Physics and Astronomy

Chair
• Philip E. Kaaret

Director, Undergraduate Studies
• Jane M. Nachtman

Director, Graduate Studies
• Vincent Rodgers

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• John P. Prineas

Undergraduate majors: physics (B.A., B.S.); applied physics (B.S.); astronomy (B.A., B.S.)
Undergraduate minors: physics; astronomy
Graduate degrees: M.S. in physics; M.S. in astronomy; Ph.D. in physics
Faculty: https://physics.uiowa.edu/people
Website: https://physics.uiowa.edu/

Courses
• Physics Courses [p. 1]
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Physics Courses

PHYS:1000 First-Year Seminar 1 s.h.
Small discussion class taught by a faculty member; topics chosen by instructor; may include outside activities (e.g., films, lectures, performances, readings, visits to research facilities). Requirements: first- or second-semester standing.

PHYS:1100 From Quarks to Quasars 3-4 s.h.
Conceptual explanations of the latest discoveries in physics—from the smallest objects, such as quarks and atoms, to the largest, such as galaxies, black holes, and quasars. Requirements: non-science major. GE: Natural Sciences with Lab; Natural Sciences without Lab.

PHYS:1200 Physics of Everyday Experience 3 s.h.
Principles of physics; basic motion, behavior of fluids, waves, temperature and heat, gravity and planetary motion, electricity and magnetism, optics, nuclear energy, radioactivity, and medical imaging technology; examples from everyday experience; for non-science majors. GE: Natural Sciences with Lab; Natural Sciences without Lab.

PHYS:1400 Basic Physics 3-4 s.h.
Quantitative treatment of mechanics, electricity, heat, liquids, gases, and atomic, nuclear, and elementary particle physics. Requirements: must have completed high school trigonometry or achieved a minimum ALEKS score of 75%. GE: Natural Sciences with Lab; Natural Sciences without Lab.

PHYS:1409 Basic Physics Lab 1 s.h.
Laboratory for PHYS:1400. Corequisites: PHYS:1400 (if not taken as a prerequisite). GE: Natural Sciences Lab only.

PHYS:1410 Physics of Sound 3-4 s.h.
Acoustical foundations of music; production of sound by vibrating objects, properties of sound waves, vocal acoustics, hearing, room acoustics, principles of electroacoustics. GE: Natural Sciences with Lab; Natural Sciences without Lab.

PHYS:1511 College Physics I 4 s.h.
Algebra-based treatment of mechanics, waves, thermodynamics, and special relativity. Requirements: must have completed high school trigonometry or achieved a minimum ALEKS score of 75%. GE: Natural Sciences with Lab.

PHYS:1512 College Physics II 4 s.h.
Continuation of PHYS:1511; algebra-based treatment of electricity, magnetism, light, and modern physics. Prerequisites: PHYS:1611 or PHYS:1511. GE: Natural Sciences with Lab.

PHYS:1611 Introductory Physics I 4 s.h.

PHYS:1612 Introductory Physics II 3-4 s.h.
Continuation of PHYS:1611; calculus-based treatment of electricity, magnetism, and light. Prerequisites: PHYS:1611. Corequisites: MATH:1560 or MATH:1860. GE: Natural Sciences with Lab; Natural Sciences without Lab.

PHYS:1619 Introductory Physics II Lab 1 s.h.
Laboratory for PHYS:1612. Requirements: 3 s.h. in PHYS:1612. GE: Natural Sciences Lab only.

PHYS:1701 Physics I 4 s.h.
Introduction to physics; calculus-based treatment of Newtonian mechanics for point particles and rigid bodies; conservation laws. Offered fall semesters. Corequisites: MATH:1850. Requirements: physics or astronomy major. GE: Natural Sciences with Lab.

PHYS:1702 Physics II 4 s.h.

PHYS:1999 Undergraduate Seminar arr.
Selected topics in physics and astronomy; discussion, presentations.

PHYS:2703 Physics III 4 s.h.
Continuation of PHYS:1702; introduction to physics; calculus-based treatment of electromagnetic waves and optics; mechanical and sound waves; thermal physics. Offered fall semesters. Prerequisites: PHYS:1702.

PHYS:2704 Physics IV 3-4 s.h.
Introduction to quantum mechanics and other topics in modern physics, including special relativity, atomic and solid state physics. Offered spring semesters. Prerequisites: (PHYS:1612 or PHYS:2703) and (MATH:1860 or MATH:1550). Requirements: for 3 s.h. option—nonmajor.

PHYS:2905 Programming for Physics 2 s.h.
Introduction to scientific programming for applications in physics.

PHYS:2990 Reading in Physics arr.
Selected topics in physics.

PHYS:3500 Undergraduate Practicum arr.
Experiences that provide special opportunities for students to gain practical and hands-on training related to topics in physics; practicums typically arranged by individual faculty members. Requirements: application and acceptance into practicum.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>PHYS:3710</td>
<td>Intermediate Mechanics</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:3730</td>
<td>Statistical Physics</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:3741</td>
<td>Introduction to Quantum Mechanics I</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:3750</td>
<td>Fundamentals of Micro and Nanofabrication</td>
<td>3 s.h.</td>
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<td>PHYS:3756</td>
<td>Intermediate Laboratory</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:3811</td>
<td>Electricity and Magnetism I</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:3812</td>
<td>Electricity and Magnetism II</td>
<td>3 s.h.</td>
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<td>PHYS:3850</td>
<td>Electronics</td>
<td>4 s.h.</td>
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<td>PHYS:4720</td>
<td>Introductory Optics</td>
<td>3 s.h.</td>
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<td>PHYS:4726</td>
<td>Electro Optics</td>
<td>3 s.h.</td>
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<td>PHYS:4728</td>
<td>Introductory Solid State Physics</td>
<td>3 s.h.</td>
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<td>PHYS:4731</td>
<td>Plasma Physics I</td>
<td>3 s.h.</td>
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<td>PHYS:4740</td>
<td>Elementary Particles and Nuclear Physics</td>
<td>3 s.h.</td>
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<td>PHYS:4750</td>
<td>Advanced Laboratory</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:4761</td>
<td>Mathematical Methods of Physics I</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:4762</td>
<td>Mathematical Methods of Physics II</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:4820</td>
<td>Optical Signal Processing</td>
<td>3 s.h.</td>
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<tr>
<td>PHYS:4860</td>
<td>Computational Physics</td>
<td>3 s.h.</td>
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Phys 4905 Special Topics in Physics 3 s.h.
Introduction to scientific programming using the Python language and linear algebra for applications in physics.

Phys 4990 Reading in Physics arr.
Selected topics in physics.

Phys 4999 Undergraduate Research arr.
Supervised research leading to written report or oral presentation.

Phys 5000 Workshops and Special Training in Physics arr.
Workshops and special training opportunities for postbaccalaureate students; may include collaborations with other departments, institutions, or externally funded research organizations.

Phys 5710 Classical Mechanics 3 s.h.
Dynamics of mass points; Lagrange multipliers, small oscillations, Hamilton's equations; canonical transformations, Hamilton-Jacobi theory; chaos. Prerequisites: Phys 3710.

Phys 5730 Statistical Mechanics I 3 s.h.
Probability concepts; kinetic equations; classical and quantum equilibrium statistical mechanics with applications, including ideal and imperfect gases and phase transitions, irreversible processes, fluctuation-dissipation theorems. Prerequisites: Phys 3730 and Phys 3741.

Phys 5741 Quantum Mechanics I 3 s.h.
Nonrelativistic quantum mechanics, Schrödinger wave mechanics, Hilbert space methods, perturbation theory, scattering, spin and angular momentum, identical particles, selected applications, introduction to relativistic theory. Prerequisites: Phys 5741 and Phys 3742.

Phys 5742 Quantum Mechanics II 3 s.h.
Continuation of Phys 5741. Prerequisites: Phys 5741.

Phys 5811 Classical Electrodynamics I 3 s.h.
Advanced electromagnetostatics, boundary value problems, Green's functions, Maxwell's equations, radiation theory, physical optics, multipole expansion of radiation field.

Phys 5812 Classical Electrodynamics II 3 s.h.
Special relativity, motion of charges in fields, theories of radiation reaction, special topics. Prerequisites: Phys 5811.

Phys 5905 Special Topics in Physics 3 s.h.
Selected topics in physics.

Phys 6723 Advanced Optics 3 s.h.
Classical theory of absorption and emission; laser theory, threshold, rate equations, saturation, spectral and spatial hole burning; resonantors and Gaussian beam optics; dispersion and light scattering; nonlinear optics, three- and four-wave mixing, harmonic generation, parametric amplification, and stimulated scattering. Prerequisites: Phys 3812.

Phys 7270 Ethics in Physics for Graduate Students arr.
Responsible conduct and ethics training.

Phys 7604 Ethics in Physics for Postdocs 0 s.h.
Responsible conduct and ethics training.

Phys 7720 Semiconductor Physics 3 s.h.
Electronic, optical, and materials properties of semiconductors. Prerequisites: Phys 4728 and Phys 5742. Same as ECE 7720.

Phys 7722 Advanced Condensed Matter 3 s.h.
Elementary excitations, plasmonics, exchange/magnetism, hyperfine interactions, resonance, superconductivity, topological materials. Prerequisites: Phys 7720.

Phys 7729 Plasma Physics II 3 s.h.
Continuation of Phys 4731; cold plasma waves, MHD stability, kinetic theory of plasmas, including Landau damping and velocity space instabilities; nonlinear evolution. Prerequisites: Phys 4731.

Phys 7730 Advanced Plasma Physics I 3 s.h.
Microscopic plasma behavior: statistical mechanics of plasmas; Liouville equation; BBGKY hierarchy; Fokker-Planck equation and relaxation processes; Balescu-Lenard equation; Vlasov equation and linearized wave motion; shocks, nonlinear plasma motions, and instabilities; fluctuations and radiation processes; topics from recent literature.

Phys 7740 Introduction to Quantum Field Theory 3 s.h.
Quantization of relativistic and nonrelativistic field theories, covariant perturbation theory, theory of renormalization, dimensional regularization, renormalization group theory, introduction to gauge theories and anomalies. Prerequisites: Phys 5742.

Phys 7746 Particle Physics 3 s.h.
Elementary particle properties and phenomenology, quark-parton models, quantum chromodynamics, unified theory of weak and electromagnetic interactions.

Phys 7760 General Relativity 2-3 s.h.
Einstein's theory of gravitation; principles of general relativity.

Phys 7761 Cosmology 3 s.h.
Einstein's theory of general relativity radically changed the way we understand the cosmos by providing a mathematical description of space-time itself—this is cosmology; the last three decades have shown remarkable evidence that cosmology is an experimentally testable theory; students explore mathematical underpinnings of cosmology by studying the early universe, the cosmic microwave background, inflation, big bang nucleosynthesis, neutrino physics, quantum field theory effects on space-time, and other issues. Prerequisites: Phys 7760.

Phys 7840 Quantum Gauge Theories 3 s.h.

Phys 7905 Special Topics in Physics arr.

Current research.

Current research. Same as ECE 7930.

Phys 7936 Seminar: Space Physics arr.
Current research.

Phys 7945 Seminar: Math/Physics arr.
Current research.

Phys 7946 Seminar: Nuclear and Particle Physics arr.
Current research.

Phys 7990 Research: Physics arr.

Phys 7992 Individual Critical Study arr.
Essay on topic chosen in consultation with faculty member. Requirements: candidacy for M.S. with critical essay.
Astronomy Courses

ASTR:1000 First-Year Seminar 1 s.h.
Small discussion class taught by a faculty member; topics chosen by instructor; may include outside activities (e.g., films, lectures, performances, readings, visits to research facilities).

ASTR:1060 Big Ideas: Origins of the Universe, Earth, and Life 3 s.h.
Origin of the universe, the biochemistry of life, and the origin of life on Earth; for non-science majors. Recommendations: first-year or sophomore standing. GE: Natural Sciences without Lab. Same as BIOL:1060, EES:1060.

ASTR:1061 Big Ideas: Evolution of Life on Earth and the Search for Life in the Universe 4 s.h.
Evolution of life on Earth, origins of plants and animals, origins of humans and humanity, and the search for life in the universe; for non-science majors. GE: Natural Sciences with Lab. Same as ANTH:1061, EES:1061.

ASTR:1070 Stars, Galaxies, and the Universe 3-4 s.h.
Students survey topics including the Sun; life cycles of stars including black holes and pulsars; diversity of galaxies including the Milky Way and distant quasars; cosmology—the history, structure, and fate of the universe; current results from recent astronomical observations; for non-science majors. Recommendations: closed to physics and astronomy majors. GE: Natural Sciences with Lab; Natural Sciences without Lab.

ASTR:1079 Introductory Astronomy Laboratory 1 s.h.
Laboratory for ASTR:1070. GE: Natural Sciences Lab only.

ASTR:1080 Exploration of the Solar System 3-4 s.h.
Survey of the solar system; topics include physical properties of the planets, comets, and asteroids; origin of the solar system; search for extrasolar planetary systems; search for life in the universe; current results of recent planetary space missions; night sky observation; for non-science majors. Recommendations: closed to physics and astronomy majors. GE: Natural Sciences with Lab; Natural Sciences without Lab.

ASTR:1085 Citizen Astronomy 3 s.h.
Survey of topics in astronomy and astrophysics; topics include the Solar System and exoplanets, nearby stars in the Galaxy, distant galaxies and unseen black holes; focus on citizen science projects that allow students to examine real data; for non-science majors. GE: Natural Sciences without Lab.

ASTR:1091 Life in the Universe 3 s.h.
Are we alone? Scientific foundations of this question, technology behind searches for extraterrestrial life in the solar system and on extrasolar planets; evolution of life on Earth, likelihood that such conditions exist elsewhere in the universe; cultural consequences of discovering extraterrestrial life. GE: Natural Sciences without Lab.

ASTR:1771 Introductory Astronomy I: Basic Astrophysics and Planetary Astronomy 4 s.h.
Quantitative introduction to physical principles needed to understand astronomical phenomena (e.g., laws of motion, gravitation, radiation), astronomical instrumentation, properties structure, and evolution of solar system bodies, exoplanets, and the search for life. Requirements: four years of high school math. GE: Natural Sciences with Lab.

ASTR:1772 Introductory Astronomy II: Stellar, Galactic, and Extragalactic Astronomy 4 s.h.
Continuation of ASTR:1771; quantitative introduction to stellar, Galactic, and extragalactic astronomy; topics include the Sun, stellar evolution, stellar corpses such as neutron stars and black holes, the Milky Way galaxy, the interstellar medium, galaxies, cosmology, and fate of the universe. Requirements: four years of high school math. GE: Natural Sciences with Lab.

ASTR:2991 Reading in Astronomy arr.
Selected topics in astronomy.

ASTR:3500 Undergraduate Practicum arr.
Undergraduate practicum experiences that provide special opportunities for students to gain practical and hands-on training related to topics in astronomy; practicums typically arranged by individual faculty members. Requirements: application and acceptance into practicum.

ASTR:3771 Introduction to Astrophysics I 3 s.h.
Topics include celestial mechanics, radiative transfer, stellar structure and evolution, and star formation; first in a two-semester sequence. Prerequisites: PHYS:2704 and ASTR:1772 and ASTR:1771 and (MATH:2850 or MATH:3550) and (MATH:2700 or MATH:2550). Recommendations: computer programming experience.

ASTR:3772 Introduction to Astrophysics II 3 s.h.
Continuation of ASTR:3771; topics include post-main-sequence stellar evolution, stellar remnants, close binary stars, the Milky Way and other galaxies, active galactic nuclei, galaxy evolution, and cosmology; second in a two-semester sequence. Prerequisites: ASTR:3771.

ASTR:4770 Radio Astronomy 3 s.h.
Survey of radio astronomy, emphasizing technical aspects; radiation, antennas, receivers, radio spectroscopy, interferometer arrays and aperture synthesis; emission mechanisms, pulsars, supernova remnants, radio galaxies.

ASTR:4850 Astronomical Laboratory 3 s.h.
Introduction to instruments of optical (and sometimes multi-wavelength) astronomy and basic skills needed for carrying out observational astronomical research; hands-on use of observing equipment; nighttime observing sessions. Prerequisites: PHYS:2704 and ASTR:1772 and ASTR:1771.

ASTR:4996 Reading in Astronomy arr.

ASTR:6782 Extragalactic Astronomy 3 s.h.
Normal and active galaxies, large scale structure, the early Universe, cosmology.

ASTR:6785 The Interstellar Medium 3 s.h.
The interstellar medium; optical properties of small interstellar grains, radiative processes in interstellar gas, structure of HI regions, interstellar shock waves, supernova remnants, modification of interstellar medium by luminous stars, molecular clouds.

ASTR:6790 Stellar Astrophysics 3 s.h.
Stellar interiors, nuclear astrophysics; advanced topics.

ASTR:6870 Radiative Processes in Astrophysics 3 s.h.
Physics of stars including interiors, spectra, nuclear processes, plasma hydrodynamics, and the extreme physics of condensed final states.

ASTR:6880 High Energy Astrophysics 3 s.h.
Detection of X-rays and gamma-rays, black holes and neutron stars, accretion onto compact objects, pulsars, supernova remnants, cosmic rays, and gamma-ray bursts.
ASTR:7775 Special Topics in Astrophysics  1-3 s.h.
Advanced lectures.

ASTR:7830 Space and Astrophysical Plasma Physics  3 s.h.
Dynamics and evolution of space and astrophysical plasmas; heliosphere, planetary magnetospheres, accretion disks; plasma waves, shock waves, turbulence.

ASTR:7970 Seminar: Astrophysics  arr.
Current research.

ASTR:7991 Research: Astronomy  arr.
Original research in observational, theoretical astronomy.