Department of Physics

306 Oceanography & Physics Building (OCNPS)
Main Office: (757) 683-3468
http://www.odu.edu/physics (http://www.odu.edu/physics/)

Sebastian Kuhn, Chair
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The Department of Physics offers programs of study leading to both the M.S. degree in physics and the Ph.D. degree in physics. Primary focus is placed on the Ph.D. program, and most students enrolled for graduate study are enrolled in that program. Students have the opportunity to perform research in state-of-the-art facilities under faculty direction. Graduates are prepared for research at the highest levels in academia, government laboratories, and corporate laboratories.

Programs

Doctor of Philosophy Program

- Physics (PhD) (http://catalog.odu.edu/graduate/sciences/physics/physics-phd/)

Master of Science Program

- Physics (MS) (http://catalog.odu.edu/graduate/sciences/physics/physics-ms/)

Courses

Physics

ASTP 506 Observational Astronomy (3 Credit Hours)
Observational techniques in astronomy with emphasis on constellation identification, celestial movements, and telescopic observation. Individualized night observations are required.

ASTP 508 Astronomy for Teachers (3 Credit Hours)
A course in astronomy dealing with stars and stellar systems. Topics will include observational astronomy, the electromagnetic spectrum, relativity, stellar and galactic structures, cosmology, and the search for extraterrestrial intelligence.

ASTP 595 Special Topics in Astrophysics (3 Credit Hours)
In-depth study of a selected topic in astrophysics at the introductory graduate level. May include a laboratory or computational component.
Prerequisites: Permission of the instructor

PHYS 503 Electronic Instrumentation (3 Credit Hours)

PHYS 513 Methods of Experimental Physics (3 Credit Hours)
Experiments in classical and modern physics, designed to develop skills in the collection, analysis, and interpretation of experimental data.

PHYS 515 Introduction to Nuclear Particle Physics (3 Credit Hours)
An introduction to the structure of the atomic nucleus, natural and artificial radioactivity, nuclear decay processes and stability of nuclei, nuclear reactions, properties of nuclear forces, and nuclear models. Also, particle phenomenology, experimental techniques and the standard model. Topics include the spectra of leptons, mesons, and baryons; strong, weak, and electromagnetic interactions.

PHYS 516 Introduction to Solid State Physics (3 Credit Hours)
Introduction to solid state physics and materials science, with emphasis placed on the applications of each topic to experimental and analytical techniques. Topics include crystallography, thermal and vibrational properties of crystals and semiconductors, metals and the band theory of solids, superconductivity and the magnetic properties of materials.

PHYS 517 Introduction to Particle Accelerator Physics (3 Credit Hours)
Fundamentals of relativistic particle dynamics including particle acceleration; weak and strong focusing; linear beam optics and particle transfer matrices; linear and non-linear synchrotron motion; introduction to the statistical descriptions of particle beams; and radiation production by accelerated relativistic particles. Examples relevant to betatrons, cyclotrons, synchrotrons, and linear accelerators will be given.
Prerequisites: PHYS 319 or MAE 205, and PHYS 425 or ECE 323

PHYS 520 Introductory Computational Physics (3 Credit Hours)
Introduction to computationally based problem solving in physics with an emphasis on understanding and applying various numerical algorithms to different types of physics problems. Topics will include numerical integration (quadrature), numerical solution of ordinary differential equations, Runge-Kutta and Numerov methods, polynomial approximations, numerical linear algebra, and Monte-Carlo methods. These computational methods will be applied to problems in classical and quantum mechanics, as well as electromagnetic theory.
Prerequisites: CS 150, CS 151 or CS 153; PHYS 319; PHYS 323; and MATH 212

PHYS 525 Electromagnetism I (3 Credit Hours)
A study of the classical theory and phenomena of electricity and magnetism. Topics include the calculation of electric and magnetic fields, magnetic and dielectric properties of matter, and an introduction to Maxwell's equations. The course contains a mandatory recitation section.

PHYS 551 Theoretical Mechanics (3 Credit Hours)
A mathematical study of the concepts of mechanics. Vector calculus methods are used. Topics include mechanics of a system of particles, Lagrangian mechanics, Hamilton’s canonical equations, and motion of a rigid body.

PHYS 552 Introduction to Quantum Mechanics (3 Credit Hours)
Introduction to the physical and mathematical structure of quantum theory. Dirac notation, Spin systems, EPR paradox and Bell’s inequality. The Schro#dinger equation is introduced for simple systems. Quantization of bound states, scattering, and tunneling are introduced for the 1-dimensional square-wave potential. In three dimensions, angular momentum and the harmonic oscillator are developed. The course contains a mandatory recitation section.
Prerequisites: PHYS 319 and PHYS 323

PHYS 553 Electromagnetism II (3 Credit Hours)
A course in electrodynamics developed from Maxwell’s Equations. Topics include Maxwell’s Equations, Conservation Laws, Electromagnetic Waves, Potentials and Fields, Radiation, and the interplay of electrodynamics and special relativity. The course contains a mandatory recitation section.

PHYS 554 Thermal and Statistical Physics (3 Credit Hours)
A study of the fundamental concepts of thermodynamics, kinetic theory, and statistical mechanics. Topics include the thermodynamics of simple systems, kinetic theory of gases, statistical mechanics of gases and an introduction to quantum statistics.

PHYS 556 Intermediate Quantum Mechanics (3 Credit Hours)
Techniques for solving the Schro#dinger equation in one, two, and three dimensions. Solution of the Hydrogen atom, variational techniques, perturbation theory and scattering. The Pauli exclusion principle. Optional topics include atoms in an electromagnetic field (Stark effect, Zeeman effect), spontaneous and stimulated emission, hydrogen molecular ion and helium ground states, Bloch waves and elementary theory of solids.

PHYS 595 Special Topics in Physics (1-3 Credit Hours)
In-depth study of a selected topic in physics at the graduate level. May include a laboratory or computational component.
Prerequisites: Permission of the instructor

PHYS 597 Special Problems and Research (1-3 Credit Hours)
These courses afford the student an opportunity to pursue individual study and research.
Prerequisites: permission of the instructor

PHYS 601 Mathematical Methods of Physics I (3 Credit Hours)
Basic mathematical methods with applications: vector analysis, linear algebra, series and series of functions, Hilbert spaces, complex variable theory.

PHYS 602 Mathematical Methods of Physics II (1 Credit Hour)
Continuation of PHYS 601. Basic mathematical methods with applications: integral transforms, ordinary differential equations and partial differential equations.
Prerequisites: PHYS 601

PHYS 603 Classical Mechanics (3 Credit Hours)
Particle in a central-force field. Dynamics in a rotating reference frame. Lagrangian and Hamiltonian formulations. Small oscillations. Kinematics and dynamics of a rigid body. Canonical transformation, Hamilton-Jacobi theory.

PHYS 604 Classical Electrodynamics I (3 Credit Hours)
Electrostatics: Gauss' Law and Poisson and Laplace equations. Methods for the solution of boundary-value problems with rectangular, cylindrical, and spherical symmetry. Expansion in multipoles. Dielectrics. Magnetostatics and Faraday's law.

PHYS 621 Quantum Mechanics I (3 Credit Hours)
Mathematical foundations of Hilbert spaces. Background on Hamiltonian mechanics and electro-magnetism. Postulates of Quantum Mechanics, measurements and Schroedinger equation. Simple systems. Schroedinger Equation in 1-3 dimensions and solutions for specific systems. Symmetries and angular momentum. Time-independent perturbation theory.

PHYS 695 Selected Topics in Pure and Applied Physics (1-3 Credit Hours)
These courses afford the student an opportunity to pursue individual study.
Prerequisites: permission of the instructor

PHYS 696 Special Topics in Accelerator Physics (3 Credit Hours)
Special topics related to particle accelerators and their applications. Departmental approval required.

PHYS 698 Research (1-9 Credit Hours)
M.S. level research supervised by the student's thesis advisor.

PHYS 699 Thesis (1-9 Credit Hours)
M.S. level research supervised by the student's thesis advisor.

PHYS 704 Classical Electrodynamics II (3 Credit Hours)
Electrodynamics: Maxwell equations, plane electromagnetic waves and wave propagation, waveguides, radiating systems, special theory of relativity, including the dynamics of relativistic particles and electromagnetic fields.
Prerequisites: PHYS 604

PHYS 707 Statistical Mechanics (3 Credit Hours)
Review of thermodynamics. Classical statistical mechanics and applications. The virial expansion. Quantum statistical mechanics and the micro-canonical, canonical, and grand-canonical ensembles. The Fermi and Bose gases, and applications. Special topics in statistical mechanics.
Prerequisites: PHYS 603

PHYS 711 Computational Physics (3 Credit Hours)
Studies of high level computer languages. Computational techniques used in physics. Numerical techniques for differential and integral problems. Algebraic processing languages. Introduction to scientific visualization techniques.

PHYS 721 Quantum Mechanics II (3 Credit Hours)
Further development of quantum mechanics. Multi-particle states, bosons and fermions. Classical Limit. Variational principle, time-dependent perturbation theory and scattering. Path integral formulation. Symmetry and groups, addition of angular moments. Examples from solid state, atomic, nuclear, and particle physics.
Prerequisites: PHYS 621

PHYS 722 Nuclear and Particle Physics I (3 Credit Hours)
Nuclear forces, models of nuclear structure and reactions, hadron and lepton scattering, introduction to constituent quark model and hadron spectroscopy.
Prerequisites: PHYS 621

PHYS 723 Nuclear and Particle Physics II (3 Credit Hours)
Discrete and continuous symmetries and application to particle physics, SU(2) and SU(3) symmetries and static properties of hadrons. Klein-Gordon and Dirac equations, quantum electrodynamics and Feynman rules, strong and weak interactions, Standard Model and physics beyond the Standard Model.
Prerequisites: PHYS 722 or PHYS 822

PHYS 724 Condensed Matter Physics I (3 Credit Hours)
Electronic and lattice properties of solids, band structures of metals, semiconductors and insulators, dynamics of electron and phonons, electromagnetic and optical properties of metals and doped semiconductors, phenomenology of superconductivity and magnetism, and selected experimental methods of solid state physics.
Prerequisites: PHYS 621, and PHYS 721 or PHYS 821

PHYS 727 Atomic Physics (3 Credit Hours)
Irreducible tensor methods. Radiative excitation and ionization processes. Atom-atom scattering. Time-evolution of atomic observables in external fields. Multiple channel quantum defect theory and complex atomic and molecular spectra.
Prerequisites: permission of the instructor

PHYS 754 Accelerator Physics (3 Credit Hours)
Overview of the underlying physics of modern particle accelerators. Beam acceleration, coupled and uncoupled beam transport, nonlinear dynamics, collective effects, phase space cooling, and free-electron lasers will be covered. Depending on the instructor, additional topics of current interest such as coherent synchrotron radiation, wakefields and impedances, and novel methods of acceleration will be discussed.

PHYS 755 Experimental and Computational Techniques in Accelerator Physics (3 Credit Hours)
Overview of the tools and techniques used in the design of particle accelerators and the measurement of their components. The course is targeted for both physicists and engineers, and its intent is to provide them with a common language and understanding. The course consists of 6 modules of 2 weeks each. Each module will be a combination of assigned readings, lectures, computer-based design, and hand-on measurements. Typical topics to be addressed in the 6 modules are: beamline design, electromagnetic cavity design, magnets, beam instrumentation, engineering principles for superconducting rf accelerators, machine learning.

PHYS 759 Classical Mechanics and Electromagnetism in Accelerator Physics (3 Credit Hours)
Further developments in classical mechanics and electromagnetism and their application to accelerator physics: Lagrangian and Hamiltonian formulation of equations of motion, canonical transformations, adiabatic invariants, linear and nonlinear resonances. Louisville's theorem, solutions of Maxwell's equation in cavities and waveguides, wakefields, radiation and retarded potentials, and synchrotron radiation.
Prerequisites: PHYS 601, PHYS 603, and PHYS 704 or PHYS 804

PHYS 760 Low Temperature Physics (3 Credit Hours)
Properties and behavior of materials and systems at low temperature with emphasis on particle accelerator and microwave applications. Macroscopic quantum phenomena in condensates. Superfluidity, electrodynamic properties of superconductors.
Prerequisites: PHYS 825

PHYS 765 Design and Operating Principles of Particle Accelerators (3 Credit Hours)
This course will introduce design and general operating principles for particle accelerators, including acceleration methods for particles and beams. Topics will include the evolution and descriptions of particle beams under acceleration, physics of accelerated particle beams, as well as the effects of space charge, high-order modes (HOMs), and other collective effects. Aspects of both normal conducting (RF) and superconducting (SRF) particle beam acceleration will be covered.
Prerequisites: PHYS 603, PHYS 604, and PHYS 754 or PHYS 854

PHYS 790 Introduction to the Processes of Quantum Chromodynamics (3 Credit Hours)
An introduction to basic Quantum Chromodynamics (QCD) methods in hadron-scattering experiments. Focus will be placed on perturbative methods and partonic interpretations of specific processes. The course will begin with a general overview of QCD, and specific processes will be studied in detail to illustrate the general features of patronic physics and their QCD interpretations. The course will close with a summary of questions of current research interest.
Prerequisites: PHYS 871

PHYS 791 Seminar I (1 Credit Hour)
This seminar is designed to enhance both written and oral communication skills as applied to physics. Topics include effective display of data, preparation of scientific reports and preparation and delivery of scientific talks.

PHYS 795 Special Topics in Physics (1-3 Credit Hours)
Thorough coverage of areas selected to meet special needs and interests.
Prerequisites: Permission of the instructor

PHYS 796 Special Topics in Accelerator Physics (3 Credit Hours)
Special topics related to particle accelerators and their applications.
Prerequisites: Department approval required

PHYS 797 Research (1-6 Credit Hours)

PHYS 804 Classical Electrodynamics II (3 Credit Hours)
Electrodynamics: Maxwell equations, plane electromagnetic waves and wave propagation, waveguides, radiating systems, special theory of relativity, including the dynamics of relativistic particles and electromagnetic fields.
Prerequisites: PHYS 604

PHYS 807 Statistical Mechanics (3 Credit Hours)
Review of thermodynamics. Classical statistical mechanics and applications. The virial expansion. Quantum statistical mechanics and the micro-canonical, canonical, and grand-canonical ensembles. The Fermi and Bose gases, and applications. Special topics in statistical mechanics.
Prerequisites: PHYS 603

PHYS 811 Computational Physics (3 Credit Hours)
Studies of high level computer languages. Computational techniques used in physics. Numerical techniques for differential and integral problems. Algebraic processing languages. Introduction to scientific visualization techniques.

PHYS 821 Quantum Mechanics II (3 Credit Hours)
Further development of quantum mechanics. Multi-particle states, bosons and fermions. Classical Limit. Variational principle, time-dependent perturbation theory and scattering. Path integral formulation. Symmetry and groups, addition of angular moments. Examples from solid state, atomic, nuclear and particle physics.
Prerequisites: PHYS 621

PHYS 822 Nuclear and Particle Physics I (3 Credit Hours)
Nuclear forces, models of nuclear structure and reactions, hadron and lepton scattering, introduction to constituent quark model and hadron spectroscopy.
Prerequisites: PHYS 621

PHYS 823 Nuclear and Particle Physics II (3 Credit Hours)
Discrete and continuous symmetries and application to particle physics, SU(2) and SU(3) symmetries and static properties of hadrons. Klein-Gordon and Dirac equations, quantum electrodynamics and Feynman rules, strong and weak interactions. Standard Model and physics beyond the Standard Model.
Prerequisites: PHYS 722 or PHYS 822

PHYS 824 Condensed Matter Physics I (3 Credit Hours)
Electronic and lattice properties of solids, band structures of metals, semiconductors and insulators, dynamics of electron and phonons, electromagnetic and optical properties of metals and doped semiconductors, phenomenology of superconductivity and magnetism, and selected experimental methods of solid state physics.
Prerequisites: PHYS 621, and PHYS 721 or PHYS 821

PHYS 825 Condensed Matter Physics II (3 Credit Hours)
Many body and collective effects in condensed matter, including phase transitions, Bose and Fermi quantum liquids, superfluidity, superconductivity and magnetism, and properties of mesoscopic and low-dimensional systems.
Prerequisites: PHYS 707 or PHYS 807, and PHYS 724 or PHYS 824

PHYS 827 Atomic Physics (3 Credit Hours)
Irreducible tensor methods. Radiative excitation and ionization processes. Atom-atom scattering. Time-evolution of atomic observables in external fields. Multiple channel quantum defect theory and complex atomic and molecular spectra.
Prerequisites: permission of the instructor

PHYS 842 Advanced Quantum Mechanics (3 Credit Hours)
Introduction to relativistic quantum mechanics; symmetries in relativistic wave equations; solutions to relativistic wave equations for bound states and scattering processes; classical field theory and role of symmetries in construction of conserved currents; introduction to second quantization of fields.
Prerequisites: PHYS 704 or PHYS 804, PHYS 721 or PHYS 821

PHYS 854 Accelerator Physics (3 Credit Hours)
Overview of the underlying physics of modern particle accelerators. Beam acceleration, coupled and uncoupled beam transport, nonlinear dynamics, collective effects, phase space cooling, and free-electron lasers will be covered. Depending on the instructor, additional topics of current interest such as coherent synchrotron radiation, wakefields and impedances, and novel methods of acceleration will be discussed.

PHYS 855 Experimental and Computational Techniques in Accelerator Physics (3 Credit Hours)
Overview of the tools and techniques used in the design of particle accelerators and the measurement of their components. The course is targeted for both physicists and engineers, and its intent is to provide them with a common language and understanding. The course consists of 6 modules of 2 weeks each. Each module will be a combination of assigned readings, lectures, computer-based design, and hand-on measurements. Typical topics to be addressed in the 6 modules are: beamline design, electromagnetic cavity design, magnets, beam instrumentation, engineering principles for superconducting rf accelerators, machine learning.

PHYS 857 Plasma Physics (3 Credit Hours)
Motion of charged particles in electromagnetic fields. Coulomb collisions and transport processes. Collisional Boltzmann equation. Generation of various forms of plasma in the laboratory. Basic plasma diagnostic methods including plasma and laser spectroscopy, measurements of electron and ion density and energy distribution.
Prerequisites: PHYS 603, PHYS 604, PHYS 704/PHYS 804, PHYS 727/PHYS 827 or permission of the instructor

PHYS 859 Classical Mechanics and Electromagnetism in Accelerator Physics (3 Credit Hours)
Further development in classical mechanics and electromagnetism and their application to accelerator physics: Lagrangian and Hamiltonian formulation of equations of motion, canonical transformations, adiabatic invariants, linear and nonlinear resonances. Louisville's theorem, solutions of Maxwell's equation in cavities and waveguides, wakefields, radiation and retarded potentials, and synchrotron radiation.
Prerequisites: PHYS 601, PHYS 603, and PHYS 704 or PHYS 804

PHYS 860 Low Temperature Physics (3 Credit Hours)
Properties and behavior of materials and systems at low temperature with emphasis on particle accelerator and microwave applications. Macroscopic quantum phenomena in condensates. Superfluidity, electrodynamic properties of superconductors.
Prerequisites: PHYS 825

PHYS 861 Nuclear Physics (3 Credit Hours)
The Yukawa potential in classical and quantum mechanics. One- and two-meson exchange amplitudes. Pion-exchange interactions: one- and two-pion exchange two-nucleon potentials, and two-pion exchange three-nucleon potentials. Electromagnetic interactions. Nucleon-nucleon scattering. Realistic models of two- and three-nucleon potentials. Relativistic corrections to the nuclear Hamiltonian. Electro-weak currents of nucleons and nuclei.
Prerequisites: PHYS 621 and either PHYS 721 or PHYS 821

PHYS 865 Design and Operating Principles of Particle Accelerators (3 Credit Hours)
This course will introduce design and general operating principles for particle accelerators, including acceleration methods for particles and beams. Topics will include the evolution and descriptions of particle beams under acceleration, physics of accelerated particle beams, as well as the effects of space charge, high-order modes (HOMs), and other collective effects. Aspects of both normal conducting (RF) and superconducting (SRF) particle beam acceleration will be covered.
Prerequisites: PHYS 603, PHYS 604, and PHYS 754 or PHYS 854

PHYS 871 Introduction to Quantum Field Theory I (3 Credit Hours)
Quantization of the Klein-Gordon field, interactions in quantum field theory and Feynman diagrams, quantization of the Dirac field, quantization of the electromagnetic field, quantum electrodynamics, renormalization, quantum chromodynamics and asymptotic freedom.
Prerequisites: PHYS 842

PHYS 872 Introduction to Quantum Field Theory II (3 Credit Hours)
Further development of topics in quantum field theory. The course addresses renormalization, non-abelian gauge theories, and advanced calculation techniques.
Prerequisites: PHYS 871

PHYS 890 Introduction to the Processes of Quantum Chromodynamics (3 Credit Hours)
An introduction to basic Quantum Chromodynamics (QCD) methods in hadron-scattering experiments. Focus will be placed on perturbative methods and partonic interpretations of specific processes. The course will begin with a general overview of QCD, and specific processes will be studied in detail to illustrate the general features of patronic physics and their QCD interpretations. The course will close with a summary of questions of current research interest.
Pre- or corequisite: PHYS 871

PHYS 891 Seminar I (1 Credit Hour)
This seminar is designed to enhance both written and oral communication skills as applied to physics. Topics include effective display of data, preparation of scientific reports and preparation and delivery of scientific talks.

PHYS 892 Seminar II (1 Credit Hour)
A continuation of PHYS 891 at an advanced level. This seminar is designed to enhance both written and oral communication skills as applied to physics. Topics include effective display of data, preparation of scientific reports and preparation and delivery of scientific talks.

PHYS 895 Special Topics in Physics (1-3 Credit Hours)
Thorough coverage of areas selected to meet special needs and interests.
Prerequisites: Permission of the instructor

PHYS 896 Special Topics in Accelerator Physics (3 Credit Hours)
Special topics related to particle accelerators and their applications.
Prerequisites: Departmental approval required

PHYS 898 Doctoral Research (1-12 Credit Hours)

PHYS 899 Dissertation (1-9 Credit Hours)