

Physics and Astronomy (PHAS)

Faculty

Professors: Sally Koutsoliotas, Edwin F. Ladd, Thomas H. Solomon, Katharina Vollmayr-Lee

Associate Professors: Katelyn Allers, Jiajia Dong, Jack F. Gallimore, Martin K. Ligare, David C. Schoepf, Michele D. Thornley (Chair), Brian C. Utter, Benjamin P. Vollmayr-Lee

Assistant Professors: A. Matthew Amthor, Deepak Iyer, Ibrahim A. Sulai

Physics is the fundamental science of the natural world. The study of physics and astronomy leads to a deeper appreciation and awareness of the world around us. From the quantum mechanical behavior at the smallest scale to the workings of the cosmos at the largest scale, physics consists of a few general principles that explain a vast range of phenomena. Coursework in physics leads to an understanding of these phenomena and gives students experience in abstract mathematical modeling as well as experimental and computational techniques. As a means to enhance the physics curriculum, research opportunities in astronomy and physics also are available and strongly encouraged.

A physics major is an appropriate first step on the path to a career as a research scientist. Since physics is such a fundamental science, it can be the basis for the understanding of principles that are relevant to a wide variety of fields. It provides preparation for graduate study in physics or in related fields such as astrophysics, biophysics, medical physics, chemical physics, geophysics, or engineering. A fundamental understanding of nature has been a goal throughout history, and a study of physics can be the focus of a liberal education because of its connections with intellectual history and philosophy. A major in physics can be the platform for pursuing a wide variety of careers including medicine, law, business, and teaching.

A major in physics may be pursued under the Bachelor of Arts or Bachelor of Science degree programs, either of which can provide adequate preparation for graduate study. Students in the Bachelor of Arts program who plan to attend graduate school in physics or astronomy should consult with their advisers to select an appropriate set of electives. The standard entry point for either degree program is the year-long introductory sequence PHYS 211-PHYS 212 Classical and Modern Physics II.

Modern astrophysics involves the application of physics toward understanding the workings of the universe. Students interested in an introductory survey are encouraged to enroll in ASTR 101 Our Solar System or ASTR 102 Stars, Galaxies, and Beyond. The department also offers an astrophysics concentration as an option in the Bachelor of Science degree program, so that interested students may obtain a strong grounding in fundamental physics along with specialized coursework in astrophysics. This concentration is primarily designed for students considering advanced study in astrophysics or careers in astronomy and related fields.

The Department of Physics and Astronomy encourages students to participate in research projects; research serves as an important complement to the classroom study of physics and astronomy. The department offers research opportunities in atomic and molecular physics, chaos and nonlinear dynamics, astronomy and astrophysics, theoretical quantum optics, laser spectroscopy, nuclear physics, positron physics, biological physics, condensed matter theory and computer simulation, and statistical physics.

Bachelor of Arts in Physics

A **Bachelor of Arts major** in physics consists of:

PHYS 211	Classical and Modern Physics I	1
PHYS 212	Classical and Modern Physics II	1
or PHYS 212E	Classical and Modern Physics II	
PHYS 221	Classical Mechanics	1
PHYS 222	Wave Mechanics and Quantum Physics	1
PHYS 310	Experimental Physics	1

A minimum of three other 200 or 300-level physics courses, two of which must be at the 300-level.

One of the 300-level courses must be one of the following: 1

PHYS 317	Thermodynamics and Statistical Mechanics	
PHYS 331	Advanced Classical Mechanics	
PHYS 332	Quantum Mechanics	
PHYS 333	Electromagnetic Theory I	

Other courses may include:

ASTR 201	Observational Astrophysics	1
ASTR 301	Astrophysics	1

Bachelor of Science in Physics

A **Bachelor of Science major** in physics consists of:

PHYS 211	Classical and Modern Physics I	1
PHYS 212	Classical and Modern Physics II	1
or PHYS 212E	Classical and Modern Physics II	
PHYS 221	Classical Mechanics	1
PHYS 222	Wave Mechanics and Quantum Physics	1
PHYS 235	Applied Electronics	1
PHYS 310	Experimental Physics	1
PHYS 317	Thermodynamics and Statistical Mechanics	1
PHYS 331	Advanced Classical Mechanics	1
PHYS 332	Quantum Mechanics	1
PHYS 333	Electromagnetic Theory I	1
A minimum of two other 300-level physics credits ¹		
MATH 212	Differential Equations	1
MATH 245	Linear Algebra	1
200 or 300-level biology, chemistry, or geology course		

¹ These courses may include ASTR 301 Astrophysics.

Bachelor of Science in Physics with a Concentration in Astrophysics

A **Bachelor of Science major in physics with a concentration in astrophysics** consists of:

PHYS 211	Classical and Modern Physics I	1
PHYS 212	Classical and Modern Physics II	1
or PHYS 212E	Classical and Modern Physics II	
PHYS 221	Classical Mechanics	1
PHYS 222	Wave Mechanics and Quantum Physics	1
ASTR 201	Observational Astrophysics	1
PHYS 310	Experimental Physics	1
PHYS 317	Thermodynamics and Statistical Mechanics	1
PHYS 331	Advanced Classical Mechanics	1
PHYS 332	Quantum Mechanics	1
PHYS 333	Electromagnetic Theory I	1
ASTR 301	Astrophysics	1
A minimum of one other 300-level physics credit		
MATH 212	Differential Equations	1
MATH 245	Linear Algebra	1
200 or 300-level biology, chemistry, or geology course		

In addition to the required coursework, students pursuing a concentration in astrophysics will be advised to participate in one or more on- or off-campus research experiences in astronomy or astrophysics; such opportunities are frequently offered by department faculty as well as through a number of research programs for undergraduates which are hosted at observatories, research institutes, and other universities across the country.

The recommended course sequence for students pursuing the Bachelor of Science physics major is the following:

First Year

First Semester	Credits	Second Semester	Credits
PHYS 211		1 PHYS 212	1
MATH 201		1 MATH 202	1
	2		2

Sophomore

First Semester	Credits	Second Semester	Credits
PHYS 221		1 PHYS 222	1
MATH 211		1 PHYS 235	1
		MATH 212	1
		2	3

Junior

First Semester	Credits	Second Semester	Credits
PHYS 332		1 PHYS 310	1
PHYS 333		1 Elective(s) in physics	
MATH 245		1	
		3	1

Senior

First Semester	Credits	Second Semester	Credits
PHYS 331		1 Elective(s) in physics	
PHYS 317		1	
Elective in science			
		2	0

Total Credits: 15

Additional Notes

A physics major leading to the Bachelor of Arts degree also is available in combination with a Bachelor of Science in engineering in a five-year program.

Courses in both of our degree programs are designed to provide students with many opportunities to practice and develop their writing, speaking, and information literacy skills, consistent with the learning objectives of the College Core Curriculum.

Students in our department also satisfy the Culminating Experience component of the College Core Curriculum by taking PHYS 310 Experimental Physics, a required course for both B.S. and B.A. majors. In this course students perform substantial multi-week experiments that explore concepts that they have learned throughout the major, including classical mechanics, wave phenomena, electricity and magnetism, quantum physics, thermodynamics, computer simulation, and astronomy. This course also stresses other learning objectives through writing of research papers and weekly oral presentations.

Honors in physics is given to those students who are accepted by the University Honors Council and successfully complete and defend an honors thesis in physics.

Study abroad is possible for students completing either a Bachelor of Arts or Bachelor of Science degree. Such study should be discussed well in advance with the academic adviser and the chair of the Department of Physics and Astronomy.

Students wishing to become certified as secondary school physics teachers should consult with the Department of Education and the chair of the Department of Physics and Astronomy to arrange a plan of study that ensures that all of the requirements for certification will be met.

Minor in Physics

A **minor** in physics consists of four 200- or 300-level physics courses, which may include ASTR 201 Observational Astrophysics. Advanced placement credit does not count toward the minor.

Majors in Physics (B.A. and B.S) will:

- Be able to solve quantitative problems that require an understanding of the fundamental principles in each of the major areas of physics. Show a working knowledge of how a broad array of physical phenomena can be explained using these fundamental concepts.
- Exhibit a proficiency in the methods of scientific inquiry in laboratory and/or research projects.
- Use critical thinking skills to formulate and solve quantitative problems.
- Present well-organized, logical and scientifically sound oral and written scientific reports.
- Understand the variety of career paths and opportunities that are open to students who have majored in physics and/or astronomy.

Non-majors in Physics (meeting lab-science requirements) will:

- Demonstrate an understanding of fundamental concepts in a field of physics and/or astronomy.
- Develop an appreciation for the methods of scientific inquiry through laboratory experiences.

- Demonstrate the critical thinking and problem solving skills required in scientific disciplines.

Astronomy Courses

ASTR 101. Our Solar System. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Lab:3

An introduction to astronomy concentrating on our evolving understanding of the solar system. Designed for non-science majors. No prerequisite.

ASTR 102. Stars, Galaxies, and Beyond. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Lab:3

An introduction to astronomy concentrating on the structure of our universe beyond the solar system. Designed for non-science majors. ASTR 101 is not a prerequisite for ASTR 102.

ASTR 201. Observational Astrophysics. 1 Credit.

Offered Alternating Spring Semester; Lecture hours:2,Other:2

This course covers spherical astronomy and observational techniques, and applications of physics to solar system objects, stars, stellar evolution, galaxies, and cosmology. Some night observing required. Laboratories focus on observational techniques and data reduction. Prerequisite: PHYS 212 or PHYS 212E.

ASTR 301. Astrophysics. 1 Credit.

Offered Alternating Spring Semester; Lecture hours:3

An introduction to general astrophysics covering mechanics of orbiting bodies, radiation laws, stellar spectra, stellar atmospheres, the internal constitution of stars, stellar energy, galaxies, and cosmology. Prerequisites: PHYS 222 and MATH 212 and permission of the instructor. Crosslisted as PHYS 301.

ASTR 337. Contemporary Problems in Astronomy/Astrophysics. .5-1 Credits.

Offered Both Fall and Spring; Lecture hours:Varies,Other:Varies; Repeatable

Seminar or independent study in areas of current interest in the astronomy/astrophysics community. Prerequisite: permission of the instructor.

ASTR 350. Undergraduate Research. .5-1 Credits.

Offered Both Fall and Spring; Lecture hours:Varies,Other:Varies; Repeatable

Undergraduate research in astronomy/astrophysics. Prerequisite: permission of the instructor.

Physics Courses

PHYS 141. Secrets of the Universe. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Other:3

The great ideas of 20th-century physics (symmetry principles, relativity, and quantum mechanics) and their application to cosmology and the evolution of the universe. Also, historical development and philosophical implications of these ideas. Designed for non-science majors. No prerequisite. Not open to students who have successfully completed a 200-level physics course.

PHYS 142. Light and Vision. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Other:3

Particle and wave theories of light, cameras and optical instruments, the visual process, lasers, and optical communications. Designed for non-science majors. No prerequisite. Not open to students who have successfully completed a 200-level physics course.

PHYS 144. How Things Work. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Other:3

This course introduces the ideas of physics in the context of everyday phenomena, including common inventions and topics in medicine, sports, and music. Designed for non-science majors. No prerequisite. Not open to students who have successfully completed a 200-level physics course.

PHYS 147. Energy and Sustainability. 1 Credit.

Offered Either Fall or Spring; Lecture hours:3,Other:3

Examination of energy, its transformations, its effects on resource depletion, and environmental degradation. Models of sustainability for transportation, architecture, waste management, and personal lifestyle choices. Designed for non-science majors. No prerequisite. Not open to students who have successfully completed a 200-level physics course.

PHYS 211. Classical and Modern Physics I. 1 Credit.

Offered Fall Semester Only; Lecture hours:2,Other:5

The first course in a two-course sequence that surveys major areas of physics. Topics include Newtonian mechanics, relativity, thermodynamics and statistical mechanics, and gravity. Corequisite: MATH 201.

PHYS 212. Classical and Modern Physics II. 1 Credit.

Offered Spring Semester Only; Lecture hours:2,Other:5

The second course in a two-course sequence that surveys major areas of physics. Topics include electricity and magnetism, light and waves, quantum mechanics, and particle physics. Prerequisite: PHYS 211 or permission of the instructor. Corequisite: MATH 202 or another mathematics course numbered above MATH 202.

PHYS 212E. Classical and Modern Physics II. 1 Credit.**Offered Spring Semester Only; Lecture hours:4,Lab:3**

Same topics as PHYS 212 with more emphasis on mathematical modeling, computer applications and extensions of the theory. This course is intended for students with a strong background in mathematics and physics. Prerequisite: PHYS 211 or permission of the instructor. Corequisite: MATH 202 or another mathematics course above 202.

PHYS 221. Classical Mechanics. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Lab:3**

Newtonian mechanics including conservation laws, rotational dynamics, forced damped harmonic motion, and coupled oscillations. Prerequisites: PHYS 211 and MATH 202.

PHYS 222. Wave Mechanics and Quantum Physics. 1 Credit.**Offered Spring Semester Only; Lecture hours:4**

Physics of coupled oscillations and waves, including classical wave equation. Wave-particle duality; origin and elementary applications of quantum mechanics; the Schrodinger wave equation; atomic and nuclear physics. Prerequisites: PHYS 212 (or PHYS 212E) and MATH 211.

PHYS 235. Applied Electronics. 1 Credit.**Offered Spring Semester Only; Lecture hours:2,Lab:4**

Circuit fundamentals, linear and digital integrated circuits, transducers, analog to digital conversion, filtering, Fourier methods, microcomputers, and computer interfacing. Designed for science and computer science majors. Prerequisite: PHYS 212 (or PHYS 212E). Open to electrical engineering students by permission only.

PHYS 301. Astrophysics. 1 Credit.**Offered Alternating Spring Semester; Lecture hours:3**

An introduction to general astrophysics covering mechanics of orbiting bodies, radiation laws, stellar spectra, stellar atmospheres, the internal constitution of stars, stellar energy, galaxies, and cosmology. Prerequisites: PHYS 222 and MATH 212. Crosslisted as ASTR 301.

PHYS 303. Modern Optics. 1 Credit.**Offered Spring Semester Only; Lecture hours:3**

Geometrical optics, interference and diffraction, quantum optics, optical properties of matter, lasers and holography. Prerequisite: PHYS 222 or permission of the instructor.

PHYS 309. Condensed Matter Physics. 1 Credit.**Offered Spring Semester Only; Lecture hours:3**

Crystal structure, phonons, free electron theory of metals, band theory, semi-conductors, magnetism, superconductivity and superfluidity, liquid crystals and other special topics. Prerequisite: PHYS 222 or permission of the instructor.

PHYS 310. Experimental Physics. 1 Credit.**Offered Spring Semester Only; Lecture hours:1,Other:5**

Methods and techniques used in experimental and computational physics, including data analysis and numerical methods, use of standard research equipment, and documentation of laboratory work emphasizing written and oral communication of scientific results. Prerequisite: PHYS 222 or permission of the instructor.

PHYS 317. Thermodynamics and Statistical Mechanics. 1 Credit.**Offered Fall Semester Only; Lecture hours:3**

The laws of thermodynamics, thermodynamic functions, kinetic theory of gases, statistical mechanics. Prerequisites: PHYS 212 (or PHYS 212E) and either PHYS 221 or PHYS 222, or permission of the instructor.

PHYS 331. Advanced Classical Mechanics. 1 Credit.**Offered Fall Semester Only; Lecture hours:3**

Kinematics and dynamics of particles, systems, and rigid bodies. Hamilton's principles, Lagrange's equations, theory of small vibrations, orbital mechanics, accelerated frames, and nonlinear dynamics. Prerequisites: PHYS 221 and MATH 212, or permission of the instructor.

PHYS 332. Quantum Mechanics. 1 Credit.**Offered Fall Semester Only; Lecture hours:3**

Basic postulates and applications, perturbation theory, angular momentum, scattering theory, relativistic effects. Prerequisites: PHYS 221, PHYS 222 and MATH 211, or permission of the instructor.

PHYS 333. Electromagnetic Theory I. 1 Credit.**Offered Fall Semester Only; Lecture hours:3**

Classical electromagnetic theory, including scalar and vector potentials, electrostatics, magnetostatics, time-dependent fields, and culminating with Maxwell's equations. Prerequisites: PHYS 212 (or PHYS 212E) and MATH 211.

PHYS 334. Electromagnetic Theory II. 1 Credit.**Offered Alternating Spring Semester; Lecture hours:3**

Continuation of PHYS 333. Electromagnetic waves, radiation theory, theory of relativity, and elements of plasma physics. Prerequisite: PHYS 333.

PHYS 336. Mathematical Methods in Physics. 1 Credit.

Offered Spring Semester Only; Lecture hours:3

Topics will include two or three of the following: complex variables, special functions, tensor analysis, group theory, partial differential equations.

Prerequisites: PHYS 221 and PHYS 222, MATH 212 and MATH 245, or permission of the instructor. Crosslisted as PHYS 636.

PHYS 337. Contemporary Study in Physics. .5-1 Credits.

Offered Either Fall or Spring; Lecture hours:Varies; Repeatable

Independent study in areas of current interest in the physics and astronomy community. Prerequisites: permission of the department and permission of the instructor. Crosslisted as PHYS 637.

PHYS 338. Contemporary Study in Physics. 1 Credit.

Offered Occasionally; Lecture hours:3; Repeatable

Seminar in topics of current interest in the physics and astronomy community. Co- and prerequisites are dependent on topic and instructor. Prerequisite: permission of the instructor. Crosslisted as PHYS 338.

PHYS 339. Advanced Quantum Mechanics and Particle Physics. 1 Credit.

Offered Alternating Spring Semester; Lecture hours:3

Advanced topics in quantum mechanics including applications to elementary particle physics. Prerequisite: PHYS 332.

PHYS 340. Biophysics. 1 Credit.

Offered Alternating Spring Semester; Lecture hours:3

Physics of cellular structures and processes, with emphasis on mechanics and thermodynamics. Juniors and seniors only. Prerequisite: PHYS 212 and either PHYS 221 or PHYS 222 or permission of the instructor.

PHYS 350. Undergraduate Research. .5-1 Credits.

Offered Either Fall or Spring; Lecture hours:Varies; Repeatable

Undergraduate research. Prerequisite: permission of the instructor.

PHYS 3NT. Physics Non-traditional Study. 1-4 Credits.

Offered Fall, Spring, Summer; Lecture hours:Varies,Other:4

Non-traditional study in Physics.