MEDICAL PHYSICS

Program Director: Michael G. Nichols, Ph.D.

The M.S. in Medical Physics program will provide training for individuals interested in pursuing a career in Medical Physics. The 43 hour master's program will provide didactic training in the fundamentals of medical and health physics, radiobiology, radiological physics and radiation dosimetry, nuclear medicine, medical imaging, as well as research (thesis option) and clinical experience (clinical rotations in local hospitals) to provide the experience needed by practicing medical physicists.

Admission Requirements

To be eligible for admission, students must have a Bachelor's degree with a major in Physics (preferred), Engineering, or another science discipline. If the Bachelor's degree is not in physics, students must have completed at least 18 credit hours of undergraduate-level physics, with at least 9 hours in upper division physics courses and a minimum 3.0 GPA. Appropriate undergraduate chemistry (at least 1 year), Biology (at least 1 year), Mathematics (two years, Calculus and Differential Equations), and computer science (proficiency in at least one programming language) preparation is also required. The general GRE exam is required. The Physics GRE subject exam is recommended, but not required. International students must complete the TOEFL exam with a minimum total score of 90 (iBT) and a minimum score of 20 in each of the four test sections.

A complete application for admission will include all undergraduate transcripts, three letters of recommendation, official test scores, and a personal statement.

Learning Outcomes

The M.S. program in medical physics provides students with the basic and applied knowledge necessary for further education and research in medical physics. Students completing the program will be well prepared for Part 1 of the ABR board certification exam and have the necessary skills to continue their training in a clinical residency program. To this end, students completing the program will:

1. demonstrate competency in physics, mathematics, computer programming and other basic science knowledge, required for research and clinical practice in medical physics;
2. demonstrate professional attributes and ethical behaviors required of medical physicists;
3. demonstrates skills in communication through writing and oral presentation;
4. demonstrate proficiency in theoretical or experimental research design;
5. effectively use the research process to pose and address relevant problems in research and clinical settings;
6. demonstrate a conceptual and methodological understanding of how research leads to the creation of new knowledge and the re-interpretation of existing knowledge;
7. present effective progress reports on their research;
8. complete a M.S. thesis which demonstrates effective synthesis and analysis of current research and scholarship in medical physics;
9. demonstrate deliberate reflection for personal and professional formation;
10. develop communication and interpersonal skills needed to function in a collaborative environment;
11. demonstrate an awareness of the complexity of knowledge in medical physics as well as receptiveness to alternative interpretations, new knowledge, and alternative approaches to problem solving.

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M.S., Medical Physics Degree requirements (http://catalog.creighton.edu/graduate/graduate-programs-courses/physics/medical-physics-ms/)

B.S, Biomedical Physics / M.S., Medical Physics Accelerated Program (http://catalog.creighton.edu/graduate/graduate-programs-courses/physics/medical-physics/bs-phyb-ms-mphy-amp/)

Courses

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.

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
Small oscillations, transformations, special functions, boundary value problems. P. MTH 347.

PHY 661. Physics of Radiation Therapy. 3 credits.
A systemic study of the use of radiation in the treatment of cancer. Topics include clinical radiation generators, interactions of ionizing radiation with matter, measurement techniques for dosimetry, gamma, electron and ion beams, beam quality, dose distribution, mathematical/computational dose estimation, treatment planning, field shaping, IMRT, brachytherapy, HDR therapy, SSRS, SBRT. P. PHY 301, BIO 202; Graduate standing.

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 792. Medical Physics Seminar. 1 credit.
A series of lectures and discussion led by program faculty students and guest speakers. Topics will include the latest research in medical physics and allied disciplines, debates on topics of social relevance, and professional development. Students will be responsible for presenting a seminar focusing on a subject that is relevant to their master's research or on a subject stimulated by their clinical rotation. P. Instructor Consent; Graduate standing.

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. 0-3 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 798. Medical Physics Clinical Rotation. 3 credits.
Clinical rotations within area hospitals under the direction of a mentoring medical physicist. Students will observe Treatment planning; Treatment delivery; Quality assurance; Routine diagnostic procedures as well as special procedures (SRS, SBRT, HDR, etc.). Students will also shadow radiologists involved in various areas of diagnostic and interventional radiology including rad/fluoroscopy, mammography, MRI, CT, ultrasound and nuclear medicine. P. Instructor Consent; Graduate standing.

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.