DEPARTMENT OF PHYSICS

Shiv Khanna, Ph.D.
Professor and chair

physics.vcu.edu (http://www.physics.vcu.edu)

The Department of Physics offers programs leading to the Bachelor of Science in Physics and the Master of Science in Physics and Applied Physics. The department also offers an accelerated B.S.-M.S. program that allows students in the baccalaureate program to take graduate courses that will count toward the M.S. in Physics and Applied Physics degree.

- Physics and Applied Physics, Master of Science (M.S.) (http://bulletin.vcu.edu/graduate/college-humanities-sciences/physics/physics-applied-physics-ms)
- Physics and Applied Physics, Master of Science (M.S.), accelerated Bachelor of Science in Physics (B.S.) to master's (http://bulletin.vcu.edu/graduate/college-humanities-sciences/physics/physics-applied-physics-ms-accelerated-physics-bs-masters)

PHYS 508. The Physical Science of Space for Teachers. 3 Hours.
Semester course; 3 credits. Prerequisites: B.S. or B.A. degree with at least two mathematics and two science courses or permission of instructor. The course is designed for the secondary physical science and physics teachers. The physical science phenomena of the solar system and the universe: mechanics, electromagnetism, optics and energy are presented for the teacher. The course curriculum closely follows the Virginia Science Standards of Learning for Physics and Physical Science. The course makes use of the Virginia Science Museum's interactive physical science exhibit galleries (aerospace, force and motion, waves and patterns, light and vision matter, crystals and electromagnetism as well as the Digistar planetarium and telescopes).

PHYS 509. Experiencing Science for Teachers. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: B.S. or B.A. degree with at least two mathematics and two science courses or permission of instructor. Designed to give physical science and physics teachers an understanding of the methods and processes actually used by scientists in different disciplines. Students repeat classic experiments, read from original works, keep detailed research journals, participate in laboratory experiments, engage in the peer review process and present results of projects in colloquium format. The course meets at the Science Museum of Virginia and uses the interactive science exhibits; visits to science sites in the area.

PHYS 510. Physical Science Demonstrations. 3 Hours.
Semester course; 3 credits. Prerequisite: PHYS 509 or permission of instructor. The course is designed to give the working secondary physical science and physics teacher a depth of experience in designing and effectively using experiments to interpret phenomena for students. Participants learn the essentials of developing effective apparatus for investigations, interactive exhibits and demonstrations in the physical sciences. Students will undertake and present a major project as part of the course.

PHYS 514. Modeling Biocomplexity. 3 Hours.
Semester course; 2.5 lecture and .5 laboratory hours. 3 credits. Prerequisite: one year of calculus. Introduction to the modeling and simulation of the behavior of complex biological systems, including models in both continuous and discrete time. Numerical methods using mathematica, analytical methods using calculus and laboratory experiments using computer interfaces will be used to study population dynamics and the behavior of physiological systems exhibiting such properties as oscillations and chaotic biological dynamics. Crosslisted as: BNFO 514.

PHYS 522. Optics and Laser Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 376 or permission of instructor. The purpose of this course is to introduce a range of topics from optics and the principles of laser operation. Topics include waves, physical optics, geometric optics, superposition, interference, polarization, diffraction, Fourier optics, coherence, lasers, second quantization.

PHYS 550. Techniques in Material Research. 3 Hours.
Semester course; 4 laboratory and 2 lecture hours. 3 credits. Prerequisite: PHYS 450 or graduate standing. This course focuses on the application of modern characterization techniques in materials research. Techniques to be studied include high-resolution X-ray diffraction, low-energy electron diffraction, light-energy electron diffraction, scanning-tunneling microscopy, molecular beam epitaxy, Auger electron spectroscopy and X-ray photoemission spectroscopy.

PHYS 571. Theoretical Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 376 and PHYS 380, or graduate standing. An introduction to advanced dynamics involving the Lagrangian and Hamiltonian formalisms.

PHYS 573. Analytical Methods in Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 376 and PHYS 380, or graduate standing. Theoretical and numerical techniques in solving differential equations in condensed matter. Classification of electronic states in solids and clusters using groups, infinite series approximations, calculus of residues and causality.

PHYS 576. Electromagnetic Theory. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 571. Maxwell's equations of electromagnetism, vector and scalar potentials, electromagnetic waves and radiation theory.

PHYS 580. Quantum Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 571. Theoretical quantum descriptions with emphasis upon mathematical techniques. Schrodinger equation, hydrogen atom, eigenfunctions and eigenvalues, angular momentum and spin and perturbation theory.

PHYS 583. Geometrical Methods of Physics and Gravitation. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 571 and PHYS 573 or permission of instructor. Introduction to the language of differential geometry that is needed for research in gravitation and cosmology. Topics include tensors, connections on manifolds, gauge-invariant field theories and Einstein's theory of general relativity. Examples include black holes and cosmological solutions of Einstein's field equations.

PHYS 591. Topics in Physics. 1-3 Hours.
Semester course; 1-3 lecture hours. 1-3 credits. Open to graduate students and to undergraduate students with advanced standing. An in-depth study of a selected topic in advanced physics. See the Schedule of Classes for specific topics to be offered each semester and prerequisites. Applicable toward physics major requirements.

PHYS 640. Equilibrium Statistical Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 571 and PHYS 580. Fundamentals of equilibrium statistical physics. Topics include review of thermodynamics, canonical and grand canonical partition functions, mean-field theories, Ising and Bragg-Williams models, Landau theory, fluctuations about the mean field, critical phenomena, exact solution to the one-dimensional Ising model, two-dimensional Ising model and the renormalization group.

PHYS 641. Solid State Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 571 and PHYS 580. Study of structure and electronic properties of materials in the solid phase.

PHYS 650. Subatomic Physics I. 3 Hours.
Semester course; 3 credits. Prerequisites: PHYS 576, PHYS 580 and CHEM 510. Studies of nuclei and elementary particles, reaction dynamics, particle accelerators, detection devices, particle classification, symmetries and conservation laws, quantum electrodynamics, the weak interaction, quantum chromodynamics, unified theories, the nuclear shell model and collective model, and nuclear reactions. Offered in cooperation with Virginia State University.

PHYS 651. Subatomic Physics II. 3 Hours.
Semester course; 3 credits. Prerequisite: PHYS 650. A continuation of PHYS 650. Offered in cooperation with Virginia State University.

PHYS 661. Surface and Materials Physics. 3 Hours.
Semester course; 3 credits. Prerequisites: PHYS 641, CHEM 510 or permission of instructor. This course will focus on the physics of surface, interfacial and other nanostructured material systems, and the experimental techniques used to assay their geometric and electronic properties. Topics include ultra-high vacuum techniques and design, surface geometric and electronic structure, adsorbates on surfaces and interface formation, thin film growth, and layered systems. Characterization techniques to be discussed include geometric probes (STM, AFM, RHEED, LEED, AFM, XRD) and synchrotron radiation-based electronic structure probes (PES, SXF, NEXAFS).

PHYS 663. Studies in Nuclear Physics. 3 Hours.
Semester course; 3 credits. Credits for only two televised courses will count toward degree requirements. Courses televised by the Virginia Cooperative Graduate Engineering Program. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

PHYS 670. Conceptual Physics for Teachers I. 3 Hours.
Semester course; 4 studio hours. 3 credits. Prerequisites: PHYS 508, PHYS 509 and PHYS 510, or permission of instructor. First of the sequence 670-672. Development of the methodology for the experimental design at middle and high school level, concentrating on the science of measurement, materials structure and characterization, and light and optical properties of matter. The 670-672 sequence uses and develops computer-based experiments and interactive multimedia materials for use in the classroom. The course contains examples of vertical integration of technological applications of physical principles across disciplines.

PHYS 671. Conceptual Physics for Teachers II. 3 Hours.
Semester course; 4 studio hours. 3 credits. Prerequisite: PHYS 670 or permission of instructor. Second of the sequence PHYS 670-672. Development of the methodology for experimental design at middle and high school level, concentrating on sound and acoustics, electromagnetism and classical mechanics.

PHYS 672. Conceptual Physics for Teachers III. 3 Hours.
Semester course; 4 studio hours. 3 credits. Prerequisite: PHYS 671 or permission of instructor. Third of the sequence PHYS 670-672. Development of the methodology for the experimental design at middle and high school level, concentrating on heat, thermodynamics and modern physics.

PHYS 690. Research Seminar. 1 Hour.
Semester course; 1 credit. May be repeated for a maximum of 4 credits. Examines current problems and developments in physics.

PHYS 691. Special Topics. 3 Hours.
Semester course; 3 credits. Prerequisites: at least one graduate-level physics course and permission of instructor. Selected topics in physics from such areas as statistical physics, quantum field theory, semi-conductor device physics, general relativity, electronic structure of solids, thin-film fabrication techniques, superconductivity, nuclear magnetic resonance techniques, crystallography and nuclear physics.

PHYS 697. Directed Research. 1-15 Hours.
Semester course; 1-15 credits. May be repeated for credit. Prerequisites: at least one graduate-level physics course and permission of instructor. Research leading to the M.S. or Ph.D. degree.