PHYSICS

Chair: Gintaras K. Duda
Department Office: Hixson-Lied Science Building, Room G81

The physics degree program provides a strong foundation for careers in the rapidly developing high-tech industries, engineering, medicine and law. For students who complete a degree in physics, the rewards are a deep understanding of nature, unusual flexibility in the choice of a career, and exceptional strength and stability in the job market.

Specific Requirements for Admission to the Physics Major

- PHY 213 General Physics for the Physical Sciences I[1], PHY 205 General Physics Laboratory I , PHY 214 General Physics for the Physical Sciences II[2] and PHY 206 General Physics Laboratory II or an "A" or "B" grade in both PHY 213 and PHY 205.

Majors in Physics

- B.S., Major in Physics (http://catalog.creighton.edu/undergraduate/arts-sciences/physics/physics-bs/)
- B.S., Major in Applied Physical Analysis (http://catalog.creighton.edu/undergraduate/arts-sciences/physics/applied-physical-analysis-bs/)
- B.S., Major in Biomedical Physics (http://catalog.creighton.edu/undergraduate/arts-sciences/physics/biomedical-physics-bs/)
- B.S. Phy., Major in Physics (http://catalog.creighton.edu/undergraduate/arts-sciences/physics/physics-bsphy/)

1 PHY 221 Advanced General Physics I:Modeling the Physical World or PHY 201 General Physics for the Life Sciences can be substituted for the PHY 213 requirement.

2 PHY 222 Advanced General Physics II:Modeling the Physical World or PHY 202 General Physics for the Life Sciences II can be substituted for the PHY 214 requirement.

Minors in Physics

- Biological Physics (http://catalog.creighton.edu/undergraduate/arts-sciences/physics/biological-physics-minor/)
- Physics (http://catalog.creighton.edu/undergraduate/arts-sciences/physics/physics-minor/)

Courses

PHY 105. Frontiers in Astronomy. 2 credits. FA, SP
Covers select topics in astronomy at the frontiers of research including the big bang and evolution of the universe, dark matter, dark energy, black holes, quasars, and the search for exoplanets and life in the universe. The scientific method and experimental tools used by astronomers are explored.

PHY 107. Introductory Astronomy. 3 credits. OD
This course provides a broad survey of our scientific understanding of the physical processes, structure, and evolution of objects in the universe. It consists of a lecture and lab component. Topics include the nature and motions of celestial objects, the solar system, stars, galaxies, stellar remnants, large-scale structure and cosmology. P. Understanding Natural Science.

PHY 109. Introductory Astronomy. 3 credits. FA, SP
This course provides a broad survey of scientific understanding of the physical processes, structure, and evolution of objects in the universe in a lecture format. Topics include the nature and motions of celestial objects, the solar system, stars, galaxies, stellar remnants, large-scale structure in the universe and cosmology. P. MTH 141 or MTH 205 or MTH 245; One Magis Core Understanding Natural Science course. CO: PHY 110 or IC.

PHY 110. Astronomy Laboratory. 1 credit. FA, SP
An introductory lab course that provides a deeper inquiry into fundamental concepts in astronomy through hands-on activities. Topics covered include the nature and motions of celestial objects, fundamental physical laws, the solar system, stars, galaxies, stellar remnants, and cosmology. P. MTH 141 or MTH 205 or MTH 245; One Magis Core Understanding Natural Science course. CO: PHY 109 or IC.

PHY 123. Science for a Changing Planet: An Introduction to Earth Systems. 3 credits. (Same as EVS 123)
Introduction to the study of the earth system science for science and non-science majors. Topics include: the earth as a system, the geosphere, the hydrosphere, the atmosphere, the biosphere and the anthroposphere. This course explores the interactions between the earth systems, including how anthropologic processes modify the Earth's environment. P. Understanding Natural Science. CO: PHY 124.

PHY 124. Earth System Science Laboratory. 1 credit. (Same as EVS 124)
Laboratory work to acquaint the student with data collection and analysis, and earth system topics such as the earth as a system, the geosphere, the hydrosphere, the atmosphere, the biosphere and the anthroposphere. Appropriate for science and non-science majors. P. Understanding Natural Science. CO: PHY 123.

PHY 127. Sound and Music. 3 credits. OD
Basic course on the nature of sound, covering the generation, propagation and detection of sound, with particular applications to music.

PHY 131. Quantum Physics and Technology for Everyone. 2 credits. (Understanding Natural Science)
Basic concepts in quantum physics and information science for non-science majors, including quantum states, measurements, quantum bits, entanglement, and coherence. Applications in quantum computing, quantum communication, and quantum sensing. Prereq: Mathematical Reasoning.

PHY 137. Light, Color, and Lasers. 3 credits. OD
A basic course on the nature of light and its applications; sources of light; wave-particle duality; lasers and holography; images and illusions; special effects; color variables and color vision. The subject of light is used as a basis to explore a wide range of physical phenomena and to examine the goals, methods and limitations of science. Since its essential characteristics are embodied in the postulates of relativity and quantum theory, light is seen to lie at the foundation of modern scientific thought. Course features many classroom demonstrations. No formal science or mathematics prerequisites.

PHY 147. Einstein and Modern Physics. 3 credits. OD
Historical and philosophical study of the reciprocal influences between Albert Einstein and the social and scientific communities of his time, including his changing attitude toward pacifism, his relationship to the Zionist movement, his philosophy of knowledge, his relationship with other scientists, and his basic contributions to science. No formal science or mathematics prerequisites.

PHY 157. Sustainable Energy. 2 credits. SP
Uses fundamental physical principles and hands-on exploration to develop an understanding of the energy sources available for our use. Covers current trends in energy production and consumption and an evaluation of the potential for a sustainable energy supply. Societal, technical and ethical considerations related to energy usage are emphasized.

PHY 187. Conceptual Physics. 2 credits. FA
Basic physics concepts and principles in areas of motion, force and energy, liquids and gases, thermodynamics, electricity and magnetism, light, sound, and x-ray and nuclear radiations, with examples from daily life as illustrations. Includes practice in conceptual, mathematical, graphical and statistical solution techniques of simple physics problems.

PHY 188. Physics in the Everyday World. 1 credit. OD
Experimental investigation of physical concepts as applied to geology, astronomy, motion, fluids, electricity, magnetism, waves, and quantum physics. This course may be taken by itself or in combination with PHY 127, 137, 147, or 187. No formal science or mathematics prerequisites.

PHY 191. Exploring the Frontiers of Physics. 1 credit. OD
Survey of the current research frontier in the physical sciences. Each week, faculty will introduce and lead a discussion on a contemporary research field, focusing on the scientific and social significance. No formal math or science pre-requisites, intended for students interested in pursuing careers in the physical sciences. Repeatable to a maximum of 4 credits.

PHY 195. Selected Topics in Physics. 1-6 credits. OD
A physics project or special study in physics outside the normal curricular boundaries.

PHY 201. General Physics for the Life Sciences. 3 credits. FA, SP, SU
First semester of the general physics sequence for life sciences majors. Topics include kinematics, Newton's laws of motion, conservation of momentum and energy, rotational dynamics, thermodynamics, and fluids. P. MTH 139 or higher OR co-req of MTH 231 or higher. CO: PHY 205.

PHY 202. General Physics for the Life Sciences II. 3 credits. FA, SP, SU
Second semester of the general physics sequence for life science majors. Topics include waves, electricity, magnetism, optics and modern physics. P. PHY 201 or PHY 213 or PHY 221 or DC; CO: PHY 206 or DC.

PHY 205. General Physics Laboratory I. 1 credit. FA, SP, SU
Laboratory work designed to acquaint the student with the measurement and uncertainty, error analysis, and physics topics such as thermodynamics and fluids. CO: PHY 201 or PHY 213 or PHY 221.

PHY 206. General Physics Laboratory II. 1 credit. FA, SP, SU
This lab is designed to accompany PHY 202, PHY 214 or PHY 222. In addition to laboratory activities, one contact hour of weekly lecture is included. Topics include oscillations, waves, optics, and d.c. circuits. This course is algebra-based. P. PHY 205; CO: PHY 202 or PHY 214 or PHY 222 or DC.

PHY 213. General Physics for the Physical Sciences I. 3 credits. FA, SP
First semester of the general physics sequence for physical science majors. Topics include kinematics, Newton's laws of motion, conservation of momentum and energy, rotational dynamics, thermodynamics, and fluids. CO: MTH 245 and; PHY 205 or PHY 223 or department consent.

PHY 214. General Physics for the Physical Sciences II. 3 credits. FA, SP
Second semester of the general physics sequence which is intended for students majoring in the physical sciences. Lecture and discussion. Topics include oscillations, waves, optics, electricity and magnetism, and modern physics. Calculus based. P. PHY 213 or PHY 221 or PHY 201, or MTH 245; CO: PHY 206 or DC.

PHY 221. Advanced General Physics I:Modeling the Physical World. 3 credits. FA
First semester in the physics sequence with a particular emphasis on mathematical modeling. Course is taught jointly with MTH 249. Topics include kinematics, Newton's laws of motion, conservation of momentum and energy, rotational dynamics, and fluids. P. MTH 245; CO: MTH 249.

PHY 222. Advanced General Physics II:Modeling the Physical World. 3 credits. SP
Second semester in the physics sequence with a particular emphasis on mathematical modeling. Course is taught jointly with MTH 349. Topics include oscillations, waves, optics, electricity and magnetism, and modern physics. P. PHY 221 or IC; CO: MTH 349.

PHY 223. Project Physics Laboratory I. 1 credit.
Project-based laboratory experiences to acquaint the student with physical phenomena, instrumentation and research methods in physics. Topics include kinematics, Newton's laws of motion, conservation of momentum and energy, rotational dynamics, thermodynamics, and fluids. CO: PHY 213.

PHY 224. Project Physics Laboratory II. 1 credit.
Project-based laboratory experiences to acquaint the student with physical phenomena, instrumentation and research methods in physics. Topics include oscillations, waves, optics, electricity and magnetism, DC and AC circuits, and modern physics. P or CO: PHY 222.

PHY 301. Modern Physics. 3 credits. FA, SP
An introduction to relativity and quantum physics. Special theory of relativity; quantization of electrical charge, energy and light; Bohr model of the atom; wave aspect of particles; wave-particle duality; Schroedinger equation in one dimension; applications of relativity and quantum theory in atomic, nuclear, and elementary particle physics. P. PHY 214 or PHY 222 or 202; and MTH 246.

PHY 302. Modern Physics Laboratory. 1 credit. FA
Laboratory work designed to acquaint the student with the quantization of electrical charge, energy and light, and the wave aspect of particles. CO: PHY 301. P. One Magis Core Mathematical Reasoning course.

PHY 303. Electronics Laboratory. 1 credit. FA
Basic course in electronics. Laboratory experiments include an introduction to measuring instruments, and applications of solid state components, and analog and digital integrated circuits. P. PHY 214 or PHY 222 or PHY 202.

PHY 351. Physics in Medicine. 3 credits. AY, FA
A review of basic physics as it applies to radiation and the human body followed by an overview of major topics in the field of medical physics: x-rays and their uses in medical imaging, physics of nuclear medicine imaging, ultrasound imaging, magnetic resonance imaging, radiation therapy for cancer, and radiation biology. P. PHY 214 or PHY 222 or PHY 202.

PHY 353. Introduction to Biological Physics. 3 credits. AY, FA
An introduction to the application of physics to the microscopic world of the living cell. Topics include: Diffusion, fluid dynamics at low Reynolds-number, thermodynamics of microscopic systems, chemical and entropic forces, self-assembly of ordered structures, mechanical and nerve impulses. P. PHY 214 or PHY 222 or PHY 202; and MTH 246.

PHY 397. Research Methods. 2 credits.
This course covers the foundational skills needed by students to conduct research in theoretical and experimental physics. Course topics include an introduction to scientific computing, measurement, data analysis, and error propagation, basic electronics skills, scientific writing, and an introduction to mathematical software packages. P. PHY 205; PHY 206; Mathematical Reasoning course.

PHY 471. Classical Mechanics. 3 credits. SP
Review of particle dynamics, the harmonic oscillator, rigid body mechanics, generalized coordinates; introduction to Lagrange's and Hamilton's equations. P. PHY 214 or PHY 222 or PHY 202; CO: MTH 347 or MTH 349 or MTH 350 or Instructor Consent.

PHY 481. Electricity and Magnetism. 3 credits. FA
Development of Maxwell's equations; Laplace's and Poisson's equations and boundary value problems; electromagnetic waves. P. PHY 214 or PHY 222 or PHY 202; and MTH 347.

PHY 491. Seminar. 1 credit. FA, SP
Undergraduate seminar. Training in the organization and presentation of papers on advanced topics in physics. May be repeated to a maximum of three credits. P. IC, One Magis Core Oral Communication course and One Magis Core Contemporary Composition course.

PHY 493. Directed Independent Readings. 1-3 credits. FA, SP, SU
A readings project under the guidance of a member of the faculty. Credit by arrangement. May be repeated to a maximum of six hours. P. IC.

PHY 495. Directed Independent Study. 1-3 credits. FA, SP, SU
A study project under the guidance of a member of the faculty. Credit by arrangement. May be repeated to a maximum of six hours. P. IC.

PHY 497. Directed Independent Research. 0-3 credits. FA, SP, SU
A research project under the guidance of a member of the faculty. Credit by arrangement. May be repeated to a maximum of six hours. P. IC.

PHY 499. Research Capstone. 1 credit.
This course serves as a capstone experience for undergraduate research. Students will organize and present, in written form, a comprehensive summary of their research project. Topics include literature search techniques and review, the use of bibliography and citation managers, scientific writing, peer review, and how to make scientific presentations. P. PHY 397; Contemporary Composition course. Co: PHY 497.

PHY 511. Physical Optics. 3 credits.
Mathematical representation of waves; interference, diffraction and polarization; coherence and incoherence; lasers; Fourier analysis and synthesis. P. PHY 214 or PHY 222 or PHY 202.

PHY 512. Optics Laboratory. 1 credit.
Experiments in geometrical and physical optics: interferometry; lasers and holography; analytical methods based on optical principles. 3L. CO: PHY 511.

PHY 521. Electronics For Scientists. 3 credits. FA, OD
Basic course in electronics. Laboratory experiments include an introduction to measuring instruments, solid state components, and digital and logic circuits. Lecture closely follows the experiments. 1R, 5L. P. PHY 214 or PHY 222 or PHY 202.

PHY 522. Electric Circuits. 3 credits. FA, OD
Kirchhoff's Laws. Solutions to homogeneous and non-homogeneous linear systems in electronics. AC and DC circuit response. Computer-assisted modeling of circuits. P. IC.

PHY 531. Quantum Mechanics. 3 credits. FA
Development of the formalism of non-relativistic quantum mechanics; applications to the harmonic oscillator, the hydrogen atom, square-well potential, and scattering. P. PHY 301 and PHY 471.

PHY 541. Thermodynamics And Statistical Mechanics. 3 credits. FA
Laws of thermodynamics, thermodynamic variables, thermodynamic potentials; kinetic theory, distribution functions, classical and quantum statistics. P. PHY 214 or CHM 331 or PHY 222 or PHY 202; and MTH 246.

PHY 551. Mathematical Physics. 3 credits. FA
Mathematical methods for the representation of physical processes in space and time. Fourier and other complete representations; vector calculus; tensors and matrices. Selection and emphasis on topics keyed to needs of students enrolled. P. PHY 212 or PHY 222; MTH 347.

PHY 553. Computational Physics. 3 credits. OD
The course offers an introduction to scientific computing techniques for physics students. The course will offer training in computational software and programming language to model complex systems and/or to analyze data. Examples are drawn from a variety of subfields of physics. P. PHY 214 or PHY 222 or DC.

PHY 559. Gravitation and Cosmology. 3 credits. OD
An introduction to standard big bang cosmology utilizing Einstein's general theory of relativity. Topics in relativity will include tensor analysis, Reimannian geometry, and the Einstein equation. Topics in cosmology will include the Friedman-Robertson-Walker metric, the age of the universe, dark matter and dark energy, and early universe thermodynamics. P. PHY 301.

PHY 561. Nuclear Physics. 3 credits. OD
Application of elementary quantum mechanical theory and relativity to the study of nuclear structure, radioactive decay, and nuclear models. P. PHY 531.

PHY 562. Nuclear Instruments And Methods. 2 credits. OD
Laboratory work in nuclear physics designed to teach the methods and procedures of experimental nuclear physics at an advanced level and to familiarize the student with modern research equipment and its use. 3L. P. PHY 302 or IC.

PHY 563. High Energy Nuclear Physics. 1 credit. OD
Students will read and discuss original journal articles related to the historical development of high energy physics. P. PHY 214 or PHY 222 or PHY 202; and MTH 246; or IC.

PHY 565. Radiation Biophysics. 3 credits.
A systematic study of the mechanisms by which ionizing radiation affect cells and biomolecules, pertaining to radiation therapy. Topics include: Physical mechanisms for radiation absorption, Kerma, dose, LET, track structure, water radiochemistry, mathematical survival models, DNA damage, repair mechanisms, RBE, OER, linear no-threshold model, bystander effects, and dose fractionation. P. Permission of instructor.

PHY 566. Physics of Medical Imaging I. 3 credits.
A systemic study of medical imaging including projection x-ray, mammography, fluoroscopy, and computed tomography. For each imaging modality, the mathematical foundation, physical mechanisms, technology involved in clinical implementation, technique strengths and limitations, quantification of image quality, and routine quality assurance procedures will be examined. P. Permission of instructor.

PHY 567. Physics of Medical Imaging II. 3 credits.
A systemic study of medical imaging including projection x-ray, mammography, fluoroscopy, and computed tomography. For each imaging modality, the mathematical foundation, physical mechanisms, technology involved in clinical implementation, technique strengths and limitations, quantification of image quality, and routine quality assurance procedures will be examined. P. PHY 566.

PHY 571. Condensed Matter Physics. 3 credits. OD
An introduction to the structure and dynamics of solids and liquids including solid state physics. Topics include the structure of crystalline, amorphous and self-similar (fractal) matter as conveyed by scattering techniques, the vibrational properties of crystals, the dynamics of liquids, electron dynamics in crystals (including band theory), response functions, percolation theory, and phase transitions (with an emphasis on critical phenomena, scaling and renormalization). P. PHY 301 or CHM 341 or IC.

PHY 572. Condensed Matter Laboratory. 1 credit. OD
Laboratory work designed to acquaint the student with spectroscopy techniques used in condensed matter and material science, including: static and dynamic light scattering, Raman spectroscopy, X-ray diffraction, scanning tunneling microscopy, and dielectric spectroscopy. 3L. CO: PHY 571 or IC.

PHY 581. Advanced Laboratory I. 1 credit. FA
Advanced laboratory work in physics designed to teach the methods of experimental research in physics. Students will work in collaborative teams on two open-ended experiments, each lasting six weeks, drawn from any physics subfield. Students will also develop a research proposal to be executed in PHY 582, Advanced Laboratory II. P. PHY 302, 303, and 332.

PHY 582. Advanced Laboratory II. 1 credit. SP
Advanced laboratory designed to teach the methods of experimental research in physics. Students will work in collaborative teams to complete a project of their own design, including literature review, design and execution of the experiment, data analysis (including statistical testing) and a written report. Students will participate in mock peer-review. P. Phy 581.

PHY 587. Laser Physics. 3 credits. OD
A thorough review of the essential optical and physical principles needed for understanding laser characteristics, operation and design. Topics include the principle of detailed balance, absorption, stimulated emission, gain, obtaining population inversions, pumping requirements, laser cavity modes, Gaussian beams, laser resonators, Q-switching, mode-locking, and an overview of specific laser systems including gas-tube and solid-state lasers. P. PHY 331 or IC.

PHY 591. Seminar in Engineering. 1-3 credits. OD (Same as ERG 591)
This course will prepare students particularly interested in careers in energy technology, engineering, or related disciplines, to gain internship and employment opportunities. Students will be exposed to diverse disciplines and fields in these areas via guest speakers and personal research which all will continue the development of written and oral communication skills as well as further the development of the students' ethical awareness in their careers. P. Contemporary Composition; Oral Communication; Ethics.

PHY 595. Special Topics. 1-3 credits. OD
A course treating physics topics of special interest. The course will be subtitled in the Schedule of Classes and may be repeated under different subtitles. P. IC.