

# PHYSICS (PHYS)

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## PHYS 100 Fundamentals of Physics (3 credits)

General Education: Natural/Integrated Science

For students in nontechnical fields. Conceptual study of laws of nature and their application, including mechanics, heat, electricity and magnetism, light, and modern physics. Three lectures per week. (Carries no credit after PHYS 111 or PHYS 211.) Typically Offered: Spring.

## PHYS 100L Fundamentals of Physics Lab (1 credit)

General Education: Natural/Integrated Science

For students in nontechnical fields. Conceptual study of laws of nature and their application, including mechanics, heat, electricity and magnetism, light, and modern physics. One 2-hour lab per week. Typically Offered: Spring.

**Coreqs:** PHYS 100

## PHYS 103 General Astronomy (3 credits)

General Education: Natural/Integrated Science

Descriptive and physical astronomy; development of astronomical thought; properties and evolution of the solar system, stars, galaxies, and the universe. Typically Offered: Fall.

## PHYS 104 Astronomy Lab (1 credit)

General Education: Natural/Integrated Science

Naked eye, telescopic, and photographic observations of constellations, stars, and planets. One 2-hour lab per week. Typically Offered: Fall.

Prereqs or

**Coreqs:** PHYS 103

## PHYS 111 General Physics I (3 credits)

General Education: Natural/Integrated Science

Kinematics, forces and dynamics, conservation laws, thermodynamics, waves. Three lectures and one recitation per week. (Carries no credit after PHYS 211.) Typically Offered: Fall and Spring.

**Prereqs:** MATH 143

## PHYS 111L General Physics I Lab (1 credit)

General Education: Natural/Integrated Science

Kinematics, forces and dynamics, conservation laws, thermodynamics, waves. One 2-hour lab per week. Typically Offered: Fall and Spring.

**Prereqs:** MATH 143

**Coreqs:** PHYS 111

## PHYS 112 General Physics II (3 credits)

General Education: Natural/Integrated Science

Electricity, magnetism, optics, and modern physics. Three lectures and one recitation per week. (Carries no credit after PHYS 212.) Typically Offered: Spring.

**Prereqs:** PHYS 111

## PHYS 112L General Physics II Lab (1 credit)

General Education: Natural/Integrated Science

Electricity, magnetism, optics, and modern physics. One 2-hour lab per week. Typically Offered: Spring.

**Coreqs:** PHYS 112

## PHYS 200 Welcome to the Physics Major (1 credit)

Introductory-level discussion of topics in modern physics; introduction to physics research topics and scientific information search techniques; written and/or oral reports of a pertinent topic in current physics. Typically Offered: Fall.

## PHYS 203 (s) Workshop (1-16 credits)

Credit arranged

## PHYS 204 (s) Special Topics (1-16 credits)

Credit arranged

## PHYS 211 Engineering Physics I (3 credits)

General Education: Natural/Integrated Science

Kinematics and dynamics, Newton's laws, work and energy, rotational dynamics, linear and angular momentum, collisions, static equilibrium, oscillations, gravity and central forces. Three lectures and one recitation per week. Typically Offered: Fall and Spring.

**Coreqs:** MATH 170

## PHYS 211L Laboratory Physics I (1 credit)

General Education: Natural/Integrated Science

Kinematics and dynamics, Newton's laws, work and energy, rotational dynamics, linear and angular momentum, collisions, static equilibrium, oscillations, gravity, central forces, and thermodynamics. One 2-hour lab per week. Typically Offered: Fall and Spring.

**Coreqs:** PHYS 211

## PHYS 212 Engineering Physics II (3 credits)

General Education: Natural/Integrated Science

Electric fields and potentials, magnetic fields, capacitance and inductance, DC and AC circuits, electromagnetic waves. Three lectures and one recitation per week. Typically Offered: Fall and Spring.

**Prereqs:** PHYS 211

**Coreqs:** MATH 175

## PHYS 212L Laboratory Physics II (1 credit)

General Education: Natural/Integrated Science

Electric fields and potentials, magnetic fields, capacitance and inductance, DC and AC circuits, electromagnetic waves, mechanical waves, and geometric optics. One 2-hour lab per week. Typically Offered: Fall and Spring.

**Coreqs:** PHYS 212

## PHYS 213 Engineering Physics III (3 credits)

Fluid dynamics, waves in elastic media, sound waves, temperature, heat and thermodynamics, kinetic theory, geometric and physical optics. Three lectures and one recitation per week. Typically Offered: Spring.

**Prereqs:** PHYS 211

**Prereqs or Coreqs:** MATH 175

## PHYS 299 (s) Directed Study (1-16 credits)

Credit arranged

## PHYS 305 Modern Physics (3 credits)

Quantum and relativity theories with applications to atomic, solid state, nuclear, and elementary particle physics. Typically Offered: Fall.

**Prereqs:** PHYS 212 and PHYS 213

## PHYS 321 Analytical Mechanics (3 credits)

Review of single-particle kinematics and dynamics; linear oscillations; Lagrangian dynamics; orbital dynamics; motion in non-inertial systems; space rotation of rigid bodies. Typically Offered: Fall (Even Years).

**Prereqs:** PHYS 212

**Coreqs:** MATH 275 and MATH 310

## PHYS 333 Statistical Thermodynamics (3 credits)

Cross-listed with CHEM 495

Classical thermodynamics, entropy, thermodynamic potentials, kinetic theory, classical and quantum statistical mechanics, ensembles, partition functions, introduction to phase transitions. Typically Offered: Spring (Even Years).

**Prereqs:** CHEM 306 or PHYS 305

**PHYS 341 Electromagnetic Fields I (3 credits)**

This course is designed to provide undergraduate physics majors advanced instruction in electrostatics. The specific areas which will be covered are electric fields, electric potentials, work and energy in electrostatics, the technique of using the concept of image charges to solve for the electric field and electric potential of complex charge distributions, Laplace's and Poisson's equations, electric dipoles, polarization and polarizable materials, and the electric dipole approximation. Typically Offered: Fall (Odd Years).

**Prereqs:** PHYS 212 and MATH 275

**PHYS 342 Electromagnetic Fields II (3 credits)**

This course is designed to provide undergraduate physics majors advanced instruction in electrodynamics and magnetism. The specific areas that will be covered are magnetostatics, magnetic fields in matter, the vector potential, electrodynamics, the complete set of Maxwell's equations, electromagnetic waves, waveguides, electric and magnetic dipole radiation, retarded and advanced potentials, and radiation arising from accelerated charges and charge distributions. Typically Offered: Spring (Even Years).

**Prereqs:** PHYS 341

**PHYS 351 Introductory Quantum Mechanics I (3 credits)**

Schrodinger equation, one-dimensional systems including the free particle, bound states, potential barriers, harmonic oscillator, matrix methods, and Dirac notation; interpretations of quantum theory; quantum mechanics in three-dimensions including the hydrogen atom, angular momentum, and spin systems; identical particles; symmetries and conservation laws in quantum mechanics. Typically Offered: Spring (Odd Years).

**Prereqs:** PHYS 305

**Coreqs:** PHYS 371 or MATH 330

**PHYS 371 Mathematical Physics (3 credits)**

Cross-listed with MATH 371

Mathematical techniques needed in upper-division physics courses, including vector analysis, matrices, Sturm-Liouville problems, special functions, partial differential equations, complex variables. Typically Offered: Fall (Even Years).

**Prereqs:** PHYS 212 and MATH 275

**PHYS 400 (s) Seminar (1-16 credits)**

Credit arranged

**PHYS 403 (s) Workshop (1-16 credits)**

Credit arranged

**PHYS 404 (s) Special Topics (1-16 credits)**

Credit arranged

**PHYS 411 Advanced Physics Lab (4 credits)**

Research skills, group dynamics, scientific literature research/drafting, automation and design techniques to prepare students for post-graduate life in a physics laboratory setting. 1-hour distributed lecture time and 3-hr effective lab time per week. Some weeks require scheduling machine utilization time outside of standard class hours per student. Typically Offered: Spring (Even Years).

**Prereqs:** PHYS 305, PHYS 211L, and PHYS 212L

**PHYS 428 Numerical Methods (3 credits)**

Cross-listed with ENGR 428, MATH 428

Joint-listed with MATH 529, PHYS 528

Systems of equations, eigenvalues and eigenvectors, root finding, error analysis, numerical solution to differential equations, interpolation and data fitting, numerical integration, related topics and applications, such as fast Fourier transforms, as time and interest permits. Typically Offered: Spring.

**Prereqs:** Math 310; and CS 120 or Math 183 or ENGR 212 or Permission

**PHYS 438 Biological Physics (3 credits)**

Joint-listed with PHYS 538

Physics principles applied to biological systems including organisms, cells, and biomolecules. Techniques for studying biological systems and phenomena. Additional projects/assignments required for graduate credit. Prereq for PHYS 438: PHYS 212 or PHYS 213; Junior or Senior standing. Prereq for PHYS 538: Graduate Standing or Permission.

**PHYS 443 Optics (3 credits)**

Joint-listed with PHYS 543

Geometrical optics, wave optics and physical optics with emphasis on modern instrumentation and methods of measurement. Additional projects/assignments required for graduate credit. Prereq for PHYS 443: PHYS 342. Prereq for PHYS 543: Admission to Physics Graduate program or Permission.

**PHYS 464 Solid State Physics (3 credits)**

Joint-listed with PHYS 564

Crystal structure and lattice dynamics including elastic and thermal properties of solids; electron dynamics including band theory, theory of metals and semiconductors, superconductivity, magnetism; solid-state device-physics; characterization of materials; special topics chosen by the instructor. Additional projects/assignments required for graduate credit. Typically Offered: Spring.

**Prereqs:** PHYS 321 and PHYS 341; or Permission

**Coreqs:** PHYS 351 or Permission

**PHYS 465 Nuclear and Particle Physics (3 credits)**

Joint-listed with PHYS 565

Particle production and detection, properties and classification of particles, the quark model of hadrons, symmetries and conservation laws, interactions, grand unification, the strong interaction and nuclear forces, models for nuclear structure and reactions. Additional projects/assignments required for graduate credit. Cooperative: open to WSU degree-seeking students. Prereq for PHYS 465: PHYS 305. Prereq for PHYS 565: Admission to physics graduate program or Permission.

**PHYS 482 Planetary Surfaces and Interiors (3 credits)**

Cross-listed with ESS 482, PHYS 582

Joint-listed with GEOL 582

Planetary geology is an integrated field that applies knowledge from several areas of science to understand the origin and evolution of the Sun, planets, and minor bodies (asteroids, comets, etc). This course will primarily focus on the geological and physical processes that create and modify planetary surfaces. Topics will include economic exploration in space, volcanology, tectonics, impact cratering, geomorphological modifications, and how those processes change when applied to physical parameters outside the natural range for Earth. Due to the inaccessible nature of space, the methods used to explore its secrets are widespread, creative, complex, and often underutilized in purely terrestrial studies. Graduate students will have extra responsibilities running group discussions and giving presentations. Typically Offered: Varies. Cooperative: open to WSU degree-seeking students.

**PHYS 484 Astrophysics of Stars and Planets (3 credits)**

Joint-listed with PHYS 584

Orbital mechanics and rocket science; planets and planetary systems; structure and evolution of stars and star systems. Additional projects/ assignments required for graduate credit. Typically Offered: Varies.

**Prereqs:** PHYS305 or MATH275; or Permission. Cooperative: open to WSU degree-seeking students.

**PHYS 489 Relativistic Astrophysics: from Cosmology to Black Holes (3 credits)**

Joint-listed with PHYS 589

Origins and evolution of the universe; general relativity and gravitational wave physics; structure and environments of white dwarfs, neutron stars, and black holes. Additional projects/assignments required for graduate credit. Typically Offered: Varies.

**Prereqs:** PHYS 305 or MATH 275, or permission Cooperative: open to WSU degree-seeking students.

**PHYS 490 Research (0-6 credits, max 6)**

Undergraduate research or thesis. Typically Offered: Varies.

**Prereqs:** Permission of Instructor.

**PHYS 492 Senior Research (1 credit)**

General Education: Senior Experience

Undergraduate research in one of the department focus areas. Scientific communication through one presentation to the scientific community and one written report.

**Prereqs:** Junior or Senior Standing; or Permission of Instructor.

**PHYS 498 (s) Internship (1-16 credits)**

Credit arranged

**PHYS 499 (s) Directed Study (1-16 credits)**

Credit arranged

**PHYS 500 Master's Research and Thesis (1-16 credits)**

Credit arranged

**PHYS 501 (s) Seminar (0-16 credits)**

Credit arranged Graded P/F.

**Prereqs:** Permission

**PHYS 502 (s) Directed Study (1-16 credits)**

Credit arranged

**PHYS 503 (s) Workshop (1-16 credits)**

Credit arranged

**PHYS 504 (s) Special Topics (1-16 credits)**

Credit arranged

**PHYS 521 Advanced Mechanics (3 credits)**

Classical mechanics; Lagrange's and Hamilton's principles, two-body problem, rigid body motion, special relativity, canonical transformation, Hamilton-Jacobi theory, small oscillations, and Lagrangian and Hamiltonian formulations for continuous systems and fields.

Cooperative: open to WSU degree-seeking students.

**PHYS 528 Numerical Methods (3 credits)**

Cross-listed with MATH 529

Joint-listed with ENGR 428, MATH 428, and PHYS 428

Systems of equations, root finding, error analysis, numerical solution to differential equations, interpolation and data fitting, numerical integration, related topics and applications. Additional projects and/or assignments required for graduate credit.

**Prereqs:** MATH 310.

**PHYS 533 Statistical Mechanics (3 credits)**

Ensembles, partition functions, classical and quantum statistics renormalization group, criticality, scaling, interacting systems, simulation.

Cooperative: open to WSU degree-seeking students.

**Prereqs:** PHYS 333.

**PHYS 538 Biological Physics (3 credits)**

Joint-listed with PHYS 438

Physics principles applied to biological systems including organisms, cells, and biomolecules. Techniques for studying biological systems and phenomena. Additional projects/assignments required for graduate credit. Prereq for PHYS 438: PHYS 212 or PHYS 213; Junior or Senior standing. Prereq for PHYS 538: Graduate Standing or Permission.

**PHYS 541 Electromagnetic Theory I (3 credits)**

Analytical tools and techniques describing electromagnetic phenomena, particularly Maxwell's equations, electrostatic and magnetostatic systems, including currents and their interactions and boundary value problems. Cooperative: open to WSU degree-seeking students.

**Prereqs:** PHYS 342.

**PHYS 542 Electromagnetic Theory II (3 credits)**

Further examinations of the analytical tools and techniques that describe electromagnetic phenomena, particularly electrodynamics, the general theory of emission, propagation and absorption of electromagnetic waves, and the relativistic formulation of electrodynamics.

**Prereqs:** PHYS 541 Cooperative: open to WSU degree-seeking students.

**PHYS 543 Optics (3 credits)**

Joint-listed with PHYS 443

Geometrical optics, wave optics and physical optics with emphasis on modern instrumentation and methods of measurement. Additional projects/assignments required for graduate credit. Prereq for PHYS 443: PHYS 342. Prereq for PHYS 543: Admission to Physics Graduate program or Permission.

**PHYS 550 Quantum Mechanics I (3 credits)**

Fundamental concepts, base kets and matrix representation, position and momentum space; Schroedinger and Heisenberg picture, Schroedinger's wave equation and solutions; theory of angular momentum. Cooperative: open to WSU degree-seeking students.

**Prereqs:** PHYS 351.

**PHYS 551 Quantum Mechanics II (3 credits)**

Theory of angular momentum continued; symmetries in quantum mechanics; approximation methods, time-dependent and time-independent perturbation theory, applications to atomic systems; radiation theory, theory of scattering. Cooperative: open to WSU degree-seeking students.

**Prereqs:** PHYS 550.

**PHYS 564 Solid State Physics (3 credits)**

Joint-listed with PHYS 464

Crystal structure and lattice dynamics including elastic and thermal properties of solids; electron dynamics including band theory, theory of metals and semiconductors, superconductivity, magnetism; solid-state device-physics; characterization of materials; special topics chosen by the instructor. Additional projects/assignments required for graduate credit. Typically Offered: Spring.

**Coreqs:** PHYS 351 or Permission

**PHYS 565 Particle and Nuclear Physics (3 credits)**

Joint-listed with PHYS 465

Particle production and detection, properties and classification of particles, the quark model of hadrons, symmetries and conservation laws, interactions, grand unification, the strong interaction and nuclear forces, models for nuclear structure and reactions. Additional projects/ assignments required for graduate credit. Cooperative: open to WSU degree-seeking students. Prereq for PHYS 465: PHYS 305. Prereq for PHYS 565: Admission to Physics Graduate program or Permission.

**PHYS 571 Mathematical Methods of Physics (3 credits)**

Methods and problems. Cooperative: open to WSU degree-seeking students.

**Prereqs:** PHYS 322 or Permission.

**PHYS 582 Planetary Surfaces and Interiors (3 credits)**

Cross-listed with ESS 482, PHYS 482

Joint-listed with GEOL 582

Planetary geology is an integrated field that applies knowledge from several areas of science to understand the origin and evolution of the Sun, planets, and minor bodies (asteroids, comets, etc). This course will primarily focus on the geological and physical processes that create and modify planetary surfaces. Topics will include economic exploration in space, volcanology, tectonics, impact cratering, geomorphological modifications, and how those processes change when applied to physical parameters outside the natural range for Earth. Due to the inaccessible nature of space, the methods used to explore its secrets are widespread, creative, complex, and often underutilized in purely terrestrial studies. Graduate students will have extra responsibilities running group discussions and giving presentations. Typically Offered: Varies. Cooperative: open to WSU degree-seeking students.

**PHYS 584 Astrophysics of Stars and Planets (3 credits)**

Joint-listed with PHYS 484

Orbital mechanics and rocket science; planets and planetary systems; structure and evolution of stars and star systems. Additional projects/ assignments required for graduate credit. Typically Offered: Varies. Cooperative: open to WSU degree-seeking students.

**PHYS 589 Relativistic Astrophysics: from Cosmology to Black Holes (3 credits)**

Joint-listed with PHYS 489

Origins and evolution of the universe; general relativity and gravitational wave physics; structure and environments of white dwarfs, neutron stars, and black holes. Additional projects/assignments required for graduate credit. Typically Offered: Varies. Cooperative: open to WSU degree-seeking students.

**PHYS 598 (s) Internship (1-16 credits)**

Credit arranged

**PHYS 599 (s) Research (1-16 credits)**

Credit arranged

**PHYS 600 Doctoral Research and Dissertation (1-45 credits)**

Credit arranged