DEPARTMENT OF PHYSICS

Department website (https://www.wm.edu/physics/)

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Vision
We envision a scholarly physics community distinguished by excellence in research, impactful undergraduate & graduate teaching, and tailored mentorship that fosters curiosity & innovation.

Mission
We pursue world-class scientific exploration across physics subfields and provide a transformative education defined by outstanding teaching, significant research experience, close mentorship, and collaboration among undergraduate, graduate, postdoctoral, and faculty researchers. We maintain a commitment to scientific discovery and the formation of future scientists & leaders. We enhance these activities through partnerships with national laboratories, regional institutions, and industry.

About the Physics Department
The Physics Department offers graduate study and research that leads to the Ph.D. degree.

Students applying with an undergraduate degree must satisfactorily complete the M.S. requirements before working towards the PhD. We do not admit students who are seeking a terminal Master's degree, though one may be awarded after completing all requirements for the M.S.

Our research mission is to understand the fundamental origin and the mathematical description of physical phenomena. Currently, the Department of Physics conducts active research in the following areas:

- Atomic, Molecular, and Optical Experiment
- Atomic, Molecular, and Optical Theory
- Condensed Matter Experiment
- Condensed Matter Theory
- Nuclear and Hadronic Experiment
- Nuclear and Hadronic Theory
- High Energy Experiment
- High Energy Theory
- Plasma and Nonlinear Physics

In addition, we have affiliated efforts in accelerator physics (in cooperation with Jefferson Lab) and materials characterization (in cooperation with NASA-Langley Research Center). The Physics Department maintains strong links with William & Mary's Applied Science Department and students can work on projects there as well.

Program Structure
The graduate program in physics at William & Mary rests on three pillars: coursework, teaching, and research.

Coursework: All candidates for graduate degrees must successfully complete a program of core plus elective courses that is approved by the department.

Teaching: Teaching is an integral part of the educational process for those who seek an advanced degree. Degree candidates will be assigned teaching duties for at least two semesters.

Research: The Department carries out experimental and theoretical research in many subfields, and the results are communicated in refereed journals, in conferences and seminars, and in books. Graduate students learn to conduct original scientific research in physics.

Graduate students are also expected to participate in the Department's public service efforts.

Admission Requirements
Students are admitted directly to the Ph.D. program. Students who have recently completed their undergraduate degree as well as students who have completed a Masters are considered for admission. The department will endeavor to provide financial support to Ph.D. students who are making satisfactory progress in their course work and research.

William & Mary uses an online application system. Application materials consist of transcripts and three letters of recommendation. The general and physics subject GRE scores are not required but may optionally be supplied. The absence of GRE scores will not negatively affect the application. Supplemental application questions are also required. If English is not your first language, your Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS) scores are required and must be sent directly to William & Mary by the Educational Testing Service or IELTS. Upon the recommendation of the physics program the TOEFL/IELTS requirement can be waived for applicants who will have received a degree from a college or university in which English is the primary language of instruction.

Although exceptions are made, it is recommended that graduate students begin their course work in the fall semester. New students who will be supported during the academic year may receive research assistantships for the summer before they begin their formal course work if funds are available.

Graduate Programs in Physics

- Physics (MS in Physics)
- Physics (PhD in Physics)

Graduate Courses in Physics

PHYS 566 Directed Studies (3-4 Credits)
No credits earned in this course may be applied to the number of credits required to satisfy graduate degree requirements. This course may be repeated for credit.

PHYS 581 Topics in Physics (1-3 Credits)
Special topics of current interest. This course may be repeated for credit when the instructor determines there will not be a duplication of material.

PHYS 600 Independent Study (3 Credits)
Course concerning special topics in physics not covered in regular course offerings. This course may be repeated for credit if instructor determines there will be no duplication of material.

PHYS 601 Classical Mechanics (4 Credits)
The mechanics of particles and rigid bodies, methods of Lagrangian and Hamiltonian mechanics, relativistic mechanics, approximation techniques.

PHYS 603 Mathematical Physics (4 Credits)
Complex variables and analytic functions. Vector spaces (finite dimensional and infinite dimensional), operators and matrix representations.

PHYS 610 Classical Electricity and Magnetism I (4 Credits)
Electrostatics. Solution of boundary value problems. Green's functions and direct solution of Laplace's equation. Magnetostatics and steady currents. Maxwell's equations and plane wave solutions.

PHYS 611 Classical Electricity and Magnetism II (3 Credits)
Waves inside conducting boundaries. Radiation from simple current systems, spherical waves and multipole radiation. Covariant formulation of electromagnetism. Interaction of radiation with matter.
Prerequisite(s): PHYS 610

PHYS 621 Quantum Mechanics I (4 Credits)
Axiomatic development of wave mechanics and the Schroedinger equation in one and three dimensions; wave packets; spin and angular momentum.

PHYS 622 Quantum Mechanics II (4 Credits)
Scattering theory; matrix methods; symmetry; perturbation theory and other approximate methods; identical particles; relativistic wave equations and their applications.
Prerequisite(s): PHYS 621

PHYS 623 Statistical Physics and Thermodynamics (4 Credits)
Statistical ensembles and averages, classical equilibrium, thermodynamics and statistical mechanics, quantum statistics, kinetic theory and transport properties.
Prerequisite(s): PHYS 601 and PHYS 621

PHYS 631 Quantum Optics and Atomics (3 Credits)
This is a graduate-level course designed to introduce the theory, current research topics and applications of Atomic Physics and Quantum Optics. Cross-listed with PHYS 430.
Prerequisite(s): PHYS 621

PHYS 632 Quantum Materials and Quantum Devices (3 Credits)
This a graduate-level course designed to introduce the basic concepts and methods for the theoretical description of quantum materials and quantum devices. The first part of the course focuses on the electronic properties of quantum materials. In the second part, the concepts of qubit, quantum gate, and quantum sensor are introduced, along with examples of their implementation based on quantum materials. Cross-listed with PHYS 432.
Prerequisite(s): PHYS 621

PHYS 634 Introduction to Plasma Physics (3 Credits)
This course provides an introduction to plasma physics, including where plasmas are found, avenues of current research, and computational methods in the field. The concepts of single-particle motion, fluid equations, magnetohydrodynamics, and waves and instabilities are covered. Cross-listed with PHYS 434.

PHYS 638 Nuclear and Particle Physics (3 Credits)
This course provides an introduction to particle and nuclear physics. Topics include: global properties of nuclei, nuclear stability, nucleon structure, elastic and deep inelastic scattering from nuclei, QCD (quarks and gluons), quarkonia and other mesons, collider physics, weak interaction phenomenology, neutrino oscillations, weak bosons, and the Standard Model. Cross-listed with PHYS 438.
Prerequisite(s): PHYS 621

PHYS 639 General Relativity and Cosmology (3 Credits)
Introduction to general relativity, tensor analysis, gravitational field equations, gravitational waves, Schwarzschild and Kerr solutions, cosmological models, gravitational collapse. Cross-listed with PHYS 439.

PHYS 651 Teaching Physics (2 Credits)
Designed for entering students teaching a lab or tutoring one of our undergraduate courses. Respective faculty will instruct students in relevant ways. This course may be repeated for credit.

PHYS 657 Careers in Physics (1 Credit)
Presentations and discussion of a wide spectrum of career options for physics graduates. Invited speakers from private enterprises, the public sector, and nonprofit organizations will describe opportunities and experiences in their professions. This course may be repeated for credit when the instructor determines there will not be duplication of material.

PHYS 685 Colloquium (0-2 Credits)
Includes presentations by invited speakers on areas of active research in physics. The course also will include an overview of physics research at William & Mary and training in the responsible and ethical conduct of research. No credits earned in this course may be applied to the number of credits required for a degree. This course may be repeated.

PHYS 690 Advanced Topics in Physics (1-4 Credits)
Special topics of current interest. This course may be repeated for credit when the instructor determines there will not be a duplication of material.

PHYS 694 Directed Non-thesis Master's Research (3-12 Credits)
Students design and conduct research on a relevant topic with a faculty advisor. This course may be repeated, but no more than 12 semester credit hours may be used to satisfy degree requirements. Students who are submitting a master's thesis may not use this course to satisfy degree requirements.

PHYS 702 Advanced Mathematical Physics (3 Credits)
Differential equations, Green's functions, some hypergeometric functions, group theory, representation of groups.

PHYS 721 Quantum Field Theory I (3 Credits)
Canonical quantization of scalar, spinor and vector fields; interacting field theories and Feynman diagrams; scattering theory; quantum electrodynamics and introduction to radiative corrections.
Prerequisite(s): PHYS 622

PHYS 722 Quantum Field Theory II (3 Credits)
Functional integral quantization of field theories. Renormalization. Quantization of gauge theories. Spontaneous Symmetry Breaking and the Higgs mechanism.
Prerequisite(s): PHYS 721

PHYS 741 Condensed Matter Physics (3 Credits)
Introduction to the frontiers of condensed matter physics research; crystal structure, phonons, electrons, electric, optical, and magnetic properties, impurities, elementary excitations, band theory and experimental methods.
Prerequisite(s): PHYS 622 and PHYS 630

PHYS 742 Advanced Condensed Matter Physics (3 Credits)
Selected topics from the frontiers of condensed matter physics research that may include semiconductors, magnetism, superconductivity, topological states of quantum matter. Discussions of modern experimental and theoretical methods.
Prerequisite(s): PHYS 741

PHYS 766 Directed Studies (1-12 Credits)
No credits earned in this course may be applied to the number of credits required to satisfy graduate degree requirements. This course may be repeated.

PHYS 772 The Standard Model of Particle Physics (3 Credits)
Gauge theory. Electroweak interactions and unification. Quantum Chromodynamics. Particle phenomenology.
Prerequisite(s): PHYS 721

PHYS 773 Topics in Nuclear and Particle Physics (3 Credits)
Topics of current interest in strong, electromagnetic and weak interactions; course may be repeated for credit when the instructor determines there will not be duplication of material.
Prerequisite(s): PHYS 772

PHYS 795 Directed Dissertation Research (3-12 Credits)
Students design and conduct research in support of their dissertation under the direction of a faculty advisor. This course may be repeated, but no more than 12 semester credit hours may be used to satisfy degree requirements for a student submitting a dissertation. Students who are not submitting a dissertation may not use this course to satisfy degree requirements.

PHYS 800 Dissertation (1-12 Credits)
Students finish the research for and the writing of their dissertation under the direction of a faculty advisor. This course may be repeated, but no more than 24 semester credit hours may be used to satisfy degree requirements for a doctorate only.