

Physics and Astronomy

Degrees Offered

- Bachelor of Arts
- Bachelor of Science

Students may not earn both a B.A. and a B.S. in Physics.

Nature of the Program

There are two degree options for students in physics. The bachelor of science degree is designed for students committed to a career in research. It can be followed by graduate work in physics, chemistry, materials science, optical sciences, astrophysics, engineering, or in other physical sciences such as meteorology, oceanography, etc. Some students instead pursue positions in industry, high school teaching, or in a government laboratory immediately after completing the B.S. This degree program provides a comprehensive grounding in the fundamentals of physics and is usually accompanied by participation in one of the active research programs within the department.

The bachelor of arts degree is designed to prepare students for a career that utilizes physics preparation in conjunction with an applied emphasis. By allowing more free elective choices, it prepares a student for a career that combines a science background with subsequent professional training.

Typical career paths for this degree program include teaching, medicine, dental school, medical school, patent law, forensics, health physics, environmental engineering, science journalism, government policy, and business management.

The courses in physics provide a mix of theoretical concepts and practical examples. Each course within a degree plan builds upon the knowledge base acquired in previous courses and, together, these courses allow a student to acquire the combination of physical insight and mathematical skill needed for success in today's demanding job markets.

The department also offers introductory survey courses in physics and astronomy that are of interest to a broad range of students in the social sciences, fine arts, humanities, health sciences, and education. These courses use a minimum of mathematics to introduce the principles of physics and they provide many examples from the "real world" of the environment, energy, space, communications, transportation, and medicine.

For the B.S. degree, an Area of Emphasis is required. The Professional Preparation Area of Emphasis is the typical plan of study for graduate study in physics. Each Area of Emphasis is designed to allow some room for customization in consultation with your physics advisor within the required number of credits to degree. Recommendations for the other areas of emphasis include:

COMPUTATIONAL PHYSICS

Computational models sometimes help solve difficult problems in physics. Students in this area of emphasis learn statistical modeling and other related skills to help analyze various concepts in physics.

MEDICAL PHYSICS

Students in the Medical Physics area of emphasis learn applications of physics that can lead to an exciting range of careers in the medical field. From researching and designing new medical equipment to helping plan radiation treatment for cancer patients, this area of physics is broad but important.

PHYSICS TEACHING

For many of us, a love of physics developed from interacting with a motivational physics teacher. This area of emphasis allows students to earn a degree in physics while simultaneously preparing for a career in teaching at the middle or high school level. Students develop pedagogical skills to help others strengthen quantitative reasoning and problem solving skills that are vital in physics -- and anywhere!

SPACE PHYSICS

Students in this area of emphasis learn skills that help address fundamental questions about our place in the universe, the history of our solar system and more. The challenges of understanding space exploration have led to fascinating expansions in technology, new industries and unprecedented relationships with other nations.

Minors

All students have the possibility of earning one or more minors; view a list of all available minors and their requirements (<http://catalog.wvu.edu/undergraduate/minors/>) here. Please note that students may not earn a minor in their major field.

Certificate of Global Engagement

Students in the Eberly College, regardless of their major, can earn a Certificate of Global Engagement. Completion of the Certificate demonstrates the student's knowledge of diverse cultures, as well as the ability to communicate and interact effectively with people of different cultural backgrounds. Students will be required to apply their knowledge of contemporary issues and global social contexts to their coursework and their broader citizenship. For details regarding Certificate requirements, please visit the Eberly College page (<http://catalog.wvu.edu/undergraduate/eberlycollegeofartsandsandsciences/#otherdegreestext>).

FACULTY

INTERIM CHAIR

- Duncan R. Lorimer - Ph.D. (University of Manchester)

ASSOCIATE CHAIR

- Paul M. Miller - Ph.D. (West Virginia University)

PROFESSORS

- Wathiq Abdul-Razzaq - Ph.D. (University of Illinois - Chicago)
Physics Education
- Paul Cassak - Ph.D. (University of Maryland)
Woodburn Fellow, Plasma Physics
- Matthew Johnson - Ph.D. (California Institute of Technology)
Experimental Condensed Matter Physics
- Mark E. Koepke - Ph.D. (University of Maryland)
Robert C. Byrd Professor, Experimental Plasma Physics
- Lian Li - Ph.D. (University of Arizona)
Robert L. Carroll Professor, Experimental Condensed Matter Physics
- Duncan R. Lorimer - Ph.D. (University of Manchester)
Eberly College Associate Dean for Research and Interim Chair
- Maura McLaughlin - Ph.D. (Cornell University)
Eberly Distinguished Professor, Astrophysics/Astronomy
- Paul M. Miller - Ph.D. (West Virginia University)
Physics Education Research
- Sheena Murphy - Ph.D. (Cornell University)
Associate VP for Research Development
- D.J. Pisano - Ph.D. (University of Wisconsin - Madison)
Astrophysics/Astronomy
- Aldo Romero - Ph.D. (University of California - San Diego)
Eberly Distinguished Professor, Condensed Matter Theory and Computation
- Earl E. Scime - Ph.D. (University of Wisconsin - Madison)
Oleg D. Jefimenko Professor, Experimental Plasma Physics
- Tudor Stanescu - Ph.D. (University of Illinois - Urbana Champaign)
Theoretical Condensed Matter Physics
- Gay Stewart - Ph.D. (University of Illinois - Urbana Champaign)
Eberly Professor of STEM Education
- John Stewart - Ph.D. (University of Illinois - Urbana Champaign)
Physics Education Research

ASSOCIATE PROFESSORS

- Loren Anderson - Ph.D. (Boston University)
Astrophysics/Astronomy
- Alan Bristow - Ph.D. (University of Sheffield)
Experimental Condensed Matter Physics
- Cheng Cen - Ph.D. (University of Pittsburgh)
Experimental Condensed Matter Physics
- Edward Flagg - Ph.D. (University of Texas - Austin)
Experimental Condensed Matter Physics

- Mikel Holcomb - Ph.D. (University of California - Berkeley)
Experimental Condensed Matter Physics
- Sean McWilliams - Ph.D. (University of Maryland)
Astrophysics/Astronomy
- Weichao Tu - Ph.D. (University of Colorado - Boulder)
Space Plasma Physics
- Kathryn Williamson - Ph.D. (Montana State University)
Astronomy Education Research

ASSISTANT PROFESSORS

- Sarah Burke-Spolaor - Ph.D. (Swinburne University of Technology)
Astrophysics/Astronomy
- Emmanuel Fonseca - Ph.D. (University of British Columbia)
Astronomy
- Katherine Goodrich - Ph.D. (University of Colorado - Boulder)
Space Physics
- Joonhee Lee - Ph.D. (Seoul National University)
Experimental Biophysics

RESEARCH ASSISTANT PROFESSOR

- Chris Fowler - Ph.D. (University of Colorado - Boulder)
Plasma Physics, Space Plasmas
- Yanjun Ma - Ph.D. (University of Pittsburgh)
Condensed Matter Physics
- Qiang Wang - Ph.D. (University of Colorado - Boulder)
Condensed Matter Physics

PROFESSORS EMERITI

- Leonardo Golubovic - Ph.D. (University of Belgrade)
Theoretical Condensed Matter and Statistical Physics
- Larry E. Halliburton - Ph.D. (University of Missouri - Columbia)
Condensed Matter Physics
- Arthur S. Pavlovic - Ph.D. (Columbia University)
Condensed Matter Physics
- Mohindar S. Seehra - Ph.D. (University of Rochester)
Eberly Distinguished Professor Emeritus, Condensed Matter Physics
- Richard Treat - Ph.D. (University of California – Riverside)
General Relativity
- H. Arthur Weldon - Ph.D. (Massachusetts Institute of Technology)
Particle Physics

Admissions

- First Time Freshmen are admitted to the major directly. For the timely completion of the degree, it is recommended that students have a minimum MATH ACT of 22, a MATH SAT of 540, or an ALEKS score of 45. Students must have a placement into a Math course to receive a complete schedule for their first semester. Students without placement may not be competitive to remain in the major.
- Students transferring from another major within WVU must meet milestones set by the department: a GPA of 2.2 in math & physics courses with at least one math & physics course completed and a 2.0 overall GPA.
- Students transferring from another institution must meet milestones set by the department: a GPA of 2.2 in math & physics courses with at least one math & physics completed and a 2.0 overall GPA.

Due to Covid-19 – Admission requirements may differ from what is listed on this page. Please review the most up-to-date program admission requirements for the Bachelor of Science and Bachelor of Arts in Physics (<https://admissions.wvu.edu/academics/majors/physics/>) major.

ADMISSION REQUIREMENTS 2023-2024

The Admission Requirements above will be the same for the 2023-2024 Academic Year.

Major Code: 1463

Degree Progress

- By the end of their the second semester (excluding summer) in the major, at minimum, students must have completed MATH 126 completion of CHEM 115/116 or 117/118 with a minimum grade of C-.
- **GPA in the major:**
 - Students must have a cumulative GPA in the major requirements of 2.2 or better after completing two physics courses, or they will be placed on probation.
 - Students who do not raise their GPA in the major requirements above 2.2 after one semester on probation will be removed from the Major.
- **Repeated MATH and PHYS courses:**
 - Students not able to attain better than a D/F/W by the second attempt in a mathematics or physics course will be placed on probation.
 - A student with three grades of D/F/W in the same physics or mathematics course will be removed from the Major.

COURSES

Astronomy

ASTR 106. Descriptive Astronomy. 3 Hours.

The celestial sphere, star time, solar time, Kepler's laws, H-R diagram and modern developments. No sophisticated mathematics used; only simple geometrical arguments employed.

ASTR 106L. Descriptive Astronomy Laboratory. 1 Hour.

PR or CONC: ASTR 106. Introduction to modern astronomical techniques and practices through research-quality astronomical data collection and analysis, computer simulation, and hands-on activities. Includes study of objects in our solar system, in the Milky Way, and located much farther away in the vast reaches of space. Students engage in authentic scientific practices while exploring the universe.

ASTR 110. Explosions in Space. 3 Hours.

PR: MATH 124 or higher, or appropriate score on MATH placement test. Topics covered include: special and general relativity, supernovae, neutron stars, black holes, wormholes, time travel and gamma-ray bursts.

ASTR 115. Honors Relativity. 1 Hour.

PR: MATH 124 or higher or appropriate score on MATH placement test. Exploration of gravity as the geometry of four-dimensional space time; the legacy of Einstein.

ASTR 250. Pulsar Search Collaboratory. 3 Hours.

PR: Consent. Online data analysis of Green Bank Telescope (GBT) data as part of the PSC effort to discover pulsars and will acquaint students with the scientific method, the power of information technology, and basic astronomical concepts. It is open to high-school students and work will be done largely remotely.

ASTR 290. Teaching Practicum. 1-3 Hours.

ASTR 293. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

ASTR 298. Honors. 1-3 Hours.

PR: Students in Honors Program and consent by the honors director. Independent reading, study, or research.

ASTR 367. Astrophysics 1. 3 Hours.

PR: PHYS 314. Physical description of the astronomical universe. Physical principles are used to explain the properties and evolution of stars. Physical properties and effects of the Milky Way's interstellar medium are examined.

ASTR 368. Astrophysics 2. 3 Hours.

PR: ASTR 367. Continuation of ASTR 367. Physical principles are applied to the properties and evolution of the Milky Way and galaxies and to the structure and evolution of the solar system. Physical properties of the universe are examined.

ASTR 393. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

ASTR 469. Observational Astronomy. 3 Hours.

PR: PHYS 314. Laboratory course consisting of three detailed projects which aim to acquaint students with current techniques for astronomy data analysis and interpretation across the electromagnetic spectrum.

ASTR 470. General Relativity. 3 Hours.

PR: PHYS 314 and PHYS 331. Innovative 'physics-first' introduction to Einstein's relativistic theory of gravity. Topics covered include special relativity, curved space time, spherical stars, gravitational collapse, black holes, gravitational waves and cosmology.

ASTR 490. Teaching Practicum. 1-3 Hours.

PR: Consent. Teaching practice as a tutor or assistant.

ASTR 491. Professional Field Experience. 1-18 Hours.

PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

ASTR 492. Directed Study. 1-3 Hours.

Directed study, reading, and/or research.

ASTR 493. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

ASTR 494. Seminar. 1-3 Hours.

PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

ASTR 495. Independent Study. 1-6 Hours.

Faculty supervised study of topics not available through regular course offerings.

ASTR 496. Senior Thesis. 1-3 Hours.

PR: Consent.

ASTR 497. Research. 1-6 Hours.

Independent research projects.

ASTR 498. Honors. 1-3 Hours.

PR: Students in honors program and consent by the honors director. Independent reading, study, or research.

Physical Science

PHSC 293. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

PHSC 490. Teaching Practicum. 1-3 Hours.

PR: PHYS 105 or consent. Teaching practice as a tutor or assistant. Opportunity to help teach an activity-based science course under the direction of experienced instructors. Emphasis on developing inquiry teaching skills useful for all levels of classroom instruction.

PHSC 491. Professional Field Experience. 1-18 Hours.

PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

PHSC 494. Seminar. 1-3 Hours.

PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

PHSC 496. Senior Thesis. 1-3 Hours.

PR: Consent.

PHSC 498. Honors. 1-3 Hours.

PR: Students in Honors Program and consent by the honors director. Independent reading, study or research.

Physics

PHYS 101. Introductory Physics 1. 4 Hours.

PR or CONC: MATH 128 or MATH 129 or MATH 150 or MATH 153 or MATH 154 or MATH 155 or MATH 156 or satisfactory performance on MATH departmental placement exam and Coreq: PHYS 101L. The fundamental philosophy and principles of physics are applied to studies of mechanics, sound, heat, and thermodynamics through demonstrations, problems, and experiments. Pre-requisites and/or co-requisites may differ on regional campuses.

PHYS 101L. Introductory Physics 1 Laboratory. 0 Hours.

PR: Corequisite of PHYS 101. Introductory Physics 1 - PHYS 101 Laboratory.

PHYS 102. Introductory Physics 2. 4 Hours.

PR: PHYS 101 and PHYS 101L and Coreq: PHYS 102L. The fundamental philosophy and principles of physics are applied to studies of electricity, magnetism, optics, light, and atomic and nuclear physics through demonstrations, problems, and experiments. Pre-requisite(s) and/or co-requisite(s) may differ on regional campuses.

PHYS 102L. Introductory Physics 2 Laboratory. 0 Hours.

PR: Corequisite of PHYS 102. Introductory Physics 2 - PHYS 102 Laboratory.

PHYS 105. Conceptual Physics. 4 Hours.

PR: Corequisite of PHYS 105L. Basic principles of physics and their relationship to our modern technological society. Major topics include properties of matter, electricity, optics, motion, heat and temperature, and energy. Nonmathematical approach emphasized.

PHYS 105L. Conceptual Physics Laboratory. 0 Hours.

PR: Corequisite of PHYS 105. Conceptual Physics - PHYS 105 Laboratory.

PHYS 107. Physics of Music. 3 Hours.

For all students including those in the liberal and fine arts. (No science or music prerequisites.) The physical and psychophysical principles underlying the nature, production, transmission, reception, and reproduction of sound.

PHYS 111. General Physics 1. 4 Hours.

PR: MATH 155 or PR or CONC: MATH 154 with a minimum grade of C- in all and Coreq: PHYS 111L. Survey of classical mechanics, thermodynamics and waves.

PHYS 111L. General Physics 1 Laboratory. 0 Hours.

PR: Corequisite of PHYS 111. General Physics 1 - PHYS 111 Laboratory.

PHYS 112. General Physics 2. 4 Hours.

PR: PHYS 111 and PHYS 111L and Coreq: PHYS 112L. Survey of electricity, magnetism, and optics.

PHYS 112L. General Physics 2 Laboratory. 0 Hours.

PR: Corequisite of PHYS 112. General Physics 2 - PHYS 112 Laboratory.

PHYS 115. Physics 112 Lab Alternative. 1 Hour.

PR: PHYS 112 with a grade of C- or higher. Laboratory component of survey of electricity magnetism and optics. (This laboratory is an alternative for students who transfer PHYS 112 without a laboratory and need to complete the lab only).

PHYS 191. First-Year Seminar. 1-3 Hours.

Engages students in active learning strategies that enable effective transition to college life at WVU. Students will explore school, college and university programs, policies and services relevant to academic success. Provides active learning activities that enable effective transition to the academic environment. Students examine school, college and university programs, policies and services.

PHYS 199. Orientation to Physics. 1,2 Hour.

Orientation to degree programs and requirements, departmental resources, curriculum options, student responsibilities and opportunities.

PHYS 211. Introduction to Mathematical Physics. 3 Hours.

PR: MATH 251 and PHYS 112. Review of basic calculus with application to Physics; e.g. vector calculus and Maxwell's Equations, Fourier Series and the vibrating string, eigenvalues, eigenvectors and coupled oscillators. Complex algebra, linear algebra, differential equations, practical differential equations, Bessel functions, Legendre Polynomials, and Fourier Transforms.

PHYS 290. Teaching Practicum. 1-3 Hours.

PHYS 293. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

PHYS 301. Computational Physics. 3 Hours.

PR: MATH 261 and PHYS 314. Using basic numerical techniques to gain insight into physical systems. Numerical solutions for projectile motion, chaotic systems, and motion in a gravitational field (including N-body simulations). Numerical solutions to Maxwell's equations, the diffusion equation, the wave equation, Schrodinger's equation, and the hydrogen atom. Implementation of discrete Fourier Transforms and wavelet methods for analysis of time series.

PHYS 312. Oscillations and Thermal Physics. 3 Hours.

PR: PHYS 111 and PHYS 112 with a minimum grade of C- in each. Introduction to wave analysis of a variety of physical systems, as well as introductory thermodynamics. Topics covered include pendula, oscillatory circuits, mechanical and sound waves, Fourier series and transforms, the Doppler effect, heat transfer, gases, fluids, entropy and the basic elements of diffraction and apertures.

PHYS 314. Introductory Modern Physics. 4 Hours.

PR: PHYS 112 and MATH 156. Topics of modern physics of interest to science majors and engineers; atomic and molecular structure and spectra, solid state and nuclear physics, relativity, and elementary particles.

PHYS 321. Optics. 3 Hours.

PR: PHYS 111 and PHYS 112 and MATH 156. A basic course in physical optics covering wave mathematics, propagation, polarization, interference, and diffraction; applications in geometrical optics and selected topics in scattering and quantum optics.

PHYS 325. Atomic Physics. 3 Hours.

PR: PHYS 314. Relativistic mechanics, atomic structure, and spectra.

PHYS 326. Medical Imaging Physics. 3 Hours.

Introduces the physics of medical imaging and is intended for non-physics majors. The fundamental concepts and clinical applications of the major imaging techniques are presented. The subject matter is ideal for pre-med majors.

PHYS 331. Theoretical Mechanics 1. 3 Hours.

PR: PHYS 111 and PHYS 112 or equiv. PR or Conc: MATH 261. Scalar, vector, and tensor fields; curvilinear coordinate systems. Kinematics and dynamics of particles, systems of particles and rigid bodies.

PHYS 332. Theoretical Mechanics 2. 3 Hours.

PR or CONC: MATH 261 and PHYS 331 or equivalent. Scalar, vector, tensor fields; curvilinear coordinate systems. Lagrangian and Hamiltonian formulation. Relativistic motion.

PHYS 333. Electricity and Magnetism 1. 3 Hours.

PR: PHYS 111 and PHYS 112 or equiv. and PR or Conc.: MATH 261. Electrostatics, electrostatics in matter, magnetostatics, magnetostatics in matter.

PHYS 334. Electricity and Magnetism. 3 Hours.

PR or CONC: PHYS 333 or equiv. and MATH 261. Maxwell's equations, reflection and refraction, wave guides and cavities.

PHYS 340. Experimental Space Physics. 3 Hours.

PR: PHYS 112. Laboratory course consisting of an experimental project designed to acquaint students with current techniques for the design and construction of scientific payloads for suborbital and orbital space missions.

PHYS 341L. Advanced Physics 1 Laboratory. 2 Hours.

PR: PHYS 111 and PHYS 112 and PHYS 314. Experiments in physics designed to complement theory courses, give experience in data taking and instrumentation, and learn methods of data evaluation and error analysis. This course focuses on learning foundational lab techniques using guided experiments.

PHYS 342L. Advanced Physics Laboratory 2. 1-3 Hours.

PR: Consent. Experiments in physics designed to complement theory courses, give experience in data taking and instrumentation, and learn methods of data evaluation, error analysis, and documentation and reporting. Emphasis on developing independence in the physics laboratory.

PHYS 376L. Research Methods Laboratory. 3 Hours.

PR: PHYS 112 and PR or CONC: ARSC 220. An introduction to the tools and mathematics that scientists use to solve scientific problems. Mathematical modeling, experimental design, hypothesis formulation, data collection, use of statistics, reading and evaluating the scientific literature, writing and reviewing scientific papers, and oral presentation of scientific research.

PHYS 393. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly schedule courses.

PHYS 451. Introductory Quantum Mechanics. 3 Hours.

PR: PHYS 314 and MATH 261. Fundamental principles of quantum mechanics; wave functions in position and momentum space, operators, Schrodinger's equation, applications to one-dimensional problems, approximation methods, the hydrogen atom, angular momentum and spin.

PHYS 452. Quantum Mechanics 2. 3 Hours.

PR: PHYS 451 and MATH 261. Angular momentum operators, including spin, and time-dependent perturbation theory. Applications of quantum mechanics, including the properties of atoms (hydrogen and multi-electron atoms), molecules, solids, identical particles of atoms (hydrogen and multi-electron atoms), molecules, solids, identical particles (e.g. black-body spectrum, Bose-Einstein condensation, and the free electron gas), and quantum effects of adiabatic changes.

PHYS 461. Thermodynamics and Statistical Mechanics. 3 Hours.

PR: PHYS 314 or equiv and MATH 251. Introduction to the statistical foundations of thermodynamics; applications of the fundamental laws of thermodynamics to physical and chemical systems.

PHYS 463. Nuclear Physics. 3 Hours.

PR: PHYS 314 and MATH 251. Study of characteristic properties of nuclei and their structure as inferred from nuclear decays and reactions, leading to a knowledge of nuclear forces and models.

PHYS 471. Solid State Physics. 3 Hours.

PR: PHYS 314 or equiv and MATH 251. Properties of crystalline solids; includes crystal structure, interatomic binding, lattice vibrations, electron theory of metals, and the band theory of solids with some applications.

PHYS 481. Plasma Physics. 3 Hours.

PR: PHYS 111 and PHYS 112 and PR or Conc: PHYS 334. Introductory course in the physics of ionized gases; particle and fluid treatment of plasmas, waves, equilibrium and stability, kinetic theory, and nonlinear effects.

PHYS 490. Teaching Practicum. 1-3 Hours.

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