DEPARTMENT OF PHYSICS

Dale Van Harlingen
209 Loomis Laboratory of Physics, 1110 West Green, Urbana, IL 61801
PH: (217) 333-3761

department website: Physics (https://physics.illinois.edu)
department faculty:
college catalog page: LAS Catalog (http://catalog.illinois.edu/las)
college website: College of Liberal Arts & Sciences (https://las.illinois.edu)
email: undergrad-info@physics.illinois.edu

Physics in the Sciences and Letters Curriculum (BSLAS) allows students maximum flexibility to develop scientifically oriented careers in fields requiring a physics background through the Major in Physics or the Physics Teaching Concentration.

The Major in Physics is a flexible program for students who plan to pursue technical or professional careers in areas requiring a sound grounding in physical science and mathematics. Students can use the concentration to prepare for employment immediately upon graduation or for continuing on to graduate study in a wide variety of fields.

The Physics Teaching Concentration fulfills state certification requirements to teach both physics and general science.

LAS Specialized Curriculum in Physics (BS) is designed for students who plan to pursue graduate study in physics or a closely allied field. In some cases, however, the greater flexibility of the Science and Letters Curriculum may make it a better choice for graduate school preparation for those who want to pursue a combined major and minor, a double major, or double degrees.

See also Engineering Physics (http://catalog.illinois.edu/undergraduate/engineer/departments/engin-physics) in the College of Engineering. See the Physics Department for additional information.

director of undergraduate studies: Enter Name
undergraduate office: Enter Address
undergraduate email: Enter Email

Undergraduate Programs:

- major: Physics, BS (http://catalog.illinois.edu/undergraduate/bs_physics_las)
- major: Physics, BSLAS (http://catalog.illinois.edu/undergraduate/bslas_physics)
- concentration: Physics Teaching, BS (http://catalog.illinois.edu/undergraduate/bslas_physics/teaching)

Graduate Programs:

- degree: Physics, MS (http://catalog.illinois.edu/graduate/graduate-majors/physics)
- degree: Teaching of Physics, MS (http://catalog.illinois.edu/graduate/graduate-majors/physics/physics-teaching-ms)
- degree: Physics, PhD (http://catalog.illinois.edu/graduate/graduate-majors/physics/#doctoraltext)

Graduate Degree Programs

The Department of Physics is actively developing a new paradigm for graduate physics education and research for the 21st century, aimed at enhancing interdisciplinary interactions and creating an integrated approach to educational and research training. Advanced degrees offered in physics are the Master of Science and the Doctor of Philosophy. Outstanding graduate research opportunities are available in many subdisciplines of physics, including:

- condensed matter physics
- high energy and nuclear physics
- astrophysics
- atomic
- molecular and optical physics
- complex systems
- quantum information
- biological physics
- physics education research

Students may select experimental, theoretical, or computational thesis projects. Multidisciplinary projects are especially encouraged, and, with the consent of other departments, students may earn master’s degrees in areas such as materials science and engineering, or computer science, simultaneously with their Ph.D. degrees in physics. Opportunity also exists for specializing in:

1. computational science and engineering via the Computational Science and Engineering (CSE) (http://www.cse.illinois.edu) transcriptable Concentration
2. energy and sustainability engineering via the Energy and Sustainability Engineering (EaSE) Option (http://ease.illinois.edu).

Admission

Admission to the physics graduate program requires an outstanding record of accomplishment in an undergraduate physics program and clear evidence of considerable academic promise, as judged by test scores, letters of recommendation, and strong intellectual achievements. A bachelor’s degree or its equivalent from an accredited college or university in the U.S. or an approved institution of higher learning abroad, with at least 20 semester hours (30 quarter hours) of intermediate and advanced undergraduate physics course work, is required for admission. Course preparation in electricity and magnetism, optics, mechanics, atomic and nuclear physics, quantum mechanics, mathematical physics, differential equations, and analysis is essential. Any deficiency in these areas may delay degree completion by as much as a year. (Students are expected to make up deficiencies during the first graduate year.)

A minimum GPA of 3.00 (A = 4.00) for the last two years of undergraduate work is required; however, because of space limitations, applicants with GPAs below 3.50 are rarely admitted. Students with prior graduate course work must have a minimum GPA of 3.50 for those courses. All applicants...
must provide test scores from both the general and the physics tests of the Graduate Record Examination (GRE) (http://www.ets.org).

Graduates of curricula in the physical and biological sciences, mathematics, or computer science may be admitted with limited standing if they are judged to have the necessary aptitudes to profit from graduate work in physics. Such students are admitted to full standing after completing course work to remove deficiencies in physics preparation.

All applicants whose native language is not English must submit a minimum TOEFL (http://www.toefl.org) score of 79 (iBT), 213 (CBT), or 550 (PBT); or minimum International English Language Testing System (IELTS) (http://www.ielts.org) academic exam scores of 6.5 overall and 6.0 in all subsections. Applicants may be exempt from the TOEFL if certain criteria (http://grad.illinois.edu/admissions/instructions/04c) are met. For those taking the TOEFL or IELTS, full admission status (http://grad.illinois.edu/admissions/instructions/04c) is granted for scores greater than 102 (TOEFL iBT), 253 (TOEFL CBT), 610 (TOEFL PBT), or 6.5 (IELTS). Limited status (http://grad.illinois.edu/admissions/instructions/04c) is granted for lesser scores and requires enrollment in English as a Second Language (ESL) courses (http://linguistics.illinois.edu/students/esl/guidelines) based on an ESL Placement Test (EPT) taken upon arrival to campus.

A few applicants may be admitted for the spring semester, in addition to the customary fall semester admissions. See the Physics graduate admissions Web site (http://physics.illinois.edu/grad/apply.asp) for lists of deadlines and application materials.

Faculty Research Interests
The research specialties of Physics faculty fall into the broad categories described in the graduate programs section of this document. Details of each individual’s specific interests are available at the department’s faculty research Web site. (http://physics.illinois.edu/research) Included are faculty whose primary appointments are in other departments but who supervise Physics students.

Facilities and Resources
The Department of Physics offers world-class research facilities in traditional areas of physics, including condensed matter, nuclear, particle, and optical physics, as well as state-of-the-art instruments for quantum information, nanoscale science and engineering, and biological physics. For a complete description of physics facilities, please consult the department’s facilities Web site (http://physics.illinois.edu/research/shops.asp).

Financial Aid
Fellowships, research assistantships, and teaching assistantships (all of which include waivers of tuition and some fees) are available for the majority of admitted students. All applicants, regardless of U.S. citizenship, whose native language is not English and who wish to be considered for teaching assistantships must demonstrate spoken English language proficiency (http://grad.illinois.edu/admissions/taengprof.htm) by achieving a minimum score of 24 on the speaking subsection of the TOEFL iBT or 8 on the speaking subsection of the IELTS. For students who are unable to take the iBT or IELTS, a minimum score of 4CP is required on the EPI test (http://cte.illinois.edu/testing/oral_eng/epi_overview.html), offered on campus. All new teaching assistants are required to participate in the Graduate Academy for College Teaching (http://cte.illinois.edu/programs/ta_train.html) conducted prior to the start of the semester.

PHYS Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/PHYS)

Courses
PHYS 100 Thinking About Physics credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/100)
Conceptual and problem solving skills in preparation for PHYS 211: --analysis and mathematical descriptions of physical situations --understanding the meaning of the solutions Prerequisite: Credit or concurrent registration in MATH 220 or MATH 221.

PHYS 101 College Physics: Mech & Heat credit: 5 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/101)
Newton’s Laws, work and energy, rotational motion, fluids, thermodynamics, and waves. A noncalculus-based approach for majors in the life sciences, preprofessional health programs, agriculture, and veterinary medicine. Credit is not given for both PHYS 101 and either PHYS 211 or PHYS 213. Prerequisite: Trigonometry. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences Qualitative Reasoning II

PHYS 102 College Physics: E&M & Modern credit: 5 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/102)
Electric forces and fields, electric potential, electric circuits, magnetic forces and fields, geometrical optics, relativity, and modern physics. A noncalculus-based approach for majors in the life sciences, preprofessional health programs, agriculture, and veterinary medicine. Credit is not given for both PHYS 102 and either PHYS 212 or PHYS 214. Prerequisite: PHYS 101.
This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences Qualitative Reasoning II

PHYS 110 Physics Careers credit: 0 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/110)
Exploration of careers founded on physics undergraduate training. Introduction to the Physics Department, faculty, research and curricula. Outside speaker presentations. Approved for S/U grading only.

PHYS 123 Physics Made Easy credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/123)
Inquiry-based, nonmathematical, hands-on study of physics for elementary school teachers. Coverage of most of the National Science Education K-4 Content Standards. Additional fees may apply. See Class Schedule. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences Qualitative Reasoning II

PHYS 140 How Things Work credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/140)
Nonmathematical approach underscoring the generality and ubiquity of basic physical laws in understanding commonplace phenomena: musical instruments, photography, electric and electronic circuits, television, motors, engines, etc. Credit is not given to engineering majors. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences Qualitative Reasoning II
PHYS 150 Physics of Societal Issues  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/150)
Physics topics and applications relevant in the modern world: energy, quantum mechanics, electricity and magnetism, nuclear physics, waves, light, and outer space. Application to satellites, alternative energy, medical imaging, radiation, nuclear weapons, climate change, and electronics. Emphasis on analytical thinking and the applicability to modern societal issues.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 192 Science and Pseudoscience  credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/PHYS/192)
Extra-sensory perception, alien abduction, and psychic crime-solving from the standpoint of scientific inquiry and exploration; the scientific method, how science progresses, and the types of argumentative fallacies that pervade the pseudoscientific community; examples of good science and how the scientific method is self-correcting.

PHYS 193 Physics of Music  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/193)
Physics of music and musical instruments; acoustical physics, propagation of sound waves, the biological physics of human hearing, and the acoustical physics associated with all types of musical instruments.

PHYS 194 Behavior of Complex Systems  credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/PHYS/194)
Exploration of systems with simple rules that nevertheless exhibit complex behavior. Lecture demonstrations on fractal growth, chaos, catastrophes, self-assembly, lightning, turbulence, explosions, and human rhythms. Simple computer models which exhibit regular, irregular, symmetric, and self-similar patterns and dynamics. Dynamics of isolated and coupled complex systems and mathematical tools for quantifying complex behavior.

PHYS 199 Undergraduate Open Seminar  credit: 0 to 5 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/199)
Approved for letter and S/U grading. May be repeated.

PHYS 211 University Physics: Mechanics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/211)
Newton's Laws, work and energy, static properties and fluids, oscillations, transverse waves, systems of particles, and rotations. A calculus-based approach for majors in engineering, mathematics, physics and chemistry. Credit is not given for both PHYS 211 and PHYS 101. Prerequisite: Credit or concurrent registration in MATH 231.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 212 University Physics: Elec & Mag  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/212)
Coulomb's Law, electric fields, Gauss' Law, electric potential, capacitance, circuits, magnetic forces and fields, Ampere's law, induction, electromagnetic waves, polarization, and geometrical optics. A calculus-based approach for majors in engineering, mathematics, physics, and chemistry. Credit is not given for both PHYS 212 and PHYS 102. Prerequisite: PHYS 211; credit or concurrent registration in MATH 241.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 213 Univ Physics: Thermal Physics  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/213)
First and second laws of thermodynamics including kinetic theory of gases, heat capacity, heat engines, introduction to entropy and statistical mechanics, and introduction to application of free energy and Boltzmann factor. A calculus-based approach for majors in engineering, mathematics, physics and chemistry. Credit is not given for both PHYS 213 and PHYS 101. Prerequisite: PHYS 211; credit or concurrent registration in MATH 241.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 214 Univ Physics: Quantum Physics  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/214)
Interference and diffraction, photons and matter waves, the Bohr atom, uncertainty principle, and wave mechanics. A calculus-based course for majors in engineering, mathematics, physics, and chemistry. Credit is not given for both PHYS 214 and PHYS 102. Prerequisite: PHYS 212.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 221 Enrichment Mechanics  credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/PHYS/221)
Supplement to PHYS 211 with a collaborative group learning approach to improving conceptual understanding and problem solving in introductory calculus-based mechanics. Prerequisite: PHYS 100; concurrent registration in PHYS 211.

PHYS 222 Enrichment E & M  credit: 1 Hour. (https://courses.illinois.edu/schedule/terms/PHYS/222)
Supplement to PHYS 212 with a collaborative group learning approach to improving conceptual understanding and problem solving in introductory calculus-based electricity & magnetism. Prerequisite: PHYS 100; concurrent registration in PHYS 212.

PHYS 225 Relativity & Math Applications  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/225)
Theory of Special Relativity, with applications to kinematics and dynamics. Key mathematical methods as they apply to aspects of electromagnetic theory and classical mechanics, including vector analysis, series expansions, matrices, Fourier analysis, partial differentiation, three-dimensional calculus, and simple differential equations. Prerequisite: Credit or concurrent registration in PHYS 212.

PHYS 246 Physics on the Silicon Prairie: An Introduction to Modern Computational Physics  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/246)
You will become a fearless code warrior, exploring the behaviors of systems that are too complicated for analytic characterization. You will calculate the trajectory of a relativistic starship and confirm an insight of Ramanujan, the "Man Who Knew Infinity." You will generate diagrams of spacetime curvature near black holes and confirm that General Relativity causes the non-Newtonian behavior of Mercury's orbit. You will calculate pi using simulated grains of sand. There will be chaos, Monte Carlo simulations, and adaptive numerical integrations. Approved for Letter and S/U grading. Prerequisite: Physics 211. Corequisites: MATH 231, Physics 212, and Physics 225. No prior programming experience is required. We welcome concurrent enrollment of high school students who meet the specified prerequisites.
PHYS 280  Nuclear Weapons & Arms Control  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/280)
Nontechnical analysis of the physics of nuclear weapons, nuclear weapon effects, delivery systems, and defenses against nuclear attack; presentation of current issues; basis for making informed judgments about nuclear armaments and arms control. Same as GLBL 280.
This course satisfies the General Education Criteria for: Advanced Composition

PHYS 298  Freshmen/Sophomore Special Topics in Physics  credit: 0 to 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/298)
Topical offerings of technical interest, skills, and knowledge in physics, and its practice, intended to augment the existing curriculum at the introductory level. Approved for Letter and S/U grading. May be repeated in separate terms up to 12 credit hours if topics vary. Prerequisite: See Class Schedule or departmental course information for topics and prerequisites. For students with freshman or sophomore standing.

PHYS 325  Classical Mechanics I  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/325)
Kinematics and dynamics of classical systems, including a review of Newtonian kinematics and dynamics. Three dimensional motion, variable mass, and conservation laws; damped and periodically driven oscillations; gravitational potential of extended objects and motion in rotating frames of reference; Lagrangian and Hamiltonian mechanics. Prerequisite: PHYS 225; credit or concurrent registration in MATH 285.

PHYS 326  Classical Mechanics II  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/326)
Continuation of PHYS 325. Central force motion, collisions and scattering, rotational motion, coupled oscillations, continuous media, and fluid dynamics. Prerequisite: PHYS 325.

PHYS 329  Atmospheric Dynamics I  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/329)
Same as ATMS 302. See ATMS 302.

PHYS 330  Atmospheric Dynamics II  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/330)
Same as ATMS 312. See ATMS 312.

PHYS 398  Sophomore/Junior Special Topics in Physics  credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/398)
Topical offerings of technical interest, skills, and knowledge in physics, and its practice, intended to augment the existing curriculum at the intermediate level. Approved for Letter and S/U grading. May be repeated in separate terms up to 12 hours if topics vary. Prerequisite: See Class Schedule or departmental course information for topics and prerequisites. For students with sophomore or junior standing.

PHYS 401  Classical Physics Lab  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/401)
Experiments and techniques in classical mechanics and electromagnetism. Dynamics of electrical and mechanical oscillators in the linear domain. Fourier analysis of system response. Measurements of electrostatic fields, transmission lines, waves, and radiation. Electromagnetic phenomena in dielectrics, conductors, and magnetic materials. Instruction in data analysis and report writing. 3 undergraduate hours. 3 graduate hours. Prerequisite: Credit or concurrent enrollment in PHYS 325.

PHYS 402  Light  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/402)
Wave kinematics; geometrical optics: basic concepts, ray-tracing and matrix formalism, Gaussian imaging by thick lenses, stops, apertures, and intensity relations; interference; interference spectroscopy and coherence; diffraction: Fresnel-Kirchhoff formulation, Fraunhofer case, Fresnel case, and holoography; polarized light. 4 undergraduate hours. 3 or 4 graduate hours. (3 hours without lab). Prerequisite: MATH 285; PHYS 102 or PHYS 214.

PHYS 403  Modern Experimental Physics  credit: 4 or 5 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/403)
Techniques and experiments in the physics of atoms, atomic nuclei, molecules, the solid state, and other areas of modern physical research. 5 undergraduate hours. 4 graduate hours. Prerequisite: Credit or concurrent registration in PHYS 486.

PHYS 404  Electronic Circuits  credit: 4 or 5 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/404)
Physics of semiconductor devices; theory and application of discrete and integrated devices in linear circuits; use of operational amplifiers and feedback; regulation, oscillators, and modulation; emphasizes practical experience. 5 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 325.

PHYS 406  Acoustical Physics of Music  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/406)
Acoustical physics associated with music and musical instruments, propagation of sound waves in and from musical instruments, and the biological physics of human hearing. Investigation of topics via advanced laboratory and data acquisition techniques. 4 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 213 and PHYS 214.

PHYS 419  Space, Time, and Matter-ACP  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/419)
Identical to PHYS 420 except for the additional writing component including a final term paper. Same as PHIL 419. 3 undergraduate hours. 4 graduate hours. Credit is not given for both PHYS 419 and PHYS 420. Prerequisite: PHIL 101; PHYS 101 or PHYS 211.
This course satisfies the General Education Criteria for: Advanced Composition

PHYS 420  Space, Time, and Matter  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/420)
Philosophical examination of some fundamental concepts and theories of the physical world, such as time, matter, space, and geometry; interpretation of quantum theory. Same as PHIL 420. 2 undergraduate hours. 2 graduate hours. Credit is not given for both PHYS 420 and PHYS 419. Prerequisite: PHIL 101; PHYS 101 or PHYS 211.

PHYS 427  Thermal & Statistical Physics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/427)
Equilibrium thermodynamics, statistical mechanics, and kinetic theory of gases. A unified treatment is used in that the principles of heat and thermodynamics are discussed along with statistical postulates and the microscopic approach of introductory quantum mechanics. 4 undergraduate hours. 4 graduate hours. Credit is not given for both PHYS 427 and any of ME 404, CHEM 444, MSE 500. Prerequisite: PHYS 213, PHYS 214, and PHYS 325.

Information listed in this catalog is current as of 04/2019
PHYS 435 Electromagnetic Fields I  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/435)
Static electric and magnetic fields, their interactions with electric charge and current, and their transformation properties; the effect of special relativity is incorporated. Macroscopic fields in material media are described. 3 undergraduate hours. 3 graduate hours. Prerequisite: MATH 285; credit or concurrent enrollment in PHYS 325.

PHYS 436 Electromagnetic Fields II  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/436)
Time-dependent fields. Electromagnetic induction, Maxwell's equations, electromagnetic wave propagation in various media and structures, and electromagnetic radiation from charge and current distributions. Relativistic covariance of Maxwell's equations. Course Information:3 undergraduate hours. 3 graduate hours. Prerequisite: PHYS 435.

PHYS 460 Condensed Matter Physics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/460)
Bonding and structure of crystals; energy bands in insulators, semiconductors, and metals; electrical conductivity; optical properties; lattice vibrations; elasticity; point defects; dislocations. 4 undergraduate hours. 4 graduate hours. Credit is not given for both PHYS 460 and MSE 304. Prerequisite: PHYS 435; PHYS 485 or PHYS 486.

PHYS 466 Atomic Scale Simulations  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/466)
Same as CSE 485 and MSE 485. See MSE 485.

PHYS 470 Subatomic Physics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/470)
The nature and properties of nuclei and elementary particles, symmetries, interactions, nuclear models, tools and techniques of experimental subatomic physics, and applications to power generation, astrophysics, chemistry, medicine, and biology. 4 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 485 or PHYS 486.

PHYS 475 Introduction to Biophysics  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/475)
Major concepts of physics inherent to biological systems. Basics of biology, including protein and DNA structure and their organization into cells with a focus on single molecule biophysics. Major experimental techniques including x-ray diffraction, optical and magnetic traps, and fluorescence microscopy, including new super-resolution techniques. Applications to cytoplasmic and nuclear molecular motors, bacterial motion, nerves, and vision. 3 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 213 and PHYS 214.

PHYS 485 Atomic Phys & Quantum Theory  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/485)
Basic concepts of quantum theory which underlie modern theories of the properties of materials; elements of atomic and nuclear theory; kinetic theory and statistical mechanics; quantum theory and simple applications; atomic spectra and atomic structure; molecular structure and chemical binding. 3 undergraduate hours. 3 graduate hours. Credit is not given for both PHYS 485 and CHEM 442. Prerequisite: MATH 285 and PHYS 214.

PHYS 486 Quantum Physics I  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/486)
Atomic phenomena integrated with an introduction to quantum theory; evidence for the atomic nature of matter and the properties of the Schrödinger equation, single particle solutions in one dimension, the hydrogen atom, perturbation theory, external fields, and atomic spectroscopy of outer electrons. 4 undergraduate hours. 4 graduate hours. Prerequisite: MATH 285; PHYS 214; credit or concurrent registration in MATH 415.

PHYS 487 Quantum Physics II  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/487)
Continuation of PHYS 486. Identical particles, spectral hyperfine structure, magnetic properties of matter, atomic spectroscopy of inner electrons, high-energy photon effects, molecular binding and spectra, emission and absorption of light, and symmetry principles. 4 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 486.

PHYS 496 Intro to Physics Research  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/496)
Examination of current research topics through extensive reading, writing, and oral-presentation activities. 3 undergraduate hours. No graduate credit. This course satisfies the General Education Criteria for: Advanced Composition

PHYS 497 Individual Study  credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/497)
Individual study at an advanced level in a subject not covered by course offerings. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated. Prerequisite: Consent of instructor.

PHYS 498 Special Topics in Physics  credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/498)
Subject offerings of new and developing areas of knowledge in physics intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary.

PHYS 499 Senior Thesis  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/499)
Faculty-guided writing of a senior thesis involving independent research Oral presentations of research and outside journal articles, proposal writing and reviewing, poster presentation, preparation of graduate school applications, and discussion of physics frontiers with outside experts. 3 undergraduate hours. No graduate credit. Prerequisite: PHYS 496.

PHYS 504 Statistical Physics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/504)
Single-particle distribution functions; classical and quantum mechanical systems, Boltzmann equation, virial theorem, and equations of state for gases; formal theory: ensembles, identical particles, thermodynamics of simple systems, and distribution functions; nonequilibrium problems; conservation laws and hydrodynamic equations, sound waves, and transport coefficients; plasmas, normal Fermi fluid, superfluids, and systems with internal degrees of freedom. Prerequisite: PHYS 427 and PHYS 486.

PHYS 505 Classical Electromagnetism  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/505)
Review of Maxwell's equations; relativistic formulation of the electromagnetic field and the motion of charged particles; plane and guided waves; retarded potentials; radiation from simple antennas; radiation from accelerated charged particles; scattering and further topics. Prerequisite: PHYS 436.
PHYS 508 Mathematical Physics I credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/508)
Core techniques of mathematical physics widely used in the physical sciences. Calculus of variations and its applications; partial differential equations of mathematical physics (including classification and boundary conditions); separation of variables, series solutions of ordinary differential equations and Sturm-Liouville eigenproblems; Legendre polynomials, spherical harmonics, Bessel functions and their applications; normal mode eigenproblems (including the wave and diffusion equations); inhomogeneous ordinary differential equations (including variation of parameters); inhomogeneous partial differential equations and Green functions; potential theory; integral equations (including Fredholm theory). Prerequisite: MATH 285.

PHYS 509 Mathematical Physics II credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/509)
Continuation of PHYS 508. Further core techniques of mathematical physics widely used in the physical sciences. Complex variables; group theory in classical and quantum systems; tensors in physics; differential forms and their applications in mechanics; electrodynamics. Prerequisite: PHYS 508.

PHYS 510 Nonlinear Dynamics credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/510)
Broad introduction to nonlinear dynamics of physical systems with varying degrees of complexity; survey of a variety of concepts associated with bifurcation phenomena, mappings, nonlinear oscillations, chaotic behavior, strange attractors, and solitons. Topics of current interest. Prerequisite: PHYS 326.

PHYS 511 Quantum Optics & Information credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/511)
Experimental and theoretical fundamentals of quantum information, using nonclassical features of quantum physics (wave-particle duality, superposition, and entanglement) to surpass the information-processing capabilities of classical systems. Underlying fundamental quantum phenomena, including tests of nonlocality, quantum erasers, the quantum Zeno effect, squeezed light, multi-particle interference, state transformations of the Bloch sphere, and decoherence; quantum cryptography and teleportation; quantum information theory; quantum computation algorithms and techniques for error correction; experimental “qubit” systems. Prerequisite: Recommended: PHYS 580.

PHYS 512 Modern Atomic Physics credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/512)
Rigorous survey of modern atomic, molecular, and optical physics, including a functional approach to theory and an overview of experimental techniques. Atomic structure, including fine and hyperfine structure, multi-electron atoms, and relativistic effects; interaction of single atoms with dynamic and static electromagnetic fields, ultra-cold collisions between atoms; laser cooling, evaporative cooling, and magnetic trapping; Paul and Penning traps; quantum degenerate gases; atom interferometry. Prerequisite: PHYS 427, PHYS 436, and PHYS 487.

PHYS 513 General Relativity I credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/513)
Systematic introduction to Einstein’s theory, with emphasis on modern coordinate-free methods of computation. Review of special relativity, modern differential geometry, foundations of general relativity, laws of physics in the presence of a gravitational field, linearized theory, and experimental tests of gravitation theories. Same as ASTR 515. Prerequisite: PHYS 436.

PHYS 514 Theoretical Stellar Physics credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/514)
Rigorous survey of modern atomic, molecular, and optical physics, including a functional approach to theory and an overview of experimental techniques. Atomic structure, including fine and hyperfine structure, multi-electron atoms, and relativistic effects; interaction of single atoms with dynamic and static electromagnetic fields, ultra-cold collisions between atoms; laser cooling, evaporative cooling, and magnetic trapping; Paul and Penning traps; quantum degenerate gases; atom interferometry. Prerequisite: PHYS 427, PHYS 436, and PHYS 487.

PHYS 515 General Relativity I credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/515)
Systematic introduction to Einstein’s theory, with emphasis on modern coordinate-free methods of computation. Review of special relativity, modern differential geometry, foundations of general relativity, laws of physics in the presence of a gravitational field, linearized theory, and experimental tests of gravitation theories. Same as ASTR 515. Prerequisite: PHYS 436.
PHYS 554  Nonequilibrium Stat Mechanics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/554)
Mathematical description of classical and quantum stochastic systems, thoroughly addressing the tools and the mode of thinking of nonequilibrium statistical mechanics. Equilibrium statistical mechanics (review); Einstein and Smoluchowski diffusion equation; generalized moment expansion of correlation functions; noise-induced limit cycles; time series analysis; diffusion-controlled reactions; classical dynamics under the influence of stochastic forces; observables connected with Brownian transport, echoes, and hysteresis; spin-boson model. Examples from biological physics and theoretical condensed matter physics. Prerequisite: PHYS 504.

PHYS 560  Condensed Matter Physics I  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/560)
Crystalline perfection, free-electron gas, screening, plasma oscillations, and dielectric response; Bloch electrons, Brillouin zones, and band structure; semiconductors, intrinsic and extrinsic, with applications; phonons, elasticity, and anharmonicity; ferromagnetism and second-order phase transitions; superconductivity. Prerequisite: PHYS 427 and PHYS 580.

PHYS 561  Condensed Matter Physics II  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/561)
Hartree-Fock theory and electron-electron interactions; electron-phonon interactions; electron dynamics and transport; BCS theory of superconductivity; elastic properties; thermal properties due to anharmonicity; defects in solids. Prerequisite: PHYS 560 and PHYS 581.

PHYS 563  Phase Transitions  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/563)
Phenomenology of phase transitions, scaling, critical behavior, and multi-criticality; Landau theory of phase transitions; renormalization group methods, including lattice models and epsilon-expansion; numerical methods; critical dynamics; selected additional topics. Prerequisite: PHYS 504.

PHYS 565  Theory of Semicon & Devices  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/565)
Same as ECE 535. See ECE 535.

PHYS 569  Emergent States of Matter  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/569)
Consequences of broken symmetry in condensed matter, the emergence of novel ground states, and the nature of the excitations that arise. Examination of specific systems such as superconductivity, superfluidity, Bose-Einstein condensates, the quantum Hall states, liquid crystals, biological systems and patterns in Rayleigh-Benard convection. Prerequisite: PHYS 504 and PHYS 580.

PHYS 570  Subatomic Physics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/570)
Nuclear systematics, nucleon-nucleon interaction, shell model, and single-particle and collective excitations; hadron spectroscopy, hadronic quantum numbers, quark-parton model, and hadron dynamics; weak interactions. Prerequisite: PHYS 580; concurrent registration in PHYS 581.

PHYS 575  Particle Physics I  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/575)
Basic calculations in elementary particle theory. Quantum electrodynamics, quantum chromodynamics, and the Glashow-Weinberg-Salam theory of weak and electromagnetic interactions as applied to the phenomenology of particle decays and high energy reactions. Prerequisite: PHYS 570. Recommended: credit or concurrent registration in PHYS 582.
PHYS 599  Thesis Research  credit: 0 to 16 Hours. (https://courses.illinois.edu/schedule/terms/PHYS/599)
Approved for S/U grading only. May be repeated.