Graduate Study in Physics
At Creighton University the graduate program in Physics is flexible and designed to combine a solid grounding in Physics with adaptability to a wide range of student interests and career objectives. There is a close association of students and faculty that facilitates responsiveness to the needs of each student. Graduates of four-year liberal arts colleges are of special interest to the Physics faculty, as are secondary-school and junior-college teachers who wish to enrich their background in physics. Most classes can be scheduled to accommodate working students in progressing toward the M.S. degree on a part-time basis.

Program Goals
In addition to the general learning goals of the Graduate School, at the completion of the physics graduate program, the student will:

1. Demonstrate advanced knowledge in graduate level physics and in their field of thesis research.
2. Demonstrate independent critical and analytical thinking, both within their field of study and beyond, for use in the service to others.
3. Identify and suggest possible solutions to ethical dilemmas that occur in their work and field of study, and understand the importance of professional ethics in all aspects of scientific communication and laboratory work.
4. Demonstrate competence in their laboratory or computational work, including application of the scientific method and appropriate use of basic and state of the art tools and techniques.
5. Demonstrate written and oral skills necessary for communication of research, knowledge, and ideas to scientists and non-scientists.

Admission Requirements
In general, properly prepared students will have undergraduate preparation in physics comparable to the present minimum Physics degree requirements at Creighton University. This must include upper-division course work covering each of the following categories: mechanics, electromagnetism, and modern physics. Additional work in physics to bring the total to 24 semester hours, plus support from mathematics, is needed. An undergraduate grade point average of 3.00 or better is preferred.

The Graduate School requires all students from countries in which English is not the native language to demonstrate competence in English by a score of 550 in the TOEFL (Test of English as a Foreign Language) examination or 80 on the Internet-based Test (iBT) at the graduate level. Higher TOEFL scores are required to be competitive for teaching or research fellowships.

Degree in Physics
- Master of Science with a Major in Physics (http://catalog.creighton.edu/graduate/graduate-programs-courses/physics/physics-ms)

Courses

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

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. 3 credits.
A systemic study of medical imaging including projection x-ray (mammography, fluoroscopy), computed tomography, nuclear imaging (SPECT, PET), magnetic resonance imaging, and ultrasound. For each imaging modality, the mathematical foundation, physical mechanism, 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 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)
A series of lectures, discussions and engineering speakers to assist pre-engineers to define more clearly their professional goals by acquainting them with diversified career options available to engineers. Topics include: engineering career exploration and development; cooperative education and internships; and job search, resume writing and interviewing techniques. P: IC.

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.

PHY 599. Special Topics. 1-3 credits. OD

PHY 611. Classical Mechanics. 3 credits. FA
Variational principles, Lagrange's equations, two-body central force motion, rigid-body motion, transformations, small oscillations.

PHY 621. Electromagnetic Theory. 3 credits. FA
Electromagnetic fields, application of Maxwell's equations to electromagnetic waves and their interaction with matter.

PHY 631. Quantum Mechanics I. 3 credits. SP
Development of the formalism of quantum mechanics with applications to simple systems.

PHY 632. Quantum Mechanics II. 3 credits. OD
Applications of quantum mechanics to current fields of interest. P: PHY 631.

PHY 641. Statistical Mechanics. 3 credits. SP
Review of thermodynamics, classical and quantum statistical theory, applications to current fields of interest.

PHY 652. Advanced Mechanical Methods. 0 credits. OD

PHY 662. Radiation Dosimetry and Protection. 3 credits.
A survey of personal and environmental dosimetry and monitoring with an emphasis on ionizing radiation. Topics include photon and neutron beams, particle interactions, stopping power, range absorbed dose, charged particle equilibrium, measurement techniques, cavity theory, ionization chambers, thermoluminescence, photographic, chemical, and calorimetric dosimetry, pulse-mode-detectors, scintillation materials, semiconductor dosimeters, biophysical models. P: PHY 301, BIO 202; Graduate standing.

PHY 785. Clinical Practice of Teaching Science. 3-7 credits. OD
Practical experience in the conduct of classroom teaching and related activities in science. This experience is obtained under the immediate supervision of a fully experienced cooperating teacher and a University supervisor in a local school in grades 7-12. Application to the Director of Field Experiences in the Education Department for all student teaching must be made before February 1 for the Fall Semester and October 1 for the Spring Semester. Secondary Education P: EDU 525, EDU 548, EDU 551, EDU 575; CO: EDU 593.

PHY 790. Research Methods. 2 credits. OD
Introduction to current research in Physics.

PHY 791. Graduate Seminar. 1-3 credits. FA, SP
Oral presentation and critical discussion of subjects in physics or related fields by invited speakers, faculty, and students.

PHY 793. Directed Independent Readings. 1-3 credits. FA, SP, SU
Advanced instruction in areas of special interest to the faculty, such as the following: atomic physics, nuclear physics, particle physics, solid state physics, surface physics, statistical mechanics, foundations of physics; biophysics. P: IC.

PHY 795. Directed Independent Study. 1-3 credits. FA, SP, SU
Advanced study in a specific area of interest to the faculty. P: IC.

PHY 797. Directed Independent Research. 1-3 credits. FA, SP, SU
An independent research project under the guidance of a member of the faculty. Weekly conferences. Written report of work required at the end of each semester. P: IC.
PHY 799. Master's Thesis. 1-6 credits. FA, SP, SU
Research in connection with the preparation of the Master's thesis. Students must register for this course in any term when engaged in formal preparation of the master's thesis; however, six credit hours are the maximum applicable toward the degree. P: DC.