Physics Department (PHY)

College of Science and Health
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www.uwlax.edu/academics/department/physics (https://www.uwlax.edu/academics/department/physics/)

The Physics Department at UW-La Crosse is one of the largest undergraduate physics programs in Wisconsin and is well-known for offering quality education, placing its graduates in successful career paths, and attracting national recognition for its successful efforts.

The diverse nature of the physics program makes our graduates highly sought after in modern industries where physics and engineering are applied. In addition, many UW-La Crosse physics graduates are accepted into top graduate degree programs where they can pursue a master's or doctoral degree in physics, engineering, chemistry, astrophysics, optical science, mathematics, medicine, or computer science.

In addition to our unique programs, the Physics Department also stands out in its emphasis on involving its physics majors in undergraduate research. This engages students to work closely with individual members of the faculty, providing hands-on learning opportunities which are very different from the traditional classroom experience. The involvement of students in research contributes to the sense of community that pervades the UW-La Crosse Physics Department. Research projects are available in the following areas: astrophysics, biomechanics, computational physics, laser spectroscopy, quantum computing, material science, nuclear physics, solid-state physics, and physics education.

General education writing emphasis

This department incorporates a significant amount of writing through the required courses instead of identifying particular courses as writing emphasis courses. Students who complete a major in this department will fulfill the general education writing emphasis requirement (http://catalog.uwlax.edu/undergraduate/generaleducation/#generaleducationrequirementstext).

2024-25 Faculty/Staff

The following is the department's faculty and staff as of the publication date of this catalog. This list will not be updated again until the next catalog is published in July.

Professor

Eric Barnes, Ph.D.

Jennifer Docktor, Ph.D. (Department Chair)

Eric Gansen, Ph.D.

Ju Kim, Ph.D. (Dean, CSH)

Seth King, Ph.D.

Shelly Lesher, Ph.D.

Robert Ragan, Ph.D.

Shauna Sallmen, Ph.D.

Assistant Professor

Shahid Iqbal, Ph.D.

Associate Teaching Professor

Eric Hall

Administrative and Lab/Technical Support

Rí Allenby

Krista Anderson

Majors

- Physics major - BA (http://catalog.uwlax.edu/undergraduate/physics/physics-ba/)
- Physics major - BS (http://catalog.uwlax.edu/undergraduate/physics/physics-bs/)
- Physics major with applied physics emphasis - BS (http://catalog.uwlax.edu/undergraduate/physics/applied-bs/#majorrequirementstext)
- Physics major with astronomy emphasis - BA (http://catalog.uwlax.edu/undergraduate/physics/astronomy-ba/)
- Physics major with astronomy emphasis - BS (http://catalog.uwlax.edu/undergraduate/physics/astronomy-bs/)
- Physics major with biomedical concentration - BS (http://catalog.uwlax.edu/undergraduate/physics/biomedical-bs/)
- Physics major with business concentration - BS (http://catalog.uwlax.edu/undergraduate/physics/business-bs/)
- Physics major with computational physics emphasis - BS (http://catalog.uwlax.edu/undergraduate/physics/computational-physics-bs/)
- Physics major with optics emphasis - BS (http://catalog.uwlax.edu/undergraduate/physics/optics-bs/)

Teacher education program

- Physics major: science education (grades 4-12) concentration -BS (http://catalog.uwlax.edu/undergraduate/physics/education/)

Dual degree programs

- Dual degree program in physics and engineering (http://catalog.uwlax.edu/undergraduate/physics/dual-degree-physics-engineering/)
- Dual degree program in physics and physical therapy (http://catalog.uwlax.edu/undergraduate/physics/dual-degree-physics-physical-therapy/)

Minors

- General science for teachers minor (http://catalog.uwlax.edu/undergraduate/physics/generalscienceforteachersminor/)
- Physics minor (http://catalog.uwlax.edu/undergraduate/physics/physicsminor/)

- Physics minor with astronomy emphasis (http://catalog.uwlax.edu/undergraduate/physics/physicsminorwithastronomy/)

Honors

- Physics and astronomy honors program (http://catalog.uwlax.edu/undergraduate/physics/honors-program/)

Courses

+PHY 103 Cr.4
Fundamental Physics I
A broad theoretical and experimental introduction to the study of physics using the techniques of algebra and trigonometry. Topics covered are kinematics with constant acceleration, vectors, Newton's laws of motion, circular motion, work, energy, momentum, rigid body motion, angular momentum, torque, oscillatory motion, gravitation, fluid mechanics, waves, resonance and sound. Additional topics may be selected from the area of thermodynamics. Wherever possible, applications to other fields of science such as chemistry, biology, and medicine will be discussed. Taking MTH 150 prior to this course is recommended. Lect. 3, Lab. 2. Offered Fall, Spring, Summer.

PHY 104 Cr.4
Fundamental Physics II
Continuation of PHY 103. Topics covered are electric forces and fields, electric potential, electrical circuit theory and applications, magnetic fields, electromagnetic induction, alternating current circuits, electromagnetic waves and the nature of light, lenses, mirrors, optical instruments, interference and diffraction of light, Einstein's theory of relativity, and the photoelectric effect. Additional topics may be selected from the area of quantum physics. Wherever possible, applications to other fields of science such as chemistry, biology and medicine will be discussed. Lect. 3, Lab 2. Prerequisite: PHY 103 or PHY 203; MTH 150 recommended. Offered Fall, Spring, Summer.

+PHY 106 Cr.4
Physical Science for Educators
A survey course focusing on applied physical science and the nature of scientific knowledge. Fundamental theories about the nature and interactions of matter and energy are developed using self-paced, small group, inquiry based teaching modules. The scientific knowledge developed is applied to issues of technology in society and everyday use situations. Emphasis is on modeling science teaching practices advocated by state and national science education standards using active learner practices. Lect. 3, Lab. 2. Prerequisite: elementary/middle level education major. Offered Fall, Spring.

PHY 134 Cr.4
Physics for Nuclear and Radiological Sciences
This course is an introductory study of physics concepts using algebra and trigonometry, designed for nuclear and radiological science students. Topics include kinematics, vectors, Newton's laws of motion, circular motion, energy, momentum, waves, electric forces and fields, electric potential, and magnetic fields. Wherever possible, applications to medical fields are discussed. Note: This class is specifically designed for students in the Nuclear Medicine Technology and Radiologic Science programs. Lect. 3, Disc 1. Offered Annually.

+PHY 142 Cr.3
Navigating Global Nuclear Issues
This course will serve as an introduction to the topic of nuclear weapons, energy and policy in society. This includes the social, economic, cultural and political aspects surrounding the development of nuclear weapons and their place in the world, especially in current events. International organizations will be discussed along with their role in regulation and recommending economic sanctions. We will look at the resurgence of nuclear energy and how it affects everything from the environment to global trade. Finally, the role of terrorism and the impact this has on shaping the human experience will be explored. Offered Occasionally.

+PHY 155 Cr.4
Solar System Astronomy
An introduction to astronomy as a science, emphasizing patterns in the night sky, our own solar system, and the possibility of life on other worlds. Throughout the course, comparison of observations with theoretical models will be stressed. Topics studied include the size and scale of the solar system relative to the universe; the scientific method; astronomical observations; motions of the earth, moon, sun, and planets; creating a model of the solar system; what we learn about planets from light and gravity; the structure and formation of the solar system; the planets and their moons; comets, asteroids, and meteoroids; and the possibility of life elsewhere in the universe. Recent results, including those from NASA missions, will be incorporated into the course. Lect. 3, Lab 2. Offered Fall.

PHY 156 Cr.3
Solar System Astronomy Lectures
An introduction to astronomy as a science, emphasizing patterns in the night sky, our own solar system, and the possibility of life on other worlds. Throughout the course, comparison of observations with theoretical models are stressed. Topics include the size and scale of the solar system relative to the universe; the scientific method; astronomical observations; motions of the earth, moon, sun, and planets; creating a model of the solar system; what we learn about planets from light and gravity; the structure and formation of the solar system; the planets and their moons; comets, asteroids, and meteoroids; and the possibility of life elsewhere in the universe. There is no lab component for this course, but PHY 155 has a lab component and covers similar material. Prerequisite: Students cannot earn credit for both PHY 155 and PHY 156. Offered Fall.

+PHY 160 Cr.4
Stars, Galaxies and the Universe
An introduction to astronomy as a science, emphasizing celestial objects beyond our solar system. Throughout the course, comparison of observations with theoretical models will be stressed. Topics studied include the size and scale of the universe, using light and gravity to study the cosmos, the sun, the properties of other stars, lives and deaths of stars, star clusters, black holes, the Milky Way galaxy, dark matter, other galaxies, quasars, Big Bang cosmology, dark energy, and gravitational waves. Particular emphasis will be placed on recent discoveries. Lect. 3, Lab 2. Offered Spring.

PHY 161 Cr.3
Stars, Galaxies and the Universe Lectures
An introduction to astronomy as a science, emphasizing celestial objects beyond our solar system. Throughout the course, comparison of observations with theoretical models be stressed. Topics include the size and scale of the universe, using light and gravity to study the cosmos, the sun, the properties of other stars, lives and deaths of stars, star clusters, black holes, the Milky Way galaxy, dark matter, other galaxies, quasars, Big Bang cosmology, dark energy, and gravitational waves. Particular emphasis will be placed on recent discoveries. There is no lab component for this course, but PHY 160 has a lab component and covers similar material. Prerequisite: Students cannot earn credit for both PHY 160 and PHY 161. Offered Spring.

+PHY 203 Cr.4
General Physics I
A broad theoretical and experimental introduction to the study of physics using the techniques of algebra, trigonometry and calculus. Topics covered are one-and two-dimensional kinematics, motion with varying acceleration, vectors, Newton's laws of motion, circular motion, work, energy, center of mass, momentum, rigid body motion, moment of inertia, angular momentum and torque. Additional topics may include oscillatory motion and gravitation. Wherever possible, applications to other fields of science and engineering will be discussed. Lect. 3, Lab. 2. Prerequisite: MTH 207 or concurrent enrollment. Offered Fall.

PHY 204 Cr.4
General Physics II
Continuation of PHY 203. Topics covered are fluid mechanics, sound, electrostatics, electric forces and fields, electric flux, electric potential, capacitance, elementary electrical circuit theory and applications, magnetic fields, magnetic flux and electromagnetic induction. Additional topics may include Maxwell's equations, alternating current circuits, electromagnetic waves and the nature of light. Wherever possible, applications to other fields of science and engineering will be discussed. Lect. 3, Lab 2. Prerequisite: PHY 103 or PHY 203; MTH 208 or concurrent enrollment. Offered Spring.

PHY 305 Cr.3
General Physics III
This is the third course of introduction to physics using calculus. Topics covered are mechanical and thermal descriptions of solids and fluids, fundamentals of thermodynamics, waves, sound, and optics. Prerequisite: PHY 104 or PHY 204; MTH 208 or concurrent enrollment. Offered Fall.

PHY 306 Cr.3
Modern Physics
The application of principles studied in fundamental or general physics to various areas of research and technology at the forefront of modern physical science. Topics include special relativity, origins of quantum mechanics, atomic spectroscopy, nuclear structure, and nuclear reactions. Select topics in heat, the laws of thermodynamics, kinetic theory, molecular spectroscopy, band theory of solids, semiconductors, and superconductors may also be included. Prerequisite: PHY 305; MTH 208. Offered Spring.

PHY 308 Cr.3
Optics
This course covers the mathematical treatment and modern applications of electromagnetic theory; propagation of light; geometrical optics, with emphasis on fiber optics and the formation of images in cameras, microscopes, and telescopes; physical optics, with emphasis on spectroscopy and the resolution limits of optical systems; and lasers. Topics in modern optics may also include holography. Prerequisite: PHY 305. Offered Occasionally.

PHY 311 Cr.2
Experimental Physics
Basic techniques of measurement used in all areas of physics and engineering. Selected experiments may include thin lens systems, spectrometers, microwave optics, interference and diffraction, aberrations, interferometers, thin films, polarization, speed of light, charge-to-mass ratio of an electron, electron spin resonance, quantization of energy states, and radioactive decay. Computational techniques include error analysis, graphing and curve fitting. Lect. 1, Lab 3. Prerequisite: PHY 250 and PHY 302 or PHY 305 and PHY 306. Offered Fall.

PHY 314 Cr.3
Introduction to Biophysics
We build on introductory physics topics that will be used to investigate biological problems. This course will be taught at the intermediate level, targeting students interested in learning more about the role of physics in biology. Topics covered in this class will include statistical physics and thermodynamics (introduced as needed). Other topics may include (but are not limited to): diffusion, entropy, filament mechanics, motor dynamics, hemodynamics, and cellular electrostatics. Additional topics may include medical physics applications. Prerequisite: PHY 306. PHY 308 strongly recommended. Offered Occasionally.

PHY 320 Cr.3
Statics
Principles of statics and free-body diagrams with applications to simple trusses, frames, and machines. Includes topics in force/movement vectors, resultants, distributed loads, internal forces in beams, properties of areas, moments of inertia and the laws of friction. Prerequisite: PHY 103 or PHY 203; MTH 208 or concurrent enrollment. Offered Fall.

PHY 321 Cr.3
Classical Mechanics
Rigorous mathematical development of classical dynamics using vector calculus. Dynamics of a single particle, oscillations, noninertial frames, central potentials, energy/momentum methods, systems of particles, collisions and plane motion of rigid bodies. Prerequisite: PHY 306; MTH 310. Offered Fall.

PHY 332 Cr.3
Electrodynamics
Fundamental concepts such as vector fields and vector operators, dipole and multipole fields, current distributions and the field quantities which describe surrounding conditions. Solution of LaPlace's and Poisson's equations for given sets of boundary conditions. Recognition and use of mathematical abstractions of the fundamental nature of the electromagnetic field. The course culminates with Maxwell's Equations, the fundamental set of four equations in classical physics which govern the behavior of electric and magnetic fields and their interactions with matter. Prerequisite: PHY 306; MTH 310. Offered Spring.

PHY 334 Cr.3
Electrical Circuits
Physical principles underlying modeling of circuit elements and fundamentals of analog electrical circuits are explored through lecture and laboratory. Topics will include the following: current and voltage sources, resistors, I-V characteristics, Ohm's Law, Kirchhoff's Laws, capacitors, inductors; Thevenin and Norton theorems; circuits in sinusoidal steady state; diodes, transistors (bipolar junction and field-effect); op-amps; and elementary amplifier circuits. Lect. 2, Lab 2. Prerequisite: PHY 104 or PHY 204; MTH 208. Offered Spring.

PHY 335 Cr.4
Electronics
This course expands upon the topics covered in PHY 334. Analog circuits are treated in greater detail, including circuit analysis, follower circuits, and operational and transistor amplifiers. Additional analog topics include transistor limitations, comparators, and oscillators. Lectures and laboratories are expanded to include digital electronics, electronic devices and applications. Digital topics include digital circuits, digital logic, flip flops, counter, memory, A/D and D/A conversion. Additional topics may include arithmetic units and microprocessors. Lect. 3, Lab 3. Prerequisite: PHY 334. Offered Fall.

PHY 343 Cr.3
Thermodynamics
This course emphasizes basic concepts of thermodynamics, beginning with fundamentals such as temperature, thermal expansion, heat flow, and calorimetry. State equations, tables, and diagrams are used to describe the properties of pure substances. The First and Second Laws of Thermodynamics are investigated, with applications to energy, enthalpy and entropy. Gas, vapor, and combined power cycles are studied, along with refrigeration cycles. Gas mixtures and gas-vapor mixtures, with applications to air conditioning and psychrometrics also are studied. Additional topics may include the thermodynamics of chemical reactions, and statistical thermodynamics. Prerequisite: PHY 306. Offered Spring.

PHY/BIO/CHM 356 Cr.2
Curriculum and Assessment in Math and Science
Students are introduced to state and national content standards and related theories on teaching and learning. They will apply this knowledge to develop a curricular framework. Topics will include: Learning outcomes, student misconceptions, balanced assessment, and lesson planning in the content areas. Prerequisite: declared math or science education major/minor; admission to teacher education. (Cross-listed with BIO/CHM/PHY; may only earn credit in one department.) Offered Fall.

PHY 362 Cr.3
Astrophysics
The application of principles studied in fundamental or general physics to various areas of astrophysical research. This course emphasizes topics like measuring star and exoplanet properties, stellar structure and evolution, the solar neutrino problem, white dwarfs, neutron stars, pulsars, the interstellar medium, and galaxies. Prerequisite: PHY 305, PHY 306; MTH 310 or concurrent enrollment. Offered Occasionally.

PHY 374 Cr.3
Computational Physics
This course is an introduction to computational physics. Students will learn the fundamentals of applying numerical and graphical methods to a variety of physics topics ranging from mechanics, optics, electrodynamics, thermodynamics, and quantum mechanics. Lect. 2, Lab 2. Prerequisite: PHY 104 or PHY 204; MTH 308 or MTH 309 or concurrent enrollment in either. Offered Occasionally.

PHY 376 Cr.3
Introduction to Nuclear Science
An introduction to the structure and properties of atomic nuclei. This course explores the production of ionizing radiation, its interactions with matter, and the instrumentation used to detect it. While all types of ionizing radiation are studied, particular emphasis will be placed on X- and gamma-rays. Lect. 2, Lab 2. Prerequisite: MTH 150; PHY 104 or PHY 134 or PHY 204. Students may not earn credit in both PHY 376 and PHY 386. Offered Fall.

PHY 386 Cr.3
Radiation Physics
This course, building on knowledge of basic physics, explores the area of radiation physics. Characteristics of x and gamma rays are described as well as their interactions in air and matter. The principles involved in the production of radiation are investigated. Methods and instrumentation of measurement of radiation are also covered. Prerequisite: MTH 150; PHY 104 or PHY 134 or PHY 204. Students may not earn credit in both PHY 376 and PHY 386. Offered Fall.

PHY 401 Cr.3
Quantum Mechanics
A comprehensive treatment of the modern theory of quantum mechanics, including Schroedinger equation, operators, free particles, particles in potentials, harmonic oscillator, angular momentum, and the hydrogen atom. The course includes the use of Fourier analysis and eigenvalue equations. Prerequisite: PHY 321; MTH 308 or MTH 309; MTH 310. Offered Fall.

PHY 411 Cr.3
Advanced Experimental Physics
This course will cover advanced experimental methods and techniques often encountered in research laboratories. Selected experiments may include x-ray diffraction, elemental and vibrational spectroscopy, microscopy, optical and electrical property measurements, material fabrication techniques, vacuum systems, and experimental apparatus fabrication. Computational techniques may include automated control, error analysis, graphing and curve fitting using LABVIEW and Python. Lect. 1, Lab 4. Prerequisite: PHY 311; MTH 310. Concurrent registration in MTH 308 or MTH 309 recommended. Offered Occasionally.

PHY 421 Cr.3
Advanced Mechanics
Continuation of PHY 321 covering advanced topics in classical and statistical mechanics. Topics include the Lagrangian and Hamiltonian formulations of mechanics, phase space and Liouville's equation; coupled oscillations, normal modes, continuous systems, and wave motion. In statistical mechanics, topics include kinetic theory, ensemble representations, partition functions, and classical/quantum statistics. Prerequisite: MTH 308 or MTH 309; MTH 310, PHY 321. Offered Occasionally.

PHY 423 Cr.3
Biomechanics of Human Movement
This course will provide a description of biological tissue properties, skeletal and joint mechanics, muscle mechanics, neurological influences related to movement. Kinematics, kinetics, static and dynamic modeling of the human body will be studied and will require problem solving. The principles of the biomechanics theory associated with human movement are presented to introduce and develop an understanding of the mechanical complexity of biological systems and movement performance. Methods and instruments of measurement (electromyography, force/pressure transducers, motion analysis and isokinetic dynamometers) in biomechanic research. Prerequisite: PHY 103 or PHY 203; MTH 310; BIO 312. Offered Fall.

PHY 432 Cr.3
Advanced Electrodynamics
This is a detailed course covering advanced topics in electricity and magnetism. Emphasis will be placed upon general, non-static electrodynamics, building upon the static cases studied in detail in PHY 332. Topics will include detailed analysis of radiation, field transformations and kinematics in Einstein's Special Theory of Relativity, dispersion, wave guides, and Lienard-Wiechert potentials. The mathematical tools for studying these phenomena will include differential equations, vector and tensor analysis, Fourier analysis, and complex analysis. Prerequisite: PHY 332; MTH 353 or concurrent enrollment. Offered Occasionally.

PHY 450 Cr.3-15
Physics and Astronomy Internship
Full- or part-time work experience in a physics or astronomy related position with a public or private agency. Not more than five credits are applicable to a major or three credits to a minor in physics. A written application, departmental acceptance, and appointment of adviser must be completed before registration. Repeatable for credit - maximum 15. Prerequisite: minimum cum GPA of 2.25 (2.50 in physics); PHY 104 or PHY 204, plus six credits in physics courses above the 204 level; junior standing. Consent of department. Offered Occasionally.

PHY/BIO/CHM/MTH 451 Cr.2
Curriculum and Content in Science and Mathematics
This is a methods course for science education and mathematics education majors that focuses on how content knowledge and pedagogical content knowledge are used to inform instruction. The course will focus on exploration of state and national standards, academic language, and methods of assessment. Prerequisite: EDS 203, EDS 206; concurrent enrollment in the department's section of BIO/CHM/MTH/PHY 454 or BIO/CHM/MTH/PHY 455; admission to teacher education. (Cross-listed with BIO/CHM/MTH/PHY; may only earn credit in one department.) Consent of instructor. Offered Spring.

PHY/BIO/CHM 452 Cr.2
The Learner and Learning in Science
This is a methods course for science education majors that focuses on learning theories, equitable practices, and culturally relevant pedagogy. The course draws on recommendations from state and national standards. Prerequisite: EDS 203, EDS 206; concurrent enrollment in the department's section of BIO/CHM/MTH/PHY 454 or BIO/CHM/MTH/PHY 455; admission to teacher education. (Cross-listed with BIO/CHM/MTH/PHY; may only earn credit in one department.) Consent of instructor. Offered Fall.

PHY 453 Cr.1-3
Topics in Physics and Astronomy
Various subjects of interest to specific groups will be offered on occasion. Specific subtopics will be assigned each time the course is offered. Such titles might include nuclear physics, low temperature physics and the interstellar medium. Repeatable for credit under different subtitles - maximum 12 credits. Prerequisite: PHY 104 or PHY 204; junior standing. Offered Fall, Spring, Summer.

PHY/BIO/CHM 454 Cr.2
Field Experience I in Science Education
This course is the first field experience in a school environment. Candidates plan and teach lessons within the designated grade range of 4-12. Candidates are introduced to classroom management and conflict resolution. A multi-day, consistent schedule in the middle or high school field experience classroom is established by the course instructor in consultation with the teacher candidate and cooperating teacher. Prerequisite: EDS 203, EDS 206; concurrent enrollment in the department's section of BIO/CHM/PHY 451 or BIO/CHM/PHY 452; admission to teacher education. (Cross-listed with BIO/CHM/PHY; may only earn credit in one department.) Consent of instructor. Offered Fall, Spring.

PHY/BIO/CHM 455 Cr.2
Field Experience II in Science Education
This course is the second field experience in a school environment. Candidates plan and teach lessons within the designated grade range of 4-12. Candidates are introduced to classroom management and conflict resolution. A multi-day, consistent schedule in the middle or high school field experience classroom is established by the course instructor in consultation with the teacher candidate and cooperating teacher. Prerequisite: EDS 203, EDS 206; concurrent enrollment in the department's section of BIO/CHM/PHY 451 or BIO/CHM/PHY 452; admission to teacher education. (Cross-listed with BIO/CHM/PHY; may only earn credit in one department.) Consent of instructor. Offered Fall, Spring.

PHY 460 Cr.3
Condensed Matter Physics
This course will include such topics as crystal structure, electrical conductivity, insulators, free electron Fermi gases, energy bands, semiconductors, superconductivity, dielectrics, and ferroelectric crystals. Magnetic phenomena such as diamagnetism, paramagnetism and ferromagnetism will also be studied. Prerequisite: PHY 306; MTH 310. Offered Occasionally.

PHY 461 Cr.3
Mathematical Physics
In depth study of topics from vector analysis, Fourier analysis and special functions with emphasis on modeling physical phenomena involving conservative fields, fluid flow, heat conduction, and wave motion. Prerequisite: grade of "C" or better in MTH 353. Offered Spring - Odd Numbered Years.

PHY 466 Cr.3
Cosmology and the Structure of The Universe
This course will emphasize topics relating to the history of our universe, from the Big Bang to galaxy evolution and the formation of the structures we see today. Students will study the cosmological distance ladder, black holes in galaxies, galaxy clusters, dark matter, the Big Bang model, the inflationary model, and the cosmological constant. The course will also include aspects of special and general relativity relevant to these subjects. Prerequisite: PHY 305, PHY 306; MTH 308 or MTH 309 or concurrent enrollment; MTH 310 or concurrent enrollment. Offered Occasionally.

PHY 470 Cr.3
Advanced Quantum Mechanics
Continuation of PHY 401. Topics include spin, addition of angular momenta, multi-particle wave functions, identical particles, Bose and Fermi distributions, band theory, time independent and time dependent perturbation theory, spontaneous emission, and scattering theory. Prerequisite: PHY 401. Offered Occasionally.

PHY 472 Cr.3
Particle Physics
An introduction to the exciting field of modern elementary particles. Topics will include the Standard Model of particles and interactions, Feynman diagrams, quantum electrodynamics, quantum chromodynamics, weak interaction theory, quarks, leptons, intermediate vector bosons, and experimental methods of particle detection. Current ideas concerning grand unified theories, supersymmetry, superstring theory and particle astrophysics also will be discussed. Prerequisite: PHY 306. Offered Occasionally.

PHY 474 Cr.3
Advanced Computational Physics
In-depth study of advanced computational techniques using the programming language Java. Programming topics will include File IO, graphics and animation, multi-threaded programs, applets and Web pages. Numerical techniques will include root-searches, numerical integration, eigenvalue equations, differential equations, and Monte Carlo Metropolis simulations on advanced physics topics drawn from mechanics, thermodynamics, optics, quantum mechanics, and chaos theory. Lect. 2, Lab 2. Prerequisite: PHY 374; CS 120. Offered Occasionally.

PHY 476 Cr.3
Advanced Optics
This course involves both theoretical and experimental work in a variety of topics in modern optics, including electromagnetic theory, laser, Gaussian beams, optical resonators and the ABCD rule, Fourier optics, nonlinear optics, detectors and color. Prerequisite: PHY 308; PHY 332 or concurrent enrollment. Offered Occasionally.

PHY 483 Cr.3
Instrumentation in Biomechanics
Theory and use of instrumentation related to the study of the clinical biomechanics and research. Students will develop skills and experience necessary for data collection in a laboratory. Topics will include methods of data acquisition using force and pressure sensors, electromyography (EMG). Methods of signal processing (filtering and post-processing), analyzing, and interpreting data will be explained and performed through laboratory exercises. Laboratory time will be available to collect and process data relative to each laboratory instrument. Clinical EMG and electrical testing of nerves and posturography will also be explained. Lect. 2, Lab 2. Prerequisite: PHY 423. Offered Summer.

PHY 491 Cr.1
Capstone in Physics
A senior level course specifically designed for physics majors to review and discuss basic concepts relevant to the physical sciences, and to assess their major in physics. Students will present seminars to physics faculty based on current physics research articles, and also communicate physics concepts to a general audience in a written format. Students are expected to participate in discussions on current developments in the physical sciences, and be actively engaged in the assessment of their major program. Prerequisite: senior standing; physics major. Consent of instructor. Offered Spring.

PHY 497 Cr.1
Physics and Astronomy Seminar
This seminar series is intended for majors and minors in the department of physics as well as other students interested in physics, engineering and astronomy. It will consist of a series of talks given by visiting scientists and engineers as well as senior research students. The course provides an excellent opportunity to find out about the latest developments in physics, astronomy, and engineering and provides an excellent medium by which students can get to know each other and also their professors. All physics majors and minors are urged to sign up for this seminar each semester of their first year. Repeatable for credit - maximum four. A maximum of two credits can be used to satisfy elective requirements. Pass/Fail grading. Offered Fall, Spring.

PHY 498 Cr.1-3
Physics and Astronomy Research
Independent work by a student under the supervision of a faculty member. Students can work on a variety of research projects including, but not limited to, the areas of astronomy, condensed matter, computational physics, physics education, low temperature physics, lasers, optics and spectroscopy. Repeatable for credit - maximum nine, with permission of department chair. Consent of department. Offered Fall, Spring, Summer.