Course Catalog

Physics and Astronomy

Faculty

Kwan Cheng, Ph.D. , Williams Endowed Professor in Interdisciplinary Physics
Nirav Mehta, Ph.D. , Associate Professor
David Pooley, Ph.D. , Associate Professor
Orrin Shindell, Ph.D. , Assistant Professor
Jennifer Steele, Ph.D. , Professor; Chair
Niescja E. Turner, Ph.D. , Charles A. Zilker Professor of Physics and Astronomy
Dennis Ugolini, Ph.D. , Professor

Requirements

- Bachelor of Arts with a major in Physics
- Bachelor of Science with a major in Physics
- Teacher Certification in Physics
- Guidelines for Acceptance of Majors
- Honors in Physics
- Minor in Physics
- Minor in Astronomy

The Major

Bachelor of Arts with a major in Physics (45 hours)

The requirements for the degree of Bachelor of Arts with a major in Physics are as follows:

I. Departmental requirements:

A. The major: 30 credit hours in Physics, including the following or equivalent courses: PHYS 1111, 1112, 1311 (or 1309), 1312 (or 1310), 2231, 3322, 3323, 4221 or 4231, and at least four of the following courses: 3321, 3324, 3325, 3333, 3335, 3412, 4350, 4395 (at least one must be either 3333 or 3335).
B. Math requirements:

i. Math 1311, 1312, 2321
ii. Either MATH 3316 or both MATH 3336 and 3323.

C. Computer Science Requirements: Either CSCI 1312 or CSCI 1320.
D. Seminar Requirement: Four semesters of PHYS 2094. Students double majoring in either MATH or CSCI may substitute up to 2 semesters of MATH 2094 or CSCI 2094.
E. Completion of Wagner Senior Assessment Exam in fall of the senior year.

II. University requirements: completion of all other required elements of the Pathways curriculum and at least 124 credit hours.

The above are minimal requirements allowing students to supplement their programs with those courses best suited to fulfill their particular needs and to further their professional growth.

Bachelor of Science with a major in Physics (56 hours)

The requirements for the degree of Bachelor of Science with a major in Physics are as follows:

I. Departmental requirements:

A. At least 38 credit hours in Physics, including the following or equivalent courses: PHYS 1111, 1112, 1311 (or 1309), 1312 (or 1310), 2231, 3321, 3322, 3323, 3324, 3325, 3333, 3335, 4221, 4231, 4395. (Honors students will take 3398, 4398, 4399 in place of 4395.)
B. At least one course from the following: PHYS 3336, 4343, 4346, or 4350.
C. Math requirements:
    i. Math 1311, 1312, 2321
    ii. Either MATH 3316 or both MATH 3336 and 3323.
D. Computer Science Requirements: Either CSCI 1312 or CSCI 1320.
E. Seminar Requirement: Four semesters of PHYS 2094. Students double majoring in either MATH or CSCI may substitute up to 2 semesters of MATH 2094 or CSCI 2094.
F. Completion of Wagner Senior Assessment Exam in fall of the senior year.

II. University requirements: completion of all other required elements of the Pathways curriculum and at least 124 credit hours.

The Bachelor of Science Program is designed to prepare students for graduate work in Physics. The above are minimal requirements allowing students to supplement their programs with those courses best suited to fulfill their particular needs and to further their professional growth.

Teacher Certification in Physics

Students completing either the B.A. or B.S. physics major have two options to receive certification to teach physics in grades 8-12 in Texas through Trinity's Master of Arts in Teaching (MAT) program. Students can pursue (1) the Grades 8-12 Physics/Mathematics certification, which would enable a graduate to teach physics and mathematics or (2) the Grades 8-12 Physical Science certification, which would enable a graduate to teach physics as well as chemistry and 8th grade general science (this would require coursework in chemistry and geosciences in addition to the physics major). Both options require undergraduate education coursework as preparation for entry into the MAT program and to fulfill state requirements. Students who complete Trinity's 5 year Teacher Education Program will earn both a Bachelor's degree in Physics and Master of Arts in Teaching as well as teacher certification. For more information and specific requirements, including middle school and elementary science teaching opportunities as well, see the Education Department's program description in the course catalog.

Guidelines for Acceptance of Majors

Full acceptance in the major is granted if the following requirements are met at the time of application:

I. Completion of PHYS 1111, 1112, 1311 (or 1309), 1312 (or 1310), 3323 with grades of C or better;
II. Completion of MATH 1311, 1312 with grades of C or better; and
III. A grade point average of at least 2.0 on all university work.

Provisional acceptance in the major is granted if it is apparent that the applicant can meet the requirements for full acceptance by the end of the semester in which the application is made.

Transfer students will be accepted provisionally pending completion at Trinity of at least one upper division course with a grade of C or better.

Honors in Physics

A student in Physics may work toward Honors in Physics under the Bachelor of Science Degree program. The requirement for Honors in Physics is the successful completion of the Bachelor of Science program except that an honors student will take PHYS 3398, 4398, 4399 in place of 4395 and will be required to take a total of 44 hours of physics. During the junior year, a student who is eligible for honors will, after consultation with the chair of the Physics and Astronomy Department, enroll in 3398; part of the requirement of this course will be to prepare a thesis proposal. In the second semester of the junior year, an honors student will present a thesis proposal and credentials to the department faculty. Upon approval of the proposal, a student may enroll in PHYS 4398, 4399 during the senior year. By the end of the senior year, the thesis must be presented and defended before the Physics

and Astronomy Department faculty.

The Minor in Physics

A minor in Physics will consist of 18 credit hours of Physics. At least 9 credit hours must be at the upper division level. The minor will normally include the following or equivalent courses: PHYS 1111, 1112, 1311 (or 1309), 1312 (or 1310), 2094 (1 semester), 3323, plus seven additional hours of physics, six of which must be upper division.

The Minor in Astronomy

The minor in astronomy will consist of 19 credit hours. Of those, 10 hours will include:

PHYS 1103	Observatory Astronomy
PHYS 1304	Solar System Astronomy
PHYS 1305	Stars and Galaxies
PHYS 1310 or 1312	General Physics II or Introduction to Electricity, Magnetism

Three hours will include:

PHYS 3350	Intermediate Astronomy
PHYS 4350	Astrophysics

The remaining 6 upper-division hours are chosen from the following:

GEOS 3307	Planetary Geology
PHYS/GEOS 3412	Applied Geophysics
PHYS 3321	Statistical Physics and Thermodynamics
PHYS 3322	Classical Mechanics and Nonlinear Dynamics
PHYS 3323	Introduction to Modern Physics
PHYS 3324	Math Methods in Physics
PHYS 3325	Waves and Optics
PHYS 3348	Atmospheric Physics

PHYS 3128	Summer Research II
PHYS 4128	Summer Research III
PHYS 3-90	Directed Studies – Junior Level
PHYS 4-90	Directed Studies – Senior Level
Students may also choose one relevant 3-hour-upper-division course approved by the department chair.	

The combined total of hours for 3128, 4128, 3-90, or 4-90 may not exceed 3 hours for the minor. The chair of the Department of Physics and Astronomy must approve the selected content of 3128, 4128, 3-90, or 4-90 as relevant to the minor in astronomy.

Courses

PHYS-1103 Observational Astronomy

A laboratory course to accompany either PHYS 1304 or 1305. Basic use of a telescope, including celestial coordinates and time systems. Visual observations of the Sun, Moon, planets and their satellites, stars, star clusters, nebulae, galaxies. Further possible topics include photometry, spectroscopy, electronic imaging. One field trip to a dark observing site may be required. May be taken only once for credit. Either PHYS 1304 or 1305 is a prerequisite or a corequisite.

PHYS-1111 Introductory Physics Laboratory

Laboratory to accompany PHYS 1309 or 1311. Topics include: one-dimensional kinematics, elastic and frictional forces, Kepler's Laws, collisions, rotational motion, oscillatory motion. Corequisite: PHYS 1311 or 1309 must be taken concurrently.

PHYS-1112 Intermediate Physics Laboratory

Laboratory to accompany PHYS 1310 and 1312. Topics include: DC, AC, and transient circuits, magnetism, geometric optics, interference and diffraction, blackbody radiation, spectroscopy, gamma ray absorption. Corequisite: PHYS 1310 or 1312 must be taken concurrently.

PHYS-1194 Physics and Society Seminar

Discussion of the historical, sociological, philosophical implications and cultural context in which physics research is done and the implications of that research. Prerequisite: PHYS 3323.

PHYS-1302 Frontiers of Physics

An introduction to the methods and results and philosophical implications of modern physics. Topics include: special and general relatively; the wave-particle theory of light and matter; atomic, nuclear and particle physics; future explorations.

PHYS-1303 Energy and Earth's Changing Environment

An introduction to understanding energy production, consumption, and resource (e.g., fossil fuels, nuclear, solar, wind, water, geothermal, biofuels, and hydrogen). Topics for discussion include: environmental, political, economic, biological, and humanitarian consequences of energy production or use. Students will become more aware of the causes and consequences of climate change and of ways for mitigating the negative effects.

PHYS-1304 Solar System Astronomy

A survey of the nature of the Solar System. Topics include: scale of the Solar System, major and minor planets; moons, asteroids, comets, and other solar system debris; gravity and orbital motion; the nature of light; lunar phases; lunar and solar eclipses; solar wind and planetary magnetospheres; seasons, planetary atmospheres, and comparative planetary climatology; evolution of planetary surfaces; extra-solar planets and the search for life elsewhere in the Galaxy. May be taken without enrolling in PHYS 1103. (Offered every Year).

PHYS-1305 Stars & Galaxies

A survey of the properties of stars, galaxies, and the universe. Topics include: observed properties of stars; stellar birth, evolution and death; white dwarfs, neutron stars, and black holes; galactic structure and evolution; supermassive black holes; large-scale structure of the universe; the Big Bang and inflation; life in the universe; the nature of light. PHYS 1304 is not a prerequisite for PHYS 1305. May be taken without enrolling in PHYS 1103.

PHYS-1307 Introduction to Nanotechnology

An introduction to current nanotechnology fabrication methods and applications aimed at nonscience majors. This course will explore how material properties change at the nanoscale and how these properties can be utilized in technological applications and consumer products. Topics include scientific concepts behind nanotechnology, microscopy at the nanoscale, medical applications, consumer applications, ethical concerns, and the environmental impact of nanotechnology.

PHYS-1309 General Physics I

A calculus-level introduction to classical mechanics and its applications. Topics include: particle kinematics, Newton's laws of motion, kinetic and potential energy, work, linear and angular momentum, torque, statics, simple harmonic motion, mechanical waves, sound, fluids, thermal physics, and applications in biology, medicine, and geology. This course is appropriate for biology, chemistry, and geosciences majors. Only one of PHYS 1309 or 1311 may be taken for credit. Prerequisite: MATH 1311 or 1307 (either may be taken concurrently); Corequisite: PHYS 1111 must be taken concurrently

PHYS-1310 General Physics II

A calculus-level introduction to electric fields, magnetic fields, light waves, and modern physics. Topics include: electric fields, electric current, electric circuits, magnetic fields, electromagnetic induction, electromagnetic waves, geometrical optics, physical optics, quantum physics, atomic physics, lasers, nuclear physics and applications in biology, medicine, and geology. This course is appropriate for biology, chemistry, and geosciences majors. Only one of PHYS 1310 or 1312 may be taken for credit. Prerequisite: PHYS 1309 or 1311; PHYS 1112 is normally taken concurrently but is not required.

PHYS-1311 Introduction to Mechanics

A calculus-level introduction to classical mechanics. Topics include: particle kinematics, Newton's laws of motion, kinetic and potential energy, linear and angular momentum, torque, statics, simple harmonic motion, mechanical waves, and sound. This course is appropriate for physics and engineering science majors. Only one of PHYS 1309 or 1311 may be taken for credit. Prerequisite: MATH 1311 or 1307 (either may be taken concurrently). Corequisite: PHYS 1111 must be taken concurrently

PHYS-1312 Introduction to Electricity, Magnetism And Waves

A calculus-level introduction to electric fields, magnetic fields, and light waves. Topics include: electric fields, Gauss's Law, electric potential, magnetism, Ampere's Law, electromagnetic induction, Lenz's Law, Maxwell's Equations, geometrical and physical optics. This course is appropriate for physics and engineering science majors. Only one of PHYS 1310 or 1312 may be taken for credit. Prerequisites: PHYS 1311 (or 1309) and MATH 1312 (may be taken concurrently). Corequisite: PHYS 1112 must be taken concurrently

PHYS-2-90 Directed Studies - Sophomore Level

Individual research under faculty supervision or independent study under faculty supervision in fields not covered by other courses. Credit may vary from 1 to 3 hours. This course may be repeated for additional credit; however, no more than 3 total hours may be counted toward a major in physics. Prerequisite: Consent of the Department Chair.

PHYS-2094 Physics Seminar

Attendance at departmental seminars. Grade is based on attendance.

PHYS-2128 Summer Research I

Individual research participation during the summer research term under faculty supervision. (Offered every semester.) Prerequisite: Consent of Department Chair

PHYS-2231 Sophomore Experimental Physics

Rigorous experimental work, including data handling and scientific writing. Experiments are drawn from the areas of mechanics, optics, nuclear, and modern physics. Meets 3 hours per week, with significant work outside of the laboratory. (Offered every Spring.) Prerequisites: PHYS 1111, 1112, 1312 (or 1310)

PHYS-3128 Summer Research II

Individual research participation during the summer research term under faculty supervision. (Offered every semester.) Prerequisite: PHYS 2128 and Consent of the Department Chair.

PHYS-3194 Speaking Physics

Speaking Physics is a junior level course designed to train physics majors to become effective communicators in their field. Students will gain experience presenting technical research-style talks, with several opportunities for feedback from the instructor and peers. (Offered every Spring)

PHYS-3311 Principles of Biophysics

This course introduces the use of physics principles to explore and understand complex biological systems on different spatial and time scales. Questions addressed include: What are the forces that hold a molecule and a cell together? What are the forces and energies involved in cell membrane structures and functions, DNA packing and functioning, protein folding, and nerve-signal transmission? Emphasis will be placed on the use of spectroscopic, imaging and computer simulation techniques to address some of these questions. This course spans the molecular, cellular and tissue levels of biology and examines current topics of biophysics. (Offered every other year.) Prerequisites: PHYS 1310 (or PHYS 1312) and one of the following courses: CHEM 3330, ENGR 3327, or PHYS 3323

PHYS-3321 Statistical Physics and Thermodynamics

An introduction to the subjects of statistical mechanics, kinetic theory, thermodynamics and heat. Prerequisites: PHYS 3323 and MATH 2321 (may be taken concurrently).

PHYS-3322 Classical Mechanics and Nonlinear Dynamics

Newtonian dynamics and kinematics utilizing the vector calculus. Topics include momentum, work and potential energy, angular momentum, rigid body dynamics, harmonic oscillators, central force motion, non-inertial systems, chaotic kinematics, and non-linear systems. Prerequisites: PHYS 1312 (or 1310), MATH 2321 (may be taken concurrently).

PHYS-3323 Introduction to Modern Physics

A quantitative survey of modern physics. Topics include: special relativity, waveparticle duality, and Schroedinger equation, identical particles, solid state, and high energy physics. Prerequisites: PHYS 1312 (or 1310), MATH 1312

PHYS-3324 Mathematical Methods for Physicists

This course is a survey of mathematical methods commonly used in the physical sciences. It covers essential aspects of complex variables, linear algebra, Fourier series and transforms, differential equations, and vector analysis, including theorems of Green, Gauss, and Stokes. (Offered every Spring.) Prerequisites: PHYS 3323 (Modern Physics)

PHYS-3325 Waves and Optics

An intermediate treatment of oscillations and wave mechanics and the nature of light as electromagnetic waves. General topics include linear oscillators, traveling waves, representations by complex numbers, and Fourier analysis. Topics from physical optics include sources of radiation, guided waves, interactions of light and matter, reflection and refraction, interference and diffraction, and scattering from particles. (Offered every other year.) Prerequisites: PHYS 1312 (or 1310) and MATH 2321.

PHYS-3333 Quantum Physics I

Introduction to the theory of quantum mechanics. Stationary states and time evolution of solutions to the Schroedinger equation. Observables, operators and eigenvalues. The harmonic oscillator, angular momentum, central potentials, and perturbation theory. Prerequisites: MATH 2321, PHYS 3323.

PHYS-3335 Electromagnetic Fields

An intermediate course on electromagnetic theory. Electrostatic field and potential, Gauss's law, conductors, electric dipole and multipoles, solutions to Laplace's equation, method of images, dielectric media, electrostatic energy, electric current. Magnetic field of steady currents, including the law of Biot and Savart, Ampere's law, magnetic vector potential. Electromagnetic induction. Introduction to Maxwell's equations. Prerequisites: PHYS 3322, MATH 3316 (may be taken concurrently).

PHYS-3336 Advanced Topics in Physics and Astronomy

Advanced topics in physics and astronomy to be selected by the instructor. Various instances of the course may cover topics such as particle physics, general relativity, advanced electricity and magnetism, fluid mechanics, and/or advanced classical mechanics. (Offered every other year.) Prerequisites: Varies by topic. Consent of instructor is required.

PHYS-3348 Atmospheric Physics

The physics of planetary atmospheres and the role of the atmosphere in determining climate. Topics include: global radiative equilibrium, radiative transfer, thermodynamic processes in the atmosphere, the general circulation, cloud formation, the ozone layer, instrumentation and data bases. Prerequisite: PHYS 1310 or 1312.

PHYS-3350 Intermediate Astronomy

An introduction to the use of physical principles in the study of modern astronomy and astrophysics. Topics include: gravitational dynamics; star formation; stellar structure and evolution; radiative processes and phenomena; special relativistic effects in astronomy; quantum effects in astronomy; gravitational lensing. Only one of PHYS 3350 or 4350 may be taken for credit. (Offered every other year.) Prerequisite: PHYS 1310 or 1312; PHYS 1305 or permission of the instructor.

PHYS-3-90 Directed Studies - Junior Level

Individual research under faculty supervision or independent study under faculty supervision in fields not covered by other courses. Credit may vary from 1 to 3 hours. This course may be repeated for additional credit; however, no more than three hours may be counted toward a major in physics. Prerequisite: Consent of the Department Chair

PHYS-3398 Honors Reading

Individual research and study under faculty supervision in preparation for Honors Thesis work. Prerequisite: Consent of the Department Chair.

PHYS-3412 Applied Geophysics

An introduction to the use of physical principles and measurements in the study of the Earth's subsurface, with an emphasis on applications in environmental science, engineering, mineral exploration and archeology. Topics include Fourier analysis, seismic waves in elastic media, refraction tomography, reflection seismology, multichannel analysis of surface waves, gravity, electrical resistivity and groundpenetrating radar. (Also listed as GEOS 3412) Three class hours and three laboratory hours per week. Field trips are required; field trip expenses must be paid by each student. Prerequisite: PHYS 1310 or 1312 (may be taken concurrently).

PHYS-4128 Summer Research III

Individual research participation during the summer research term under faculty supervision. (Offered every semester.) Prerequisite: PHYS 3128 and Consent of the Department Chair.

PHYS-4191 Nanofabrication

This course is an introduction to nanometer scale aspects of chemistry, physics, and biology, and how these can be combined to fabricate architectures with dimensions in the nanometer scale. Principles of fabrication techniques that underpin this field will be presented with recent developments as case studies, including nanoparticles, self-assembled monolayers (SAMs), electromaterials, and other new materials. An extensive series of hands-on laboratory activities is a central part of the course. Students will fabricate and characterize nanoscale structures using a variety of techniques from biology, chemistry, physics, and materials science. In the first few weeks of the semester, we will focus on principles, concepts, and instrumentation utilized in nonfabrication. During the rest of the semester, students will choose a current paper from the literature and attempt to recreate the fabrication process and all characterization techniques. (Offered occasionally). Prerequisite: Permission of Instructor

PHYS-4221 Electronics Lab

Rigorous experimental work covering RLC circuits, diodes, transistors, oscilloscopes, logic gates, and operational amplifiers. There will be a significant expectation for work outside of class, whether on prelab preparation, circuit building, or assignments for practicing specific skills. Meets 3 hours per week, with significant work outside of the laboratory. (Offered every other year.) Prerequisites: PHYS 2231

PHYS-4231 Advanced Photonics Lab

Advanced experimental techniques covering topics typically not addressed in coursework. Rigorous analysis of experimental data and competent scientific writing form an integral part of the course. Topics include: atomic physics, advanced optics, laser physics, and nanotechnology. There will be a significant expectation for work outside of class, including pre-lab and writing activities. Meets 3 hours per week, with significant work outside of the laboratory. (Offered every other year.) Prerequisites: PHYS 2231

PHYS-4328 High-Frequency Electromagnetics

The fundamental theory of electromagnetic waves is developed and applied to the design of high-frequency electrical circuits. Topics include: how electromagnetic waves travel and are usefully directed; how to design signal transmission lines, filters and couplers; analysis of high-frequency circuit networks, and high-frequency circuit concepts such as distributed impedance. Students will also prepare an individually researched assignment on a subject of their choice exploring an emerging technology in the electrical engineering area. (Also listed as ENGR 4328.) Prerequisite: Math 2321 and either ENGR 2320 or PHYS 2131.

PHYS-4343 Quantum Physics II

A formal treatment of quantum mechanics emphasizing Dirac notation and matrix methods. Topics include: three dimensional systems, angular momentum, multiparticle systems, identical particles, spin perturbation theory, scattering, and an introduction to high-energy and particle physics. Prerequisites: PHYS 3333, 3335.

PHYS-4350 Astrophysics

The rigorous application of physics to understanding stars and stellar evolution, astrophysical sources of radiation, compact objects, and gravitational lensing. Topics include: gravitational dynamics; star formation, stellar structure and evolution; several radiative processes and phenomena such as blackbody, bremsstrahlung, synchrotron, Compton, inverse Compton, self Compton, dispersion, and Faraday rotation; special relativistic effects in astronomy such as Doppler shifts, aberration, and astrophysical jets; quantum effects in astronomy such as degenerate gases, hyperfine transition, and Zeeman absorption; gravitational lensing. Only one of PHYS 3350 or 4350 may be taken for credit. (Offered every other year.) Prerequisites: PHYS 1310 or 1312; PHYS 1305; PHYS 3323.

PHYS-4346 Condensed Matter Physics

An advanced treatment of quantum theories of atoms and solids. Physics of solids and solutions, reciprocal lattices and crystallography, thermodynamic properties of condensed systems. Properties of atoms and photon. Laser cooling, coherent excitation, and atom optics. Prerequisite: PHYS 3333.

PHYS-4-90 Directed Studies - Senior Level

Individual research under faculty supervision or independent study under faculty supervision in fields not covered by other courses. Credit may vary from 1 to 3 hours. This course may be repeated for additional credit; however, no more than 3 total hours may be counted toward a major in physics. Prerequisite: Consent of the Department Chair

PHYS-4395 Senior Project

Individual research and scholarly investigation under faculty supervision. A written summary of results and presentation at a department seminar are required. Required of all B.S. Physics majors. (Offered every semester.) Prerequisite: Senior standing.

PHYS-4396 Senior Thesis

Continuation of PHYS 4395 including written preparation of a thesis and oral presentation of results at a department seminar. Not required of but highly recommended for B.S. Physics majors. Prerequisite: PHYS 4395.

PHYS-4398 Honors Project

Individual research and scholarly investigation under faculty supervision. A written summary of results and presentation at a department seminar are required. Required for honors in physics. (Offered every semester.) Prerequisite: Senior standing.

PHYS-4399 Honors Thesis

Continuation of PHYS 4398 including written preparation of a thesis and oral presentation of results at a department seminar. Required for honors in physics. Prerequisite: PHYS 4398.