(s) Offered:** Fall, All Years

**PHY 240 Earth and Planetary Systems 4 Credits**

This course features a detailed examination of the unique interaction between the Earth's geosphere, biosphere, hydrosphere and atmosphere, and how these systems contrast with those of the other planets in the solar system. The course includes a lecture and an integrated lab component. The lecture discussion and reading emphasizes the history of Earth systems, from the birth of the solar system and differentiation of the Earth, to the emergence of biological life, chemical evolution of the modern atmosphere, and the changes to the Earth's climate, ocean and lithosphere throughout geologic history. The lab introduces students to important tools in Earth Science research, including radiometric dating, chemical studies of natural materials, remote sensing and database analysis. The course provides advanced students with the necessary scientific and intellectual background for pursuing further studies in Earth and planetary science, geography, and environmental studies.

**Requisites:** Pre or co-req: ENV 140 and ENV 141

**Cross-listed as:** PHY 240/ENV 240

**Term(s) Offered:** Other, Non Conforming

**PHY 252 Scientific Modeling & Data Analysis 4 Credits**

This course serves as a focused introduction to programming for scientists and engineers. Topics include algorithm development, statistical tests, the fast Fourier transform (FFT), simulating the dynamics of systems represented by coupled ordinary differential equations (e.g. planetary motion via Runge-Kutta methods), numerical integration, root finding, fitting functions to experimental data, and the creation of publication-quality graphics. Students choose and complete an independent research project on a topic related to their major. This course enables students to integrate computation into advanced courses in theoretical and/or experimental science. Programming language: Python.

**Requisites:** Pre or co-req: MAT 112 . PHY 112

**Cross-listed as:** PHY 252/MAT 252/CSI 252

**Term(s) Offered:** Spring, All Years

**PHY 290 Internship 4 Credits**

A learning contract is developed prior to enrollment in an internship. Evaluation of student performance is completed by the faculty mentor based on the fulfillment of the contract terms and written evaluation by the internship site supervisor. Students must work at least 45 hours for each internship credit and be enrolled in the course prior to beginning work. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

**PHY 292 Sophomore Physics Seminar 1 Credit**

The departmental seminar consists of weekly meetings of students and faculty. Meetings include both formal presentations and informal discussion. Students solve problems in physics, conduct reviews of current scientific literature, deliver oral presentations, and develop writing skills appropriate to the physics discipline. The physics seminar is also the venue for presentations of SCE projects. One credit per semester. The course is open for credit to physics majors and minors only.

**Term(s) Offered:** Spring, All Years

**PHY 294 Special Topics 4 Credits**

Topics not regularly offered in a department's normal course offerings, chosen based on current student interest and faculty expertise. Special topic courses can only be offered 3 times; after this, the course must be approved as a regular course. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

**PHY 295 Off-Campus Research 4 Credits**

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted on campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 296 Off-Campus Research 4 Credits**

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted off-campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 297 Physics Independent Study 4 Credits**

The study of areas of physics not covered in other courses. Instructor and student meet weekly to discuss any progress. Designed for students interested in pursuing a professional career in physics or engineering. Available to physics majors and others by agreement of instructor. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 321 Classical Mechanics 4 Credits**

Kinematics and dynamics of particles and rigid bodies. Topics include: Conservation laws, central forces, motion in non-inertial frames, small oscillations, and Lagrangian and Hamiltonian equations of motion.

**Requisites:** Pre-req: PHY 211, PHY 252 and MAT 310

**Term(s) Offered:** Fall, Odd Years

**PHY 322 Quantum Mechanics 4 Credits**

An introduction to the fundamental principles of quantum mechanics: quantum states and the principle of superposition, probability distributions and expectation values, observables and operators, operator representations, and perturbation theory. There will be a discussion of selected applications of the theory to atomic, solid state, and nuclear physics.

**Requisites:** Pre-req: PHY 211, PHY 252 and MAT 310

**Term(s) Offered:** Spring, Even Years

**PHY 323 Thermodynamics & Statistical Mechanics 4 Credits**

An in-depth presentation of the three laws of thermodynamics and their applications followed by a study of the statistical foundations that underpin these phenomenological laws. Additional topics include the theory of ideal gases, heat engines, statistical properties of systems of particles, the Boltzmann distribution, entropy, partition functions and quantum gases. Other topics may be included at the discretion of the instructor.

**Requisites:** Pre-req: PHY 211, PHY 252 and MAT 310

**Term(s) Offered:** Fall, Even Years

**PHY 324 Electricity and Magnetism 4 Credits**

Electric and magnetic fields in vacuum. A survey of experiments and theory leading to Maxwell's equations. Topics include: electrostatics, electric currents, magnetic fields, electromagnetic induction, Maxwell's equations, and electromagnetic waves.

**Requisites:** Pre-req: PHY 211, PHY 252 and MAT 310

**Term(s) Offered:** Spring, Odd Years

**PHY 352 Electronics with Lab 4 Credits**

The study of electronics as it is used in the physical sciences. Theory, operation and applications of R-L-C electrical circuits, diodes, transistors, operational amplifiers, timers, analog, digital, mixed-signal and microprocessor circuits.

**Requisites:** Pre-req: PHY 211 ; Pre or co-req: MAT 310

**Term(s) Offered:** Fall, All Years

**PHY 354 Optics with Lab 4 Credits**

This is a first course on electromagnetic waves, a physics/engineering students or other science/math majors with the necessary physics and mathematics background. Topics include geometrical optics and lens systems, the human eye and vision correction, the interaction of light with matter, interference and diffraction effects, and the theory and applications of lasers. A selected number of more advanced topics are covered as time allows, which may include waveguides, Fourier optics, nonlinear optics, or optical pulses and dispersion. The lab component focuses on teaching optics related skills and techniques commonly used in physics, chemistry, and engineering research.

**Requisites:** Pre-req: PHY 211 ; Pre or co-req: PHY 252

**Term(s) Offered:** Spring, Non Conforming

**PHY 390 Physics Internship 2 Credits**

A learning contract is developed prior to enrollment in an internship. Evaluation of student performance is completed by the faculty mentor based on the fulfillment of the contract terms and written evaluation by the internship site supervisor. Students must work at least 45 hours for each internship credit and be enrolled in the course prior to beginning work. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

**PHY 391 Junior Physics Seminar I 1 Credit**

The departmental seminar consists of weekly meetings of students and faculty. Meetings include both formal presentations and informal discussion. Students solve problems in physics, conduct reviews of current scientific literature, deliver oral presentations, and develop writing skills appropriate to the physics discipline. The physics seminar is also the venue for presentations of SCE projects. One credit per semester. The course is open for credit to physics majors and minors only.

**Term(s) Offered:** Fall, All Years

**PHY 392 Junior Physics Seminar II 1 Credit**

The departmental seminar consists of weekly meetings of students and faculty. Meetings include both formal presentations and informal discussion. Students solve problems in physics, conduct reviews of current scientific literature, deliver oral presentations, and develop writing skills appropriate to the physics discipline. The physics seminar is also the venue for presentations of SCE projects. One credit per semester. The course is open for credit to physics majors and minors only.

**Term(s) Offered:** Spring, All Years

**PHY 394 Special Topics 4 Credits**

Topics not regularly offered in a department's normal course offerings, chosen based on current student interest and faculty expertise. Special topic courses can only be offered 3 times; after this, the course must be approved as a regular course. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

**PHY 395 On-Campus Guided Research 4 Credits**

An on-campus summer research project guided by a faculty mentor. Based on mutual interests, the student and faculty mentor develop a research project supported by a reading list and involving theoretical, laboratory, or field investigations supervised by the faculty mentor. Participants produce a final report detailing the findings of their research. Selection of students depends on academic background, scholastic achievement, and the results of a personal interview with the faculty mentor.

**Term(s) Offered:** Summer, All Years

**PHY 396 Off-Campus Research 4 Credits**

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted off-campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

**Term(s) Offered:** Summer, All Years

**PHY 397 Independent Study 4 Credits**

The study of areas of physics not covered in other courses. Instructor and student meet weekly to discuss any progress. Designed for students interested in pursuing a professional career in physics or engineering. Available to physics majors and others by agreement of instructor. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years

**PHY 451 Advanced Physics Laboratory 4 Credits**

Advanced experiments in mechanics, electromagnetism, waves, physical and geometrical optics, thermal and statistical physics, atomic, and nuclear physics.

**Requisites:** Pre or co-req: PHY 352 or PHY 354

**Term(s) Offered:** Fall, All Years

**PHY 490 For-Credit Internship 1 Credit**

A learning contract is developed prior to enrollment in an internship. Evaluation of student performance is completed by the faculty mentor based on the fulfillment of the contract terms and written evaluation by the internship site supervisor. Students must work at least 45 hours for each internship credit and be enrolled in the course prior to beginning work. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

**PHY 491 Senior Physics Seminar I 1 Credit**

The departmental seminar consists of weekly meetings of students and faculty. Meetings include both formal presentations and informal discussion. Students solve problems in physics, conduct reviews of current scientific literature, deliver oral presentations, and develop writing skills appropriate to the physics discipline. The physics seminar is also the venue for presentations of SCE projects. One credit per semester. The course is open for credit to physics majors and minors only.

**Term(s) Offered:** Fall, All Years

**PHY 492 Senior Physics Seminar II 1 Credit**

Weekly meetings of students and faculty. Students are required to read journal articles of current interest in physics and astronomy and give oral presentations summarizing their contents. One credit per semester. Can be taken up to four times for credit. Open for credit to physics majors and minors only.

**Term(s) Offered:** Spring, All Years

**PHY 494 Special Topics 4 Credits**

Topics not regularly offered in a department's normal course offerings, chosen based on current student interest and faculty expertise. Special topic courses can only be offered 3 times; after this, the course must be approved as a regular course. Graded A-F or Pass/Fail.

**Term(s) Offered:** All Terms, All Years

**PHY 495 On-Campus Guided Research 4 Credits**

An on-campus summer research project guided by a faculty mentor. Based on mutual interests, the student and faculty mentor develop a research project supported by a reading list and involving theoretical, laboratory, or field investigations supervised by the faculty mentor. Participants produce a final report detailing the findings of their research. Selection of students depends on academic background, scholastic achievement, and the results of a personal interview with the faculty mentor.

**Term(s) Offered:** Summer, All Years

**PHY 496 Off-Campus Research 4 Credits**

An agreement between a sponsoring faculty member and a student researching a topic of interest that is relevant to a student's major or minor. Research is conducted off-campus. Students must be enrolled before the research can begin. Graded A-F or Pass/Fail. 45 hours are required per credit.

**Term(s) Offered:** Summer, All Years

**PHY 497 Independent Study 4 Credits**

The study of areas of physics not covered in other courses. Instructor and student meet weekly to discuss any progress. Designed for students interested in pursuing a professional career in physics or engineering. Available to physics majors and others by agreement of instructor. 45 hours are required per credit.

**Term(s) Offered:** All Terms, All Years