

# Physics (PHYS)

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## **PHYS 110. Introductory Astronomy. 3 Credits.**

Qualitative survey of the current understanding of the universe including planetary explorations, solar phenomena, stars, black holes, nebulae, galaxies.

## **PHYS 110L. Introductory Astronomy Lab. 1 Credit.**

Qualitative survey of the current understanding of the universe including planetary explorations, solar phenomena, stars, black holes, nebulae, galaxies.

## **PHYS 120L. Fundamentals of Physics Laboratory. 1 Credit.**

Application of physics concepts and principles to the real world. Topics selected from mechanics, heat, optics, electricity, and magnetism.

## **PHYS 120. Fundamentals of Physics. 3 Credits.**

Application of physics concepts and principles to the real world. Topics selected from mechanics, heat, optics, electricity, and magnetism.

## **PHYS 171. Introductory Projects in Physics. 1 Credit.**

Basic computer controlled instrumentation for automation and data acquisition. Design of simple measurement and control projects covering waveforms, temperature measurement and robotics. Elementary data analysis: curve fitting, Fourier theory and statistics.

## **PHYS 194. Individual Study. 1-5 Credits.**

## **PHYS 196. Field Experience. 1-15 Credits.**

## **PHYS 199. Special Topics. 1-5 Credits.**

## **PHYS 211L. College Physics I Laboratory. 1 Credit.**

Beginning course for students without a calculus background. Includes basic principles of bodies at rest and in motion, fluids, vibrations, waves, sound and thermodynamics. Prereq: MATH 105. Co-req: PHYS 211.

## **PHYS 211. College Physics I. 3 Credits.**

Beginning course for students without a calculus background. Includes basic principles of bodies at rest and in motion, fluids, vibrations, waves, sound and thermodynamics. Prereq: MATH 105 or higher.

## **PHYS 212. College Physics II. 3 Credits.**

Second course for students without a calculus background. Includes electricity, magnetism, optics and modern physics. Prereq: PHYS 211, PHYS 211L.

## **PHYS 212L. College Physics II Laboratory. 1 Credit.**

Second course for students without a calculus background. Includes electricity, magnetism, optics and modern physics. Prereq: PHYS 211, PHYS 211L.

## **PHYS 215. Research For Undergraduates. 1-3 Credits.**

Special research studies in physics under the supervision of an instructor.

## **PHYS 251. University Physics I. 4 Credits.**

Newtonian mechanics of translational and rotational motion, work, energy, power, momentum, conservation of energy and momentum, periodic motion, waves, sound, heat, and thermodynamics. Prereq: MATH 165.

## **PHYS 251R. University Physics I Recitation. 1 Credit.**

A recitation that complements PHYS 251 with theory and applications. Coreq: PHYS 251.

## **PHYS 251L. University Physics I Laboratory. 1 Credit.**

Newtonian mechanics of translational and rotational motion, work, energy, power, momentum, conservation of energy and momentum, periodic motion, waves, sound, heat, and thermodynamics. Prereq: MATH 165.

## **PHYS 252R. University Physics II Recitation. 1 Credit.**

A recitation that complements PHYS 252 with emphasis on theory and applications. Coreq: PHYS 252.

## **PHYS 252. University Physics II. 4 Credits.**

Electric charge, field, potential, and current; magnetic field; capacitance; resistance; inductance; RC, RL, LC and RLC circuits; waves; optics. Prereq: PHYS 251 or ME 222. Coreq: MATH 166.

## **PHYS 252L. University Physics II Laboratory. 1 Credit.**

Electric charge, field, potential, and current; magnetic field; capacitance; resistance; inductance; RC, RL, LC and RLC circuits; waves; optics. Coreq: PHYS 252.

## **PHYS 291. Seminar. 1-3 Credits.**

## **PHYS 292. Global Practicum: Study Abroad. 1-15 Credits.**

Pre-Arranged study at accredited foreign institutions (study abroad), domestic institutions (National Student Exchange) or on approved study abroad programs. Pre-requisite: Sophomore standing and prior approval by International Student and Study Abroad Services and major department. Graded 'P' or 'F' (Undergraduate), or 'S' or 'U' (Graduate).

**PHYS 294. Individual Study. 1-5 Credits.****PHYS 299. Special Topics. 1-5 Credits.****PHYS 303. The Science of Learning. 1 Credit.**

This course is designed for students serving as Learning Assistants in the College of Science and Mathematics and who are interested in the science behind learning in the STEM disciplines.

**PHYS 350. Modern Physics. 3 Credits.**

Breakdown of classical physics, special relativity, Bohr model, Schrodinger mechanics of simple systems, atomic structure, selected topics from nuclear and solid state physics. Prereq: PHYS 252, coreq of MATH 259 or MATH 265.

**PHYS 355. Classical Mechanics. 3 Credits.**

Basic concepts, single and coupled oscillators, variational calculus, Lagrangian and Hamiltonian dynamics, central force motion, accelerated coordinate systems. Prereq: PHYS 252 and MATH 265. Co-req: MATH 266.

**PHYS 360. Modern Physics II. 3 Credits.**

Continuation of modern physics covering molecular structure, nuclear physics and solid state physics with an embedded modern physics laboratory with experiments such as atomic and molecular spectroscopy, electron diffraction, nuclear spectroscopy, photoelectric effect and computer simulations of experiments. Prereq: PHYS 350.

**PHYS 361. Electromagnetic Theory. 3 Credits.**

Electrostatics, magnetostatics, dielectrics, electric circuits, time varying electric and magnetic fields, electromagnetic induction, and application of Maxwell's equations. Prereq: PHYS 252, MATH 266.

**PHYS 370. Introduction to Computational Physics. 3 Credits.**

Introduction to computational methods, with applications to planetary motion, numerical integration, chaotic oscillations, percolation, random walks, diffusion limited aggregation, molecular dynamics simulation, Monte Carlo methods, and Fourier transforms. 2 lectures, 2 one-hour laboratories. Prereq: PHYS 251, MATH 166 and CSCI 160 or ECE 173. Coreq: PHYS 252.

**PHYS 379. Global Seminar. 1-6 Credits.**

NDSU instructed experience or field study in a foreign country. Conducted in English for residence credit. Pre-requisite: Prior approval by International Student and Study Abroad Services and major department. May be repeated. Standard Grading.

**PHYS 391. Seminar. 1-3 Credits.****PHYS 392. Global Practicum: Study Abroad. 1-15 Credits.**

Pre-Arranged study at accredited foreign institutions (study abroad), domestic institutions (National Student Exchange) or on approved study abroad programs. Pre-requisite: Sophomore standing and prior approval by International Student and Study Abroad Services and major department. Graded 'P' or 'F' (Undergraduate), or 'S' or 'U' (Graduate).

**PHYS 394. Individual Study. 1-5 Credits.****PHYS 397. Fe/Coop/Internship. 1-4 Credits.****PHYS 399. Special Topics. 1-5 Credits.****PHYS 411L. Optics for Scientists and Engineers Lab. 1 Credit.**

Required laboratory for PHYS 411 or ECE 411. Ten optics experiments plus a major related optics project. Preq: PHYS 252. Coreq: PHYS 411. Cross-listed with ECE 411L. {Also offered for graduate credit - see PHYS 611L.}.

**PHYS 411. Optics for Scientists & Engineers. 3 Credits.**

Introduction to modern optics. Geometric optics, electromagnetic nature of light, polarization, interference, diffraction, fiber optics. Corequisite laboratory with major related optics project. Prereq: PHYS 252. Coreq: PHYS 411L. Cross-listed with ECE 411. {Also offered for graduate credit - see PHYS 611.}.

**PHYS 413. Lasers for Scientists and Engineers. 3 Credits.**

Lecture and laboratory introduction to lasers. Spontaneous and stimulated transitions, line-broadening, gain, gain saturation, optical resonators, Fabry-Perot interferometers, theory of laser oscillation, rate equations, transverse modes, coherence, and Gaussian beams. Prereq: PHYS 252. Cross-listed with ECE 413. {Also offered for graduate credit - see PHYS 613.}.

**PHYS 415. Elements of Photonics. 3 Credits.**

Analysis of optical systems using the matrix formulation, wave propagation in anisotropic media, electro-optic effect and laser modulation, physical origin of optical non-linearities, phase matching, optical second harmonic and parametric generation. Prereq: PHYS 252. Cross-listed with ECE 415. {Also offered for graduate credit - see PHYS 615.}.

**PHYS 417. Optical Signal Transmission. 3 Credits.**

Optical signal transmission including geometric optics and modal analysis for homogeneous and inhomogeneous light guides. Systems studies including coupling, inter-symbol interference, sources, photodetectors, and modulation. Prereq: ECE 351. Cross-listed with ECE 417. {Also offered for graduate credit - See PHYS 617.}.

**PHYS 430. Quantum Computation. 3 Credits.**

Students will master the foundations of quantum computation and quantum information, including underlying physical concepts and practical applications. Topics covered include Quantum Bits (Qubits), Single and Multiple Qubit Gates, Quantum Circuits, Quantum Computation, Quantum Algorithms, and Quantum Computers. Graduate students enrolled will also to gain experience with programming and executing the standard quantum algorithms, such as Fourier Transform, Grover's, Shor's Algorithms using, e.g., IBM Quantum Experience platform. Prereq: PHYS 252. Cross-listed with CSCI 430. Dual-listing: PHYS 630.

**PHYS 462. Thermal and Statistical Physics. 3 Credits.**

Classical postulates and laws of thermodynamics; cyclic processes and entropy; thermodynamic potentials, equilibrium, stability, and phase transitions; Maxwell-Boltzmann distribution, applications to classical gases and magnets; quantum statistics, Bose-Einstein and Fermi-Dirac distributions, applications to quantum gases. Prereq: PHYS 350. {Also offered for graduate credit - see PHYS 662.}.

**PHYS 481. Materials Physics. 3 Credits.**

Introduction to the physics of soft condensed matter, composed of polymers, colloids, amphiphiles, and liquid crystals, and of hard condensed matter, including metals, semiconductors, and superconductors, emphasizing phase transitions and materials properties (electrical, magnetic, optical, elastic). Pre-req: PHYS 252. {Also offered for graduate credit - see PHYS 681.}.

**PHYS 485. Quantum Mechanics I. 3 Credits.**

Operators, one-dimensional wells and barriers, Schrodinger equation, uncertainty, duality, Born interpretation, unstable states, bosons and fermions, central force problems, angular momentum, spin. Prereq: PHYS 350, MATH 266. {Also offered for graduate credit - see PHYS 685.}.

**PHYS 486. Quantum Mechanics II. 3 Credits.**

Continuation of PHYS 485. Perturbation theory, angular momentum addition, variational schemes, WKB method, scattering theory, time dependent problems. Prereq: PHYS 485. {Also offered for graduate credit - see PHYS 686.}.

**PHYS 488. Senior Project I. 1 Credit.**

This is the first course of the capstone experience in physics. It results in the proposal of an undergraduate research project that is carried out in the second capstone course. Pass/Fail only. Department consent required.

**PHYS 489. Senior Project II. 2 Credits.**

This is the second course of the capstone experience in physics. The student carries out the research project proposed in the first capstone course. Prereq: PHYS 488.

**PHYS 491. Seminar. 1-5 Credits.****PHYS 492. Global Practicum: Study Abroad. 1-15 Credits.**

Pre-Arranged study at accredited foreign institutions (study abroad), domestic institutions (National Student Exchange) or on approved study abroad programs. Pre-requisite: Sophomore standing and prior approval by International Student and Study Abroad Services and major department. Graded 'P' or 'F' (Undergraduate), or 'S' or 'U' (Graduate).

**PHYS 494. Individual Study. 1-5 Credits.****PHYS 496. Field Experience. 1-15 Credits.****PHYS 499. Special Topics. 1-5 Credits.****PHYS 611. Optics for Scientists & Engineers. 3 Credits.**

Introduction to modern optics. Geometric optics, electromagnetic nature of light, polarization, interference, diffraction, fiber optics. Corequisite laboratory with major related optics project. Coreq: PHYS 611L. Cross-listed with ECE 611. {Also offered for undergraduate credit - see PHYS 411.}.

**PHYS 611L. Optics for Scientists and Engineers Lab. 1 Credit.**

Required laboratory for PHYS 611 or ECE 611. Ten optics experiments plus a major related optics project. Coreq: PHYS 611. Cross-listed with ECE 611L. {Also offered for undergraduate credit - see PHYS 411L.}.

**PHYS 613. Lasers for Scientists and Engineers. 3 Credits.**

Lecture and laboratory introduction to lasers. Spontaneous and stimulated transitions, line-broadening, gain, gain saturation, optical resonators, Fabry-Perot interferometers, theory of laser oscillation, rate equations, transverse modes, coherence, and Gaussian beams. Cross-listed with ECE 613. {Also offered for undergraduate credit - see PHYS 413.}.

**PHYS 615. Elements of Photonics. 3 Credits.**

Analysis of optical systems using the matrix formulation, wave propagation in anisotropic media, electro-optic effect and laser modulation, physical origin of optical non-linearities, phase matching, optical second harmonic and parametric generation. Cross-listed with ECE 615. {Also offered for undergraduate credit - see PHYS 415.}.

**PHYS 617. Optical Signal Transmission. 3 Credits.**

Optical signal transmission including geometric optics and modal analysis for homogeneous and inhomogeneous light guides. Systems studies including coupling, inter-symbol interference, sources, photodetectors, and modulation. Cross-listed with ECE 617. {Also offered for undergraduate credit - See PHYS 417.}.

**PHYS 630. Quantum Computation. 3 Credits.**

Students will master the foundations of quantum computation and quantum information, including underlying physical concepts and practical applications. Topics covered include Quantum Bits (Qubits), Single and Multiple Qubit Gates, Quantum Circuits, Quantum Computation, Quantum Algorithms, and Quantum Computers. Graduate students enrolled will also to gain experience with programming and executing the standard quantum algorithms, such as Fourier Transform, Grover's, Shor's Algorithms using, e.g., IBM Quantum Experience platform. Cross-listed with CSCI 630. Dual-listing: PHYS 430.

**PHYS 662. Thermal and Statistical Physics. 3 Credits.**

Classical postulates and laws of thermodynamics; cyclic processes and entropy; thermodynamic potentials, equilibrium, stability, and phase transitions; Maxwell-Boltzmann distribution, applications to classical gases and magnets; quantum statistics, Bose-Einstein and Fermi-Dirac distributions, applications to quantum gases. {Also offered for undergraduate credit - see PHYS 462.}.

**PHYS 681. Materials Physics. 3 Credits.**

Introduction to the physics of soft condensed matter, composed of polymers, colloids, amphiphiles, and liquid crystals, and of hard condensed matter, including metals, semiconductors, and superconductors, emphasizing phase transitions and materials properties (electrical, magnetic, optical, elastic). Dual-listing: PHYS 481.

**PHYS 685. Quantum Mechanics I. 3 Credits.**

Operators, one-dimensional wells and barriers, Schrodinger equation, uncertainty, duality, Born interpretation, unstable states, bosons and fermions, central force problems, angular momentum, spin. {Also offered for undergraduate credit - see PHYS 485.}.

**PHYS 686. Quantum Mechanics II. 3 Credits.**

Continuation of PHYS 685. Perturbation theory, angular momentum addition, variational schemes, WKB method, scattering theory, time dependent problems. Prereq: PHYS 685. {Also offered for undergraduate credit - see PHYS 486.}.

**PHYS 690. Graduate Seminar. 1-5 Credits.****PHYS 696. Special Topics. 1-5 Credits.****PHYS 752. Mathematical Methods in Physics I. 3 Credits.**

Review of practical mathematical methods routinely used by physicists, including applications. Focus on differential equations, variational principles, and other selected topics. Cross-listed with MATH 782.

**PHYS 753. Mathematical Methods in Physics II. 3 Credits.**

Tensor analysis, matrices and group theory, special relativity, integral equations and transforms, and selected advanced topics. Prereq: MATH 629 and MATH 652. Cross-listed with MATH 783.

**PHYS 758. Statistical Physics. 3 Credits.**

Review of thermodynamics and statistical mechanics; Monte Carlo and molecular dynamics simulation; applications to phase transitions.

**PHYS 761. Electromagnetism. 3 Credits.**

Review of Maxwell's equations, radiation, collisions between charged particles, dynamics of relativistic particles and fields.

**PHYS 771. Quantum Physics I. 3 Credits.**

Schrodinger equation, wave packets, uncertainty, angular momentum, spin, second quantization, harmonic oscillator, resistance mechanisms.

**PHYS 772. Quantum Physics II. 3 Credits.**

Schrodinger equation, wave packets, uncertainty, angular momentum, spin, second quantization, harmonic oscillator, resistance mechanisms. Prereq: PHYS 771.

**PHYS 781. Solid State Physics. 3 Credits.**

Crystal structure and binding, reciprocal lattices and x-ray diffraction, lattice vibrations, thermal properties, free electron model, band theory, magnetism, superconductivity. Prereq: PHYS 685.

**PHYS 782. Condensed Matter Physics. 3 Credits.**

An introduction to soft condensed matter, focusing on colloids, polymers, liquid crystals, surfactants, and biological systems. Topics will include characterization of soft materials, interparticle interactions, structure, equilibrium phase behavior, non-equilibrium properties, and practical applications. Prereq: PHYS 663.

**PHYS 790. Graduate Seminar. 1-3 Credits.****PHYS 791. Temporary/Trial Topics. 1-5 Credits.****PHYS 793. Individual Study/Tutorial. 1-5 Credits.****PHYS 794. Practicum. 1-10 Credits.****PHYS 796. Special Topics. 1-5 Credits.****PHYS 797. Master's Paper. 1-3 Credits.****PHYS 798. Master's Thesis. 1-10 Credits.****PHYS 899. Doctoral Dissertation. 1-15 Credits.**