

# HOMER L. DODGE DEPARTMENT OF PHYSICS AND ASTRONOMY

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## General Information

The Homer L. Dodge Department of Physics and Astronomy has a long tradition of educating scientists, engineers and teachers who have achieved distinguished careers as researchers and leaders in industry and education. Our graduates include a former Science Advisor to the President of the United States, a former director of NSF, university president, U.S. ambassador, founders of corporations, Arctic explorer, founder and first editor of the American Journal of Physics, journal editors, inventors, research laboratory managers, university department chairs, Rhodes Scholar and Guggenheim Fellows, university professors, and hundreds of people devoted to advancing knowledge and improving the quality of life.

## Programs & Facilities

### Programs for Academic Excellence

Innovative education programs have been an integral part of the department since its inception and are still our tradition. In addition to our own faculty, post-doctoral fellows and weekly colloquium speakers promote academic excellence within the department. With additional support from state monies and private endowment, the department hosts a large number of visiting scientists each year who bring the latest developments in their areas of interest and who present opportunities to exchange scientific ideas.

The department offers all undergraduate majors the opportunity to perform research with faculty mentors, and runs a federally funded summer research experience for undergraduates from all across the country.

The OU Soonertarium is an educational outreach program whose goal is to share the joy of exploring the cosmos with fellow Oklahomans, one classroom at a time. They provide traveling planetarium shows and lectures, free of charge, to interested science classrooms in Oklahoma.

### Special Facilities and Programs

#### Library Resources

The Homer L. Dodge Department of Physics and Astronomy library possesses an excellent scientific library of over 20,000 volumes and more than 150 journal subscriptions. Ancillary library holdings include the world-famous History of Science Collection and the Engineering Library.

#### Instrument Shop

The instrument shop at the Homer L. Dodge Department of Physics and Astronomy has supported the experimental research needs of the department for a century. This facility has designed, built and collaborated on a wide variety of apparatus including, but not limited to: High Energy Physics work on DØ, Higgs Boson, and Monopole detector

systems; Atomic Molecular scattering systems – Electron-Photon Coincidence, Electric Dipole Moment, Cold Atom systems; UHV chambers and associated hardware; Thin film sputtering systems; High Pressure (100,000 PSI) systems, Electro-mechanical drive and control; Furnace construction and PID control; Telescope repair.

#### Laboratory Resources

The department has well-equipped laboratories for research in laser cooling and trapping of atoms and molecules, atomic and molecular collisions, nanostructured materials and devices, materials characterization, and high-energy physics instrumentation. We are also home to a multi-million dollar NSF funded Materials Research Science and Engineering Center. This center greatly expands our research effort in nanostructures. Additionally, many programs make use of facilities at national laboratories, such as Argonne, Fermilab, Lawrence Berkeley Labs and Los Alamos. The high-energy group is part of the ATLAS collaboration and hosts one of the ATLAS tier 2 computing centers. The HEP group owns a clean room to work on silicon pixel detector technology for the Phase II upgrade of the ATLAS detector. The Astronomy group has access to two telescopes at the Apache Point Observatory. They have 10.625% of the observing time on the Astronomical Research Consortium (ARC) 3.5 meter telescope and the 0.5-meter Astrophysical Research Consortium Small Aperture Telescope. Individual faculty have access to other telescopes/projects including Sloan Digital Sky Survey V, ASAS-SN, and 4MOST. There is also a small on-campus observatory for class use and public viewing. Astronomy faculty compete successfully for use on ground-based observational facilities including the Karl G. Jansky Very Large Array, NSF's National Optical-Infrared Astronomy Research Laboratory telescopes, and the Gemini telescopes. They also compete for time on space-based observational facilities including the Hubble Space Telescope, JWST, the Chandra X-ray Observatory, XMM-Newton X-ray Observatory. The department has a network of linux computers and individual faculty groups run Linux servers. All faculty have access to OSCER; there is no charge for using this facility. Some faculty/groups have access to privately-owned servers operated by OSCER.

#### Scholarships and Financial Aid

The department offers a number of scholarships each year to students majoring in physics, astronomy, or engineering physics. Undergraduate majors and students who are considering becoming physics, astrophysics, or engineering physics majors are encouraged to apply for scholarships through the University of Oklahoma Centralized Academic Scholarship Hub (CASH).

Teaching and research assistantships are offered on a competitive basis to graduate students.

## Undergraduate Study

### Physics Degrees

The student whose major is physics may work for the professional degree of Bachelor of Physics or for the standard degree of Bachelor of Science, both of which are awarded by the College of Arts and Sciences. The Engineering Physics Bachelor of Science program is an interdisciplinary degree program which combines the course offerings and research activities of the Homer L. Dodge Department of Physics and Astronomy and the College of Engineering. This degree program is offered by the College of Engineering and detailed information concerning the program can be found in the College of Engineering section of this catalog.

## Astrophysics Degree

Students whose major interest is the application of physics to modern astrophysics may work for the Astrophysics Bachelor of Science.

## Astronomy Degree

The student whose major is astronomy may work for the standard degree of Bachelor of Science.

## Minors

Minors are offered in physics and astronomy.

## Graduate Study

### Areas of Specialization

Research areas available for both M.S. and Ph.D. degrees include:

- Astrophysics
- Atomic, Molecular and Optical Physics
- High Energy Physics
- Condensed Matter Physics

## Master Of Science Degree

The department offers a Master of Science in Physics program with or without the thesis.

## Master Of Science (Engineering Physics)

The Engineering Physics, Master of Science degree is offered as either a thesis or non-thesis program.

## Doctoral Programs

The Physics Ph.D. program requires the student to complete at least 90 hours of coursework, take and pass the written Qualifying and General (Specialist) examinations, and complete and successfully defend the results of original research as a dissertation. The department also offers an Astrophysics Ph.D. program.

All Ph.D. students are required to take an appointment as a teaching assistant with a minimum of two semester contact hours for two semesters. This teaching practicum is independent of financial support by the department.

Students who are interested in the **Engineering Physics Ph.D.** should refer to the general requirements of the Graduate College and the College of Engineering. Every student will be assigned an advisory committee who will determine the specific requirements within the guidelines set by these colleges and the career study goals of the student.

The required physics core courses and the Qualifying and Specialist exams are the same as for physics.

## Courses

### ASTR 1504 Astronomy: Exploring the Universe 4 Credit Hours

An introduction to the concepts of modern astronomy. The solar system, the sun and stars, the Milky Way and other galaxies, current theories of the origin, evolution and fate of the universe. Not for major credit. A student may not receive credit for this course and ASTR 1514. (F, Sp, Su) [I-NS].

### ASTR 1514 Astronomy: Exploring the Universe with Laboratory 4 Credit Hours

0 to 4 hours. An introduction to the concepts of modern astronomy. The solar system, the sun and stars, the Milky Way and other galaxies, current theories of the origin, evolution, and fate of the universe. Not for major credit. A student may not receive credit for this course and ASTR 1504. Laboratory (F, Sp, Su) [I-NSL].

### ASTR 1523 Life in the Universe 3 Credit Hours

Introductory astronomy course focusing on general physical conditions under which life is thought to arise and evolve in the universe. Topics include historical astronomy, gravitation and planetary orbits, the solar system. The earth's geology and atmosphere, stellar evolution, theories for the origin of life on earth, the discoveries of extrasolar planets, and the search for extraterrestrial life. (Sp) [I-NS].

### ASTR 2513 Introductory Astrophysics 3 Credit Hours

Prerequisite: PHYS 1215 or 2524, or permission of instructor. An introduction to solar system astronomy and basic astrophysical concepts for majors and students with a knowledge of introductory physics and calculus. Includes planetary system formation, asteroids, comets, terrestrial planets and giant planets. Astrophysical concepts including Keplers laws, blackbody radiation, hydrostatic equilibrium and heat transfer. Elements of astronomy, including time, celestial coordinates, telescopes and detectors, magnitudes and color indices. (F)

### ASTR 2970 Special Topics/Seminar 1-3 Credit Hours

Special Topics. 1 to 3 hours. May be repeated; Maximum credit nine hours. Special topics course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research, and field projects. (Irreg.)

### ASTR 3103 Stars 3 Credit Hours

Prerequisite: 2513 or permission of instructor. Stellar properties and stellar evolution. Includes fundamental properties of stars (temperature, luminosity, mass) and how to determine them, star formation, main sequence, post main sequence, supernovae, black holes, neutron stars, white dwarfs, binary stars. (F)

### ASTR 3113 Galaxies and Cosmology 3 Credit Hours

Prerequisite: 2513 or permission of instructor; 3103 strongly recommended. Galactic and extragalactic astronomy. Includes the Milky Way galaxy, the interstellar medium, normal and active galaxies, clusters of galaxies, cosmology. (Sp)

### ASTR 3190 Topics in Astronomy 1-3 Credit Hours

1 to 3 hours. Prerequisite: permission of instructor. May be repeated with change of subject matter; maximum credit nine hours. (F, Su)

### ASTR 3440 Mentored Research Experience 3 Credit Hours

0 to 3 hours. Prerequisites: ENGL 1113 or equivalent, and permission of instructor. May be repeated; maximum credit 12 hours. For the inquisitive student to apply the scholarly processes of the discipline to a research or creative project under the mentorship of a faculty member. Student and instructor should complete an Undergraduate Research & Creative Projects (URCP) Mentoring Agreement and file it with the URCP office. Not for honors credit. (F, Sp, Su)

### ASTR 3960 Honors Reading 1-3 Credit Hours

1 to 3 hours. Prerequisite: Admission to Honors Program. May be repeated; maximum credit six hours. Consists of topics designated by the instructor in keeping with the student's major program. The topics will cover materials not usually presented in the regular courses. (F, Sp, Su)

- ASTR 3970 Honors Seminar 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Subjects covered vary. Deals with concepts not usually treated in regular courses. (Irreg.)
- ASTR 3980 Honors Research 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Provides an opportunity for the gifted Honors candidate to work at a special project in the student's field. (F, Sp, Su)
- ASTR 3990 Independent Study 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: one course in general area to be studied; permission of instructor and department. May be repeated; maximum credit six hours. Contracted independent study for topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (Sp, Su)
- ASTR G4303 Stellar Astrophysics 3 Credit Hours**  
Prerequisite: 3113 or permission of instructor. Physics of stars: gas and radiation laws, stellar atmospheres and spectra, stellar interiors and evolution. (F)
- ASTR 4523 Advanced Observatory Methods 3 Credit Hours**  
Prerequisite: 2513 and 3103. Techniques of multiwavelength observational astronomy. Includes time and coordinates, physics of astronomical ccds, telescopes, photometry, extinction correction, technical feasibility calculations, optical spectroscopy, and x-ray astronomy. Introductions to gamma-ray, infrared, UV radio astronomy. No student may earn credit for both 4523 and 5523. (Irreg.)
- ASTR 4960 Directed Readings 1-4 Credit Hours**  
1 to 4 hours. Prerequisite: good standing in University; permission of instructor and dean. May be repeated; maximum credit four hours. Designed for upper-division students who need opportunity to study a specific problem in greater depth than formal course content permits. (Irreg.)
- ASTR 4970 Special Topics/Seminar 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: Senior standing or permission of instructor. May be repeated; maximum credit nine hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)
- ASTR 4990 Independent Study 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: three courses in general area to be studied; permission of instructor and department. May be repeated; maximum credit six hours. Contracted independent study for topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (F, Sp, Su)
- ASTR 5403 High-Energy Astrophysics 3 Credit Hours**  
Prerequisite: 4303 or permission of instructor. High-energy radiation processes in astronomy: synchrotron radiation, bremsstrahlung, inverse Compton-effect. New wavebands of observation, UV, X-ray and gamma-ray astronomy. Radioastronomy: supernova remnants, pulsars, neutron stars. Radiogalaxies, active galactic nuclei, quasars. Theories of the origin of cosmic rays. (Irreg.)
- ASTR 5453 Extragalactic Astronomy and Cosmology 3 Credit Hours**  
Prerequisite: 3113 or 4303 or permission of instructor. Basic properties of stars. Review of observational tools for extragalactic work. Stellar content and interstellar medium in normal galaxies. Introduction to the theory of Big Bang cosmology. Comparison of observational data to cosmological predictions. The extragalactic distance scale and the age of the universe. Large scale structure: galaxy clusters and superclusters. Active galaxies -- radio galaxies and quasars. (Irreg.)
- ASTR 5463 Stellar Atmospheres 3 Credit Hours**  
Prerequisite: 4303 or permission of instructor. Local thermodynamic equilibrium. Radiative transfer, continuous absorption coefficient and model stellar atmospheres. Atomic and molecular spectroscopy and the quantitative analysis of stellar spectra. Atomic processes and departures from local thermodynamic equilibrium. Extended and expanding atmospheres, novae, supernovae. (Irreg.)
- ASTR 5473 Stellar Interiors 3 Credit Hours**  
Prerequisite: 4303 or permission of instructor. Evolution and energy balance of stars including gravitational attraction, nucleosynthesis, radiative and convective energy, transport and equilibrium, construction of stellar models for pre-main sequence and main sequence stars, and the theory of giants and white dwarfs. (Irreg.)
- ASTR 5513 Interstellar Medium 3 Credit Hours**  
4303 or permission. Processes in low-density media are explored, including the physics relevant to emission line objects such as HII and HI regions, molecular clouds, and active galaxies. Techniques for deriving chemical abundances are explored, as are interstellar absorption by gas and dust and radiation transfer. (Irreg.)
- ASTR 5523 Advanced Observatory Methods 3 Credit Hours**  
Prerequisite: 2513 and 3103. Techniques of multiwavelength observational astronomy. Includes time and coordinates, physics of astronomical ccds, telescopes, photometry, extinction correction, technical feasibility calculations, optical spectroscopy, and x-ray astronomy. Introductions to gamma-ray, infrared, UV radio astronomy. No student may earn credit for both 4523 and 5523. (Irreg.)
- ASTR 5900 Seminar in Astrophysics 3 Credit Hours**  
Prerequisite: permission of instructor. May be repeated with change of subject matter; maximum credit nine hours. A research seminar devoted to the study of specialized topics in astronomy and astrophysics. Topics selected will reflect the interest of the instructor and students. (Irreg.)
- ASTR 5960 Directed Readings 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: graduate standing and permission of department. May be repeated; maximum credit twelve hours. Directed readings and/or literature reviews under the direction of a faculty member. (F, Sp, Su)
- ASTR 5970 Special Topics/Seminar 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: Graduate standing or permission of instructor. May be repeated; maximum credit nine hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)
- ASTR 5990 Independent Study 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: Graduate standing and permission of instructor. May be repeated; maximum credit nine hours. Contracted independent study for a topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (Irreg.)
- PHYS 1114 General Physics for Non-Science Majors 4 Credit Hours**  
Prerequisite: high school algebra II. Not open to students who intend to do major work in mathematics or physical science. Concepts of force, energy, matter, atomic physics, electricity, light, presented as a part of a liberal education. A student may not receive credit for this course and PHYS 1205, PHYS 2414 or PHYS 2514. (F, Sp, Su) [II-NS].

- PHYS 1205 Introductory Physics I for Physics Majors 5 Credit Hours**  
Prerequisite: enrollment in Mathematics 1823 or 1914 or permission of instructor. To be taken by physics, astronomy and engineering physics majors during the first semester of their freshman year. Kinematics, dynamics, work and energy, many-particle systems, rigid body rotation, simple harmonic motion. Laboratory is an integral part of the course. Laboratory (F) [II-NSL].
- PHYS 1215 Introductory Physics II for Physics Majors 5 Credit Hours**  
Prerequisite: 1205 or permission of instructor. Electricity and magnetism: static fields and forces, circuits, electromagnetic induction. Thermodynamics: the First and Second Laws, temperature, heat, work and entropy. Laboratory is an integral part of the course. Laboratory (Sp)
- PHYS 1311 General Physics Lab I 1 Credit Hour**  
Prerequisite: Corequisite: 2414 or 2514. Experiments in basic law of mechanics and thermodynamics. (F, Sp, Su) [II-NSL].
- PHYS 1321 General Physics Lab II 1 Credit Hour**  
Prerequisite: Corequisite: 2424 or 2524. Experiments in basic laws of electricity, magnetism, and optics. (F, Sp, Su) [II-NSL].
- PHYS 1453 Musical Acoustics 3 Credit Hours**  
An introduction to the science of sound and its propagation with special emphasis on the production of sound by musical instruments and the voice, psychological aspects of sound perception, and room acoustics. Topics are explored through lectures, demonstrations, and discussions. No previous musical experience or proficiency is required. Not for major credit. (F) [II-NS].
- PHYS 2203 Introductory Physics III: Modern Physics 3 Credit Hours**  
Prerequisite: 1215 or 2524 (or concurrent enrollment), or permission of instructor. An introduction to and overview of key concepts in contemporary physics, with emphasis on the contrast between classical and modern ways of thinking about the physical universe. Includes an introduction to selected major subject areas, which might include light and optics, relativity, atoms and molecules, the solid state, nuclei, elementary particles, fundamental interactions, cosmology and/or chaos. Students will also explore selected topics in current physics research. (F)
- PHYS 2222 Computational Physics 2 Credit Hours**  
Prerequisite: MATH 2433 and PHYS 2203. Students will learn basic skills in programming in the context of solving physics problems. It is assumed that the student has no computer programming experience, and only modest understanding of physics. Through a variety of projects, the students are to obtain a deeper understanding of physical principles by implementing computer simulations. (Sp)
- PHYS 2303 Electronics 3 Credit Hours**  
Prerequisite: 1215 or 2524 (or concurrent enrollment), or permission of instructor. An introduction to the characteristics of semiconductor electronic components and their use in the design and operation of practical analog and digital electronic circuits. The emphasis will be on gaining a working knowledge of basic circuits and preparation for understanding and building electronic circuits encountered by experimental research physicists. (F)
- PHYS 2414 General Physics for Life Science Oriented Majors 4 Credit Hours**  
Prerequisite: Mathematics 1523 or 1743. Kinematics and dynamics of particles and rigid bodies, gravitation, equilibrium, momentum, energy, static and flowing fluids, kinetic theory, heat and thermodynamics, vibrations, waves and sound. A student may not receive credit for this course and PHYS 1205 or PHYS 2514. (F, Sp, Su) [II-NS].
- PHYS 2424 General Physics for Life Science Oriented Majors 4 Credit Hours**  
Prerequisite: PHYS 2414 or PHYS 2514. Electric charge, electric field, electric potential, energy, DC and AC currents, magnetic fields, electromagnetic induction, geometrical optics, wave nature of light, optical instruments, early quantum theory, models of the atom, the nucleus, radioactivity, nuclear reactions and nuclear energy. A student may not receive credit for this course and PHYS 1215 or PHYS 2524. (F, Sp, Su)
- PHYS 2514 General Physics for Engineering and Science Majors 4 Credit Hours**  
Prerequisite: MATH 1823 or MATH 1914 with grade of C or better. Vectors, kinematics and dynamics of particles, work and energy systems of particles, rotational kinematics and dynamics, oscillations, gravitation, fluid mechanics, waves. A student may not receive credit for this course and PHYS 1205. (F, Sp, Su) [II-NS].
- PHYS 2524 General Physics for Engineering and Science Majors 4 Credit Hours**  
Prerequisite: PHYS 2514 and MATH 2423 or MATH 2924 with grade of C or better. Temperature, heat, thermodynamics, electricity, magnetism, optics. A student may not receive credit for this course and PHYS 1215. (F, Sp, Su)
- PHYS 2970 Selected Topics in Physics 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: sophomore standing or permission of instructor. May be repeated; maximum credit six hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)
- PHYS 3043 Physical Mechanics I 3 Credit Hours**  
Prerequisite: 1205 or 2514, and Mathematics 3113 or 3413 (or concurrent enrollment); or permission of instructor. Differential equations based continuum mechanics: Newtonian particle mechanics, driven and damped oscillations, vibrations and waves, and their application to other linear systems, non-linear oscillations, introduction to Lagrange's equations. (Sp)
- PHYS 3053 Physical Mechanics II 3 Credit Hours**  
Prerequisite: 3043 or permission of instructor. Lagrangian and Hamiltonian dynamics. Non-inertial reference frames. Rigid body motion. Central forces and collisions. Special relativity. (F)
- PHYS 3183 Electricity and Magnetism I 3 Credit Hours**  
Prerequisite: 2203, Mathematics 3413 or concurrent enrollment; or permission of instructor. Electrostatics, dielectrics, continuity conditions, magnetic forces and fields, magnetic induction, magnetization, Maxwell's equations. (F)
- PHYS 3223 Modern Physics for Engineers 3 Credit Hours**  
Prerequisite: Mathematics 3113 or equivalent. Relativity, atomic structure, nuclear theory, wave mechanics, statistical physics, solid state physics. (F)
- PHYS 3302 Advanced Lab I 2 Credit Hours**  
Prerequisite: 2303 or permission of instructor. Junior-level experiments in physics. (F, Sp)
- PHYS 3312 Advanced Lab II 2 Credit Hours**  
Prerequisite: 3302 or permission of instructor. Junior-level experiments in physics. (F, Sp)

- PHYS 3440 Mentored Research Experience 3 Credit Hours**  
0 to 3 hours. Prerequisites: ENGL 1113 or equivalent, and permission of instructor. May be repeated; maximum credit 12 hours. For the inquisitive student to apply the scholarly processes of the discipline to a research or creative project under the mentorship of a faculty member. Student and instructor should complete an Undergraduate Research & Creative Projects (URCP) Mentoring Agreement and file it with the URCP office. Not for honors credit. (F, Sp, Su)
- PHYS 3803 Introduction to Quantum Mechanics I 3 Credit Hours**  
Prerequisite: PHYS 3043 and MATH 3413 or permission of instructor. Fundamental ideas of quantum physics. Postulates of quantum theory, wave functions, operators, the Schrodinger equation, one-dimensional systems. Mathematical tools of quantum mechanics. Theory of measurement. Stationary and nonstationary states. (Sp)
- PHYS 3960 Honors Reading 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Will consist of topics designated by the instructor in keeping with the student's major program. Covers materials not usually presented in the regular courses. (F, Sp, Su)
- PHYS 3970 Honors Seminar 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. The projects covered will vary. Deals with concepts not usually presented in regular coursework. (Su)
- PHYS 3980 Honors Research 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Provides an opportunity for the gifted Honors candidate to work at a special project in the student's field. (F, Sp, Su)
- PHYS 3990 Independent Study 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: one course in general area to be studied; permission of instructor and department. May be repeated; maximum credit six hours. Contracted independent study for topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (F, Sp, Su)
- PHYS G4153 Statistical Physics and Thermodynamics 3 Credit Hours**  
Prerequisite: 3803. Statistical properties of physical systems. Entropy and temperature, the Boltzmann distribution, Fermi-Dirac and Bose-Einstein gases. Thermodynamic functions. Statistical interpretation of thermodynamics. (F)
- PHYS G4183 Electricity and Magnetism II 3 Credit Hours**  
Prerequisite: 3183. Maxwell's equations, electromagnetic wave equations, propagation of electromagnetic waves, reflection and refraction, radiation. (Sp)
- PHYS 4213 Nuclear and Particle Physics 3 Credit Hours**  
(Slashlisted with 5213) Prerequisite: 3803. Basic nuclear structure, nuclear models, radioactivity, nuclear reactions. Particle interactions and families, quark model, weak decays of quarks and leptons. No student may earn credit for both 4213 and 5213. (F)
- PHYS 4223 Optics 3 Credit Hours**  
(Slashlisted with PHYS 5223) Prerequisite: Junior standing. Geometrical optics; optical systems; optical aberrations; electromagnetic optics; diffraction theory; Fourier optics; interference; optical coherence and statistical properties of light; advanced topics such as, e.g., lasers and fiber optics. No student may earn credit for both 4223 and 5223. (Irreg.)
- PHYS 4243 Solid State Physics 3 Credit Hours**  
(Slashlisted with 5243) Prerequisite: 3803. Crystal structure, electrons in simple metals, electron band theory, semiconductors, superconductivity, phonons. No student may earn credit for both 4243 and 5243. (Sp)
- PHYS 4300 Senior Research Project 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: senior standing in major and permission of instructor. May be repeated once. Research project, experimental or theoretical, to be arranged with individual faculty, leading to a senior thesis. Group seminars to discuss projects and other topics of current interest in physics and astronomy. Total of four hours required for general education capstone. (F, Sp) [V]
- PHYS 4310 Senior Research Project I 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: Senior standing or permission of instructor. Research project, experimental or theoretical, to be arranged with individual faculty, leading to a senior thesis. Group seminars to discuss projects and other topics of current interest in physics and astronomy. Total of four hours between PHYS 4310 and PHYS 4320 are required. (F, Sp) [V].
- PHYS 4320 Senior Research Project II 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: PHYS 4310. A continuation of the research project, experimental or theoretical, arranged with individual faculty, producing a senior thesis. Group seminars to discuss projects and other topics of current interest in physics and astronomy. Total of four hours between PHYS 4310 and PHYS 4320 are required. (F, Sp) [V].
- PHYS G4803 Introduction to Quantum Mechanics II 3 Credit Hours**  
Prerequisite: 3803 or permission of instructor. Quantum mechanics of three-dimensional systems. Angular momentum. Approximation methods: perturbation theory, variational methods. Time-dependent perturbations: transition rates, selection rules. Interaction of radiation with matter. Applications. Quantum mechanics of atoms and molecules. (F)
- PHYS 4813 Atomic Physics 3 Credit Hours**  
(Slashlisted with PHYS 5813) Prerequisite: PHYS 4803. Hydrogen atom: fine structure, hyperfine structure, and external field effects; helium and many-electron atoms; two-level atom: rotating wave approximation, Rabi oscillation, and Bloch sphere; atom interferometry; broadening mechanisms; saturation spectroscopy; photon echoes. No student may earn credit for both 4813 and 5813. (Sp)
- PHYS 4960 Directed Readings 1-4 Credit Hours**  
1 to 4 hours. Prerequisite: good standing in University; permission of instructor and dean. May be repeated; maximum credit four hours. Designed for upper-division students who need opportunity to study a specific problem in greater depth than formal course content permits. (Irreg.)
- PHYS 4970 Seminar-Selected Topics in Physics 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: permission of instructor. May be repeated with change of subject; maximum credit six hours. (Irreg.)
- PHYS 4990 Independent Study 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: three courses in general area to be studied, permission of instructor and department. May be repeated; maximum credit six hours. Contracted independent study for topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (F, Sp, Su)
- PHYS 5000 Introduction to Graduate Studies in Physics 0 Credit Hours**  
Prerequisite: Graduate standing. The course is an introduction to research in general as well as specific research done within the department. It will familiarize students with departmental procedures, improve their teaching of Physics, and convey the expectations and demands of a career in Physics or Astronomy. (F)

- PHYS 5013 Mathematical Methods in Physics 3 Credit Hours**  
Prerequisite: graduate standing. Orthogonal transformations and tensor analysis; partial differential equations and special functions; Green's functions; perturbation theory; calculus of variations; theory of complex variables; integral definition of special functions. (F)
- PHYS 5153 Classical Mechanics 3 Credit Hours**  
Prerequisite: PHYS 3053 or equivalent. Hamilton's principle, Lagrange's equations, mechanics of particles and rigid bodies, Hamilton's equations, canonical transformations, Poisson brackets, action-angle variables. (F)
- PHYS 5163 Statistical Mechanics 3 Credit Hours**  
Prerequisite: PHYS 4153 or equivalent. Classical and quantum statistical mechanics, fluctuations, thermodynamics, ideal gases, phase equilibrium and transitions, Bose-Einstein and Fermi-Dirac statistics, blackbody radiation, Einstein-Debye model, electrons in metals, critical exponents, spin models. (Sp)
- PHYS 5213 Nuclear and Particle Physics 3 Credit Hours**  
(Slashlisted with 4213) Prerequisite: 4803; graduate standing. Basic nuclear structure, nuclear models, radioactivity, nuclear reactions. Particle interactions and families, quark model, weak decays of quarks and leptons. No student may earn credit for both 4213 and 5213. (F)
- PHYS 5223 Optics 3 Credit Hours**  
(Slashlisted with PHYS 4223) Prerequisite: Graduate standing. Geometrical optics; optical systems; optical aberrations; electromagnetic optics; diffraction theory; Fourier optics; interference; optical coherence and statistical properties of light; advanced topics such as, e.g., lasers and fiber optics. No student may earn credit for both 4223 and 5223. (Irreg.)
- PHYS 5243 Solid State Physics 3 Credit Hours**  
(Slashlisted with 4243) Prerequisite: 4803; graduate standing. Crystal structure, electrons in simple metals, electron band theory, semiconductors, superconductivity, phonons. No student may earn credit for both 4243 and 5243. (Sp)
- PHYS 5293 Electronic, Optical and Magnetic Properties of Materials 3 Credit Hours**  
Prerequisite: Graduate standing and permission of instructor. This course surveys the electronic, optical and magnetic properties of materials and how these properties can be designed for specific applications. Topics include: forces, energies and timescales in condensed matter, electrons in crystalline semiconductors, electromagnetic waves in matter, optical and transport properties of polymers and small molecules, origins of magnetization in materials, structural and magnetic order/disorder phase transitions. (Irreg.)
- PHYS 5393 Quantum Mechanics I 3 Credit Hours**  
Prerequisite: PHYS 4803 or equivalent. Topics in nonrelativistic quantum mechanics including the Heisenberg and Schrodinger pictures, Dirac formalism, angular momentum, bound states of spherically symmetric potentials, spin and angular momentum coupling, density matrix, 1d potential scattering. (Sp)
- PHYS 5403 Quantum Mechanics II 3 Credit Hours**  
Prerequisite: PHYS 5393. Time-independent perturbation theory, time-dependent perturbation theory, electromagnetic interactions, potential scattering, symmetry and statistics, multiparticle systems, relativistic quantum mechanics including Klein-Gordon and Dirac equation. (F)
- PHYS 5573 Electrodynamics I 3 Credit Hours**  
Prerequisite: PHYS 4183 or equivalent. Electrostatics; Poisson equation; solution via Green's functions; ponderable media; magnetism and Ampere's law; Faraday's law; Maxwell equations, solution via potentials; gauge fixing; advanced and retarded Green's functions; causality. (Sp)
- PHYS 5583 Electrodynamics II 3 Credit Hours**  
Prerequisite: PHYS 5573. Electromagnetic waves and radiation; scattering and diffraction; special relativity and relativistic electrodynamics; radiation by moving charges. (F)
- PHYS 5813 Atomic Physics 3 Credit Hours**  
(Slashlisted with PHYS 4813) Prerequisite: Graduate standing and PHYS 4803. Hydrogen atom: fine structure, hyperfine structure, and external field effects; helium and many-electron atoms; two-level atom: rotating wave approximation, Rabi oscillation, and Bloch sphere; atom interferometry; broadening mechanisms; saturation spectroscopy; photon echoes. No student may earn credit for both 4813 and 5813. (Sp)
- PHYS 5910 Problems in Natural Science 1-2 Credit Hours**  
1 to 2 hours. Prerequisite: admission to candidacy for degree of Master of Natural Science. (F, Sp, Su)
- PHYS 5960 Directed Readings 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: graduate standing and permission of department. May be repeated; maximum credit twelve hours. Directed readings and/or literature reviews under the direction of a faculty member. (F, Sp, Su)
- PHYS 5970 Seminar--Selected Topics in Modern Physics 1-3 Credit Hours**  
1 to 3 hours. Prerequisite: permission. May be repeated with change of subject matter; maximum credit for master's degree six hours, for doctor's degree 12 hours. (F, Sp, Su)
- PHYS 5980 Research for Master's Thesis 2-9 Credit Hours**  
Variable enrollment, two to nine hours; maximum credit applicable toward degree, four hours. (F, Sp, Su)
- PHYS 5990 Special Studies 1-4 Credit Hours**  
Prerequisite: 12 hours of physics, permission. May be repeated with change of subject matter; maximum credit for a master's degree four hours, for a doctor's degree ten hours. (F, Sp, Su)
- PHYS 6213 Advanced Particle Physics 3 Credit Hours**  
Prerequisite: 5213, 5403 or equivalents. The theory and phenomenology of the "standard model" of particle physics which encompasses the electro-weak and strong interactions. Topics will include: symmetries, groups and conservation laws; bound states, quarkonium; Feynman diagrams, QED; QCD; weak interactions; gauge theories. (Irreg.)
- PHYS 6243 Advanced Solid State Physics 3 Credit Hours**  
Prerequisite: 4243, 5403, or equivalents. The physics of metals, semiconductors and insulators. Free electron theory, crystal structure and phonons, electron band theory, semiclassical model, applications to electronic and optical properties of solids, effects of magnetic fields. (Irreg.)
- PHYS 6283 Advanced Atomic/Molecular Physics 3 Credit Hours**  
Prerequisite: Graduate standing and PHYS 5403 (QMII), PHYS 5813 (AMOI), or equivalent. Beyond the two-level atom approximation: effects such as lambda system, STIRAP, dark states, and slow light; Doppler-free spectroscopy; optical pumping; collective atomic effects; laser cooling; Bose-Einstein condensates; electronic wave functions of atoms and molecules: variational principle, Hartee-Fock, and configuration interaction; molecular interaction potentials; interaction of light and molecules. (Irreg.)
- PHYS 6333 General Relativity 3 Credit Hours**  
Prerequisite: 5013, 5583. The mathematical and physical basis for the relativistic theory of gravitation; the principle of equivalence; tensor analysis; Einstein's field equations; tests of general relativity; gravitational collapse; cosmology; toward a quantum theory of gravity. (Irreg.)

**PHYS 6433 Quantum Field Theory 3 Credit Hours**

Prerequisite: 5403. Canonical quantization of scalar and spinor fields; perturbation theory and Feynman diagrams; renormalization; path integral formulation; renormalization group; gauge fields with selected applications to QED, electro-weak theory and QCD. (Irreg.)

**PHYS 6443 Advanced Quantum Field Theory 3 Credit Hours**

Prerequisite: graduate standing and 6433. Path integral quantization; renormalization; renormalization group equations; gauge theories of strong and electroweak interactions. (F)

**PHYS 6543 Advanced Quantum Optics 3 Credit Hours**

Prerequisite: Graduate standing, PHYS 5393, PHYS 5403, PHYS 5573, and PHYS 5813, or equivalent; Recommended - PHYS 5223. This course introduces students to advanced topics in quantum optics, with reference to both historic and current state-of-the-art developments. Students will be introduced to core concepts such as quantum noise, phase-space, atom-light interactions, entanglement, and open systems. Students will learn how to apply these theoretical concepts to experimental systems that study the generation and manipulation of quantum states of light. (Irreg.)

**PHYS 6663 Non-Relativistic Many Body Theory 3 Credit Hours**

Prerequisite: Graduate standing, PHYS 5393 (QMI), PHYS 5403 (QMII), PHYS 5573 (EMI), PHYS 5153 (Class Mech), and PHYS 5163 (Stat Mech), or equivalent. This course introduces students to several many-body treatments and illustrates the techniques on a variety of examples, focusing on applications of historical importance and recent modern developments. The course focuses on non-relativistic (as opposed to relativistic) quantum many-body techniques and applications. Students will be introduced to mean-field theory, Green's functions, broken symmetries and transformations, path integrals, and diagrammatic techniques. (Irreg.)

**PHYS 6860 Advanced Topics in Mathematical Methods in Physics 1-3 Credit Hours**

1 to 3 hours. Prerequisite: 5013 or permission. May be repeated with change of content; maximum credit nine hours. Topics covered will be selected by instructor and announced prior to the term in which it will be offered. The course is intended to offer material currently used in theoretical physics. (Irreg.)

**PHYS 6960 Directed Readings 1-3 Credit Hours**

1 to 3 hours. Prerequisite: graduate standing or permission of instructor. May be repeated; maximum credit six hours. Directed readings and/or literature review under the direction of a faculty member. (Irreg.)

**PHYS 6970 Special Topics/Seminar 1-3 Credit Hours**

1 to 3 hours. Prerequisite: graduate standing or permission of instructor. May be repeated; maximum credit 12 hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or research and field projects. (Irreg.)

**PHYS 6980 Research for Doctoral Dissertation 2-16 Credit Hours**

2 to 16 hours. Prerequisite: Graduate standing and permission of instructor; may be repeated. Directed research culminating in the completion of the doctoral dissertation. (F, Sp, Su)

**PHYS 6990 Independent Study 1-3 Credit Hours**

1 to 3 hours. Prerequisite: Graduate standing and permission of instructor. May be repeated; maximum credit nine hours. Contracted independent study for a topic not currently offered in regularly scheduled courses. Independent study may include library and/or laboratory research and field projects. (Irreg.)

## Faculty

Last Name	First/Middle Name	Middle init.	OU Service start	Title(s), date(s) appointed	Degrees Earned, Schools, Dates Completed
Abbott	Braden	K	2000	PROFESSOR OF PHYSICS AND ASTRONOMY, 2013	PhD, Purdue, 1994; MS, Purdue, 1992; BA, Univ of Minnesota Morris, 1989
Abraham	Eric	R	1998	ASSOCIATE PROFESSOR OF PHYSICS AND ASTRONOMY, 2004; L.J. SEMROD PRESIDENTIAL PROFESSOR, 2005; ASSOCIATE PROFESSOR ENGINEERING PHYSICS	PhD, Rice Univ, 1996; BA, St. Olaf College, 1991
Baer	Howard	A	2008	HOMER L. DODGE CHAIR IN HIGH ENERGY PHYSICS, 2008; GEORGE LYNN CROSS RESEARCH PROFESSOR OF PHYSICS AND ASTRONOMY, 2014	PhD, Univ of Wisconsin, 1984; MS, Univ of Wisconsin, 1981; BS, Univ of Wisconsin, 1979
Baron	Edward	A	1990	GEORGE LYNN CROSS RESEARCH PROFESSOR OF PHYSICS AND ASTRONOMY, 2011	PhD, Stony Brook Univ; 1985; MA, Stony Brook Univ, 1982; BA, Univ of Pennsylvania, 1980
Biederman	Grant			ASSOCIATE PROFESSOR OF PHYSICS	PhD, Stanford Univ, 2007; MS, Yale Univ, 2002; BS, Univ of Oklahoma, 2001
Blume	Doerte		2017	PROFESSOR OF PHYSICS AND ASTRONOMY, 2017	PhD, Georg-August Univ, 1998; BS, Georg-August Univ, 1995
Bumm	Lloyd	A	2001	ASSOCIATE PROFESSOR OF PHYSICS AND ASTRONOMY, 2007; ASSOCIATE PROFESSOR ENGINEERING PHYSICS	PhD, Northwestern Univ, 1991; BS, Clarkson Univ, 1982
Dai	Xinyu		2011	ASSOCIATE PROFESSOR OF PHYSICS AND ASTRONOMY, 2017	PhD, Penn State Univ, 2004; BS, Peking Univ, 1998
Gutierrez	Phillip		1989	PROFESSOR OF PHYSICS AND ASTRONOMY, 2001; PROFESSOR ENGINEERING PHYSICS	PhD, Univ of California Riverside, 1983; MS, Univ of California Riverside, 1980; BS, Univ of California Riverside, 1976
Kaib	Nathan		2015	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2015	PhD, Univ of Washington, 2010; BS, Case Western Reserve Univ, 2002
Kao	Chung		2000	PROFESSOR OF PHYSICS AND ASTRONOMY, 2013	PhD, Univ of Texas, 1990; MS, Univ of Oregon, 1985; BS, National Taiwan Norman Univ, 1980

Kilic	Mukremin		2011	ASSOCIATE PROFESSOR OF PHYSICS AND ASTRONOMY, 2017	PhD, Univ of Texas, 2006; BS, Bogazici Univ, 1999	Sinha	Kuver		2017	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2017;	PhD, Rutgers Univ, 2008
Leighly	Karen	M	2000	PROFESSOR OF PHYSICS AND ASTRONOMY, 2013	PhD, Montana State Univ, 1991; MS, Montana State Univ, 1987; BS, New Mexico Inst Mining & Tech, 1983					CARL T. BUSH PROFESSOR OF THEORETICAL PHYSICS, 2017	
Marino Valle	Alberto		2012	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2012; ASSISTANT PROFESSOR ENGINEERING PHYSICS	PhD, Univ of Rochester, 2006; MS, Univ of Rochester, 2002; BS, Universidad de Monterrey, 1998	Strauss	Michael	G	1995	CARLISLE AND LURLINE MABREY PRESIDENTIAL PROFESSOR, 2006; DAVID ROSS BOYD PROFESSOR OF PHYSICS AND ASTRONOMY, 2012; PROFESSOR ENGINEERING PHYSICS	PhD, Univ of California Los Angeles, 1988; MS, Univ of California Los Angeles, 1983; BS, Biola Univ, 1981
Mason	Bruce	A	1989	ASSOCIATE PROFESSOR OF PHYSICS AND ASTRONOMY, 1995	PhD, Univ of Maryland, 1985; MS, Univ of Maryland, BA, Oberlin College, 1980	Stupak	John		2016	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2016; ASSISTANT PROFESSOR ENGINEERING PHYSICS	PhD, SUNY at Stonybrook, 2012; BS, Fairfield Univ, 2007
Mullen	Kieran	J	1994	PROFESSOR OF PHYSICS AND ASTRONOMY, 2007; PRESIDENT'S ASSOCIATES PRESIDENTIAL PROFESSOR, 2009	PhD, Univ of Michigan, 1989; BS, Georgetown Univ, 1982						
Munshi	Ferah	A	2017	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2017	PhD, Univ of Washington, 2013; MS, Univ of Washington, 2010; BA, Univ of California Berkeley, 2007	Uchoa	Bruno			ASSOCIATE PROFESSOR OF PHYSICS; TED AND CUBA WEBB PRESIDENTIAL PROFESSOR	PhD, State Univ of Campinas, 2004; BS, State Univ of Campinas, 1997
Santos	Michael	B	1993	SAMUEL ROBERTS NOBLE PRESIDENTIAL PROFESSOR, 1997; TED AND CUBA WEBB PRESIDENTIAL PROFESSOR, 2003; PROFESSOR OF PHYSICS AND ASTRONOMY, 2004; CHARLES L. BLACKBURN CHAIR IN ENGINEERING PHYSICS, 2006	PhD, Princeton Univ, 1992; MA, Princeton Univ, 1989; BS, Cornell Univ, 1986	White	Daniel	R	2018	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2018	PhD, Ohio State Univ, 2016; BS, Univ of Oklahoma, 2008
Schwettmann	Arne		2014	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2014; ASSISTANT PROFESSOR ENGINEERING PHYSICS	PhD, Univ of Oklahoma, 2012; MS, Univ of North Texas, 2003; BS, Universität Hannover, 2001	Wisniewski	John	P	2012	ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, 2012; PRESIDENT'S ASSOCIATES PRESIDENTIAL PROFESSOR, 2016	PhD, Univ of Toledo, 2005; MS, Univ of Toledo, 2002; BS, Univ of Wisconsin, 1999
Sellers	Ian	R	2011	ASSOCIATE PROFESSOR OF PHYSICS AND ASTRONOMY, 2017	PhD, Univ of Sheffield, 2004; MS, Imperial College London, 2000; B Eng, Univ of Liverpool, 1999						