DEPARTMENT OF PHYSICS AND ASTRONOMY

Physics seeks to understand the fundamental workings of nature, from the constituents of matter deep within the nuclei of atoms, to the most distant galaxies of our expanding universe, to everyday phenomena of emergent complexity, self-organization and chaos. The resulting basic physical knowledge provides a firm foundation for innovations and is often the driving force of advanced technology. Computers, global positioning systems (GPS), the internet, lasers, magnetic resonance imaging (MRI) and other medical diagnostic tools, and space flight, along with many others, were all made possible by key advances in physics.

Physicists have a curiosity that thrives on the challenge of solving problems. Consistent with this, the physics program at Texas A&M strives to teach analytical thinking and quantitative problem-solving skills. This enables students to work productively in physics, in areas closely related to physics, and in a wide variety of areas outside of physics proper. Physicists can be found in almost any discipline that requires complex problem-solving skills. Some engage in cutting-edge research to increase our basic knowledge of the universe. Some apply new-found knowledge to make practical advances in the fields of computer science, medical science and engineering. Still others use their knowledge to advocate, advise, inform, instruct and administrate as lawyers, consultants, journalists/writers, teachers and managers.

The Department of Physics and Astronomy offers two undergraduate degree programs, a Bachelor of Arts and a Bachelor of Science, as well as minors in Astrophysics and Physics. The Department of Physics and Astronomy also offers Master of Science degrees in Astronomy and Physics, and Doctor of Philosophy degrees in Applied Physics, Astronomy and Physics.

The faculty members of the department carry out theoretical and experimental research in the areas of astronomy and astrophysics, atomic, molecular and optical physics, computational physics, cosmology, high-energy and elementary particle physics, condensed matter physics and materials science, nuclear physics and quantum optics. During the course of their undergraduate experience at Texas A&M, Physics majors have the opportunity to work with faculty in all of these areas.

Faculty

Abanov, Artem G, Associate Professor
Physics And Astronomy
PHD, Texas A&M University, 1998

Adair, Thomas W, Professor
Physics And Astronomy
PHD, Texas A&M University, 1965

Agnolet, Glenn, Professor
Physics And Astronomy
PHD, Cornell University, 1983

Akimov, Alexey, Assistant Professor
Physics And Astronomy
PHD, Moscow Institute of Technology, 2003

Allen, Roland E, Professor
Physics And Astronomy
PHD, The University of Texas at Austin, 1969

Aronson, Meigan C, Professor
Physics And Astronomy
PHD, University of Illinois at Urbana-Champaign, 1988

Bassichis, William H, Professor
Physics And Astronomy
PHD, Case Western Reserve University, 1963

Becker, Katrin, Professor
Physics And Astronomy
PHD, University of Bonn, Germany, 1994

Becker, Melanie, Professor
Physics And Astronomy
PHD, University of Bonn, Germany, 1994

Belyanin, Alexey A, Professor
Physics And Astronomy
PHD, Institute of Applied Physics, Russian Academy of Sciences, 1995

Chin, Siu A, Professor
Physics And Astronomy
PHD, Massachusetts Institute of Technology, 1975

Christian, Gregory A, Assistant Professor
Physics And Astronomy
PHD, Michigan State University, 2011

Depoy, Darren L, Professor
Physics And Astronomy
PHD, University of Hawaii at Manoa, 1987

Dierker, Steven B, Professor
Physics And Astronomy
PHD, University of Illinois at Urbana-Champaign, 1983

Dutta, Bhaskar, Professor
Physics And Astronomy
PHD, Oklahoma State University, 1995

Erukhimova, Tatiana L, Instructional Associate Professor
Physics And Astronomy
PHD, Institute of Applied Physics, Russian Academy of Sciences, 1999

Eusebi, Ricardo, Associate Professor
Physics And Astronomy
PHD, University of Rochester, 2006

Finkelstein, Alexander, Professor
Physics And Astronomy
PHD, Landau Institute for Theoretical Physics, 1972

Ford, Albert L, Professor
Physics And Astronomy
PHD, The University of Texas at Austin, 1972

Fries, Rainer J, Associate Professor
Physics And Astronomy
PHD, University of Regensburg, Germany, 2001
Fry, Edward S, Distinguished Professor
Physics And Astronomy
PHD, University of Michigan, 1969

Gagliardi, Carl A, Professor
Physics And Astronomy
PHD, Princeton University, 1982

Hardy, John C, Distinguished Professor
Physics And Astronomy
PHD, McGill University, 1965

Herschbach, Dudley R, Distinguished Professor
Physics And Astronomy
PHD, Harvard University, 1958

Holt, Jeremy W, Assistant Professor
Physics And Astronomy
PHD, Stony Brook University, 2016

Kamon, Teruki, Professor
Physics And Astronomy
PHD, University of Tsukuba, 1986

Katzgraber, Helmut G, Professor
Physics And Astronomy
PHD, University of California, Santa Cruz, 2001

Ko, Che-Ming, Professor
Physics And Astronomy
PHD, State University of New York at Stony Brook, 1973

Kocharovsky, Vitaly V, Professor
Physics And Astronomy
PHD, Institute of Applied Physics, Russian Academy of Sciences, 1986

Kocharovsky, Olga A, Distinguished Professor
Physics And Astronomy
PHD, Institute of Applied Physics, Russian Academy of Sciences, 1986

Kosciusko, Kevin L, Instructional Assistant Professor
Physics And Astronomy
PHD, University of Washington, 2000

Kwiatkowski, Anna A, Assistant Professor
Physics And Astronomy
PHD, Michigan State University, 2011

Lee, David M, Distinguished Professor
Physics And Astronomy
PHD, Yale University, 1959

Lyuksyutov, Igor F, Professor
Physics And Astronomy

Macri, Lucas M, Professor
Physics And Astronomy
PHD, Harvard University, 2001

Mahapatra, Rupak K, Professor
Physics And Astronomy
PHD, University of Minnesota, Twin Cities, 2000

Marshall, Jennifer L, Assistant Professor
Physics And Astronomy
PHD, The Ohio State University, 2006

McIntyre, Peter M, Professor
Physics And Astronomy
PHD, University of Chicago, 1973

Melconian, Daniel G, Associate Professor
Physics And Astronomy
PHD, Simon Fraser University, 2006

Mioduszewski, Saskia, Professor
Physics And Astronomy
PHD, University of Tennessee, 1999

Mirabolfathi, Nader, Research Associate Professor
Physics And Astronomy
PHD, University of Paris XI, 2002

Nanopoulos, Dimitri V, Distinguished Professor
Physics And Astronomy
PHD, University of Sussex, Falmer, Brighton, England, 1973

Naugle, Donald G, Professor
Physics And Astronomy
PHD, Texas A&M University, 1965

Papovich, Casey J, Professor
Physics And Astronomy
PHD, Johns Hopkins University, 2002

Pokrovskiy, Valery, Distinguished Professor
Physics And Astronomy
PHD, Tomsk State University, 1957

Pope, Christopher N, Distinguished Professor
Physics And Astronomy
PHD, University of Cambridge, 1980

Rapp, Ralf F, Professor
Physics And Astronomy
PHD, Rheinische Friedrich-Wilhelma University, Bonn, 1996

Rogachev, Grigory V, Professor
Physics And Astronomy
PHD, National Research Centre, 1999

Ross, Joseph H, Professor
Physics And Astronomy
PHD, University of Illinois at Urbana-Champaign, 1986

Safonov, Alexei N, Professor
Physics And Astronomy
PHD, University of Florida, 2001

Saslow, Wayne M, Lecturer
Physics And Astronomy
PHD, University of California, Irvine, 1968

Schuessler, Hans A, Professor
Physics And Astronomy
PHD, Universitat Heidelberg, 1964
Scully, Marlan O, Distinguished Professor
Physics And Astronomy
PHD, Yale University, 1966

Sezgin, Ergin, Professor
Physics And Astronomy
PHD, State University of New York at Stony Brook, 1980

Sokolov, Alexei V, Professor
Physics And Astronomy
PHD, Stanford University, 2001

Strigari, Louis E, Assistant Professor
Physics And Astronomy
PHD, The Ohio State University, 2014

Suntzeff, Nicholas B, Professor
Physics And Astronomy
PHD, University of California, Santa Cruz, 1980

Svidzinsky, Anatoly A, Research Associate Professor
Physics and Astronomy
PHD, Stanford University, 2001

Teizer, Winfried, Professor
Physics And Astronomy
PHD, University of Massachusetts Amherst, 1998

Toback, David, Professor
Physics And Astronomy
PHD, University of Chicago, 1997

Tran, Kim-Vy H, Professor
Physics And Astronomy
PHD, University of California, Santa Cruz, 2002

Tribble, Robert E, Distinguished Professor
Physics And Astronomy
PHD, Princeton University, 1973

Ulmer, Keith A, Assistant Professor
Physics And Astronomy
PHD, University of Colorado, 2007

Wang, Dawei, Professor
Physics and Astronomy
PHD, Chinese University of Hong Kong, 2012

Wang, Lifan, Research Associate Professor
Physics And Astronomy
PHD, University of Science and Technology of China, 1993

Webb, Robert C, Professor
Physics And Astronomy
PHD, Princeton University, 1972

Weimer, Michael B, Professor
Physics And Astronomy
PHD, California Institute of Technology, 1986

Welch, George R, Professor
Physics And Astronomy
PHD, Massachusetts Institute of Technology, 1989

Wu, Wenhao, Associate Professor
Physics And Astronomy
PHD, University of Chicago, 1992

Zheltikov, Alexey M, Professor
Physics And Astronomy
PHD, M.V. Lomonosov Moscow State University, 1999

Zubairy, Muhammad S, Professor
Physics And Astronomy
PHD, University of Rochester, 1979

Majors

- Bachelor of Arts in Physics (http://catalog.tamu.edu/undergraduate/science/physics-astronomy/physics-ba)
- Bachelor of Science in Physics (http://catalog.tamu.edu/undergraduate/science/physics-astronomy/physics-bs)

Minors


Courses

- Astronomy (ASTR) (p. 3)
- Physics (PHYS) (p. 3)

Astronomy

**ASTR 101 Basic Astronomy**
Credits 3. 3 Lecture Hours.

(ARTR 1030) Basic Astronomy. A qualitative approach to basic stellar astronomy; earth-moon-sun relationships then studies of distances to stars, stellar temperatures, and other physical properties; birth, life on the main sequence of the H-R diagram, and ultimate fates of stars; not open to students who have taken ASTR 111 or ASTR 314.

**ASTR 102 Observational Astronomy**
Credit 1. 3 Lab Hours.

Observational and laboratory course which may be taken in conjunction with ASTR 101 or ASTR 314. Use of techniques and instruments of classical and modern astronomy.

Prerequisite: ASTR 101 or ASTR 314, or registration therein.

**ASTR 103 Introduction to Stars and Exoplanets**
Credits 3. 3 Lecture Hours.

A qualitative study of stellar birth, stellar structure and evolution, stellar nucleosynthesis, the Hertzsprung-Russell Diagram, white dwarfs, neutron stars, supernovae, black holes, proto-planetary systems, origin of the solar system and the search for exoplanets; utilizes active learning methods that incorporate observations from the current generation of ground and space-based telescopes. Open to all majors.

**ASTR 104 Introduction to Galaxies and Cosmology**
Credits 3. 3 Lecture Hours.

A qualitative study of properties of galaxies, galaxy evolution through cosmic time, galactic archaeology, active galactic nuclei, super-massive black holes, large-scale structure, the expansion history of the universe, cosmological parameters and Big Bang nucleosynthesis; utilizes active learning methods that incorporate observations from the current generation of ground and space-based telescopes. Open to all majors.
ASTR 109/PHYS 109 Big Bang and Black Holes Credit 3.3 Lecture Hours.
Designed to give an intuitive understanding of the Big Bang and Black Holes, without mathematics, and de-mystify them for the non-scientist.

ASTR 111 Overview of Modern Astronomy Credits 4.3 Lecture Hours. 2 Lab Hours.
(ASR 1303 and ASTR 1103, ASTR 1403, PHYS 1303 and PHYS 1103, PHYS 1403) Overview of Modern Astronomy. Roots of modern astronomy; the scientific method; fundamental physical laws; the formation of planets, stars, and galaxies; introduction to cosmology; includes an integrated laboratory that reinforces the lecture topics, including hands-on experience with telescopes and imaging of celestial objects; not open to students who have taken ASTR 101 or ASTR 314.

ASTR 119/PHYS 119 Big Bang and Black Holes: Laboratory Methods Credit 1.2 Lab Hours.
Hands-on understanding of the concepts surrounding the Big Bang and Black Holes; emphasis on the evidence-based decision making process, methods and presentation; for non-scientists. Companion course for ASTR 109/PHYS 109/PHYS 109/ASTR 109.
Prerequisite: ASTR/PHYS 109/ASTR 109 or registration therein.
Cross Listing: PHYS 119/ASTR 119.

ASTR 285 Directed Studies Credits 1 to 4.1 to 4 Other Hours.
Special work in laboratory or theory to meet individual requirements in cases not covered by regular curriculum; intended for use as lower-level credit.
Prerequisite: Approval of department head.

ASTR 289 Special Topics in... Credits 1 to 4.1 to 4 Lecture Hours. 0 to 4 Lab Hours.
Selected topics in an identified area of astronomy. May be repeated for credit.
Prerequisite: Approval of instructor.

ASTR 291 Research Credits 0 to 4.0 to 4 Other Hours.
Research conducted under the direction of faculty member in astronomy. May be repeated 2 times for credit.
Prerequisite: ASTR/PHYS 109 or registration therein; or approval of instructor.

ASTR 314 Survey of Astronomy Credits 3.3 Lecture Hours.
Primarily for majors in science and engineering. Kepler’s laws, law of gravitation, solar system, stars, stellar evolution, nucleosynthesis, cosmology, clusters, nebulae, pulsars, quasars, black holes.
Prerequisite: PHYS 208.

ASTR 320 Astrophysical Research Methods Credits 2.2 Lecture Hours.
Background and tools used by astronomical researchers in performing analyses; topics include reduction of photometric and spectroscopic data, bivariate and multivariate statistical methods and chi-squared minimization.
Prerequisites: MATH 171 and MATH 172.

ASTR 401 Stars and Extrasolar Planets Credits 3.3 Lecture Hours.
How stars are born, how internal structure changes, nuclear fuel burned and ultimate fate; extrasolar planet detection, formation, properties and habitability.
Prerequisite: ASTR 314.

ASTR 403 Extragalactic Astronomy and Cosmology Credits 3.3 Lecture Hours.
Physical makeup of individual galaxies and large scale structure in the universe; origin and eventual fate of the universe; interpretation of observational data as it relates to baryonic matter, Dark Matter and cosmological models with Dark Energy.
Prerequisite: ASTR 314.

ASTR 485 Directed Studies Credits 1 to 12.1 to 12 Other Hours.
Special work in laboratory or theory to meet individual requirements in cases not covered by regular curriculum.
Prerequisite: Approval of department head.

ASTR 489 Special Topics in... Credits 1 to 4.0 to 4 Lecture Hours. 0 to 4 Lab Hours.
Selected topics in an identified area of astronomy. May be repeated for credit.
Prerequisite: Approval of instructor.

PHYS 101 Freshman Physics Orientation Credit 1.1 Lecture Hour.
Critical thinking skills and problem solving in physics: time management and teaming skills. For physics majors. Registration by non-majors requires approval of instructor.
Prerequisite: PHYS 218 or registration therein; MATH 171 or registration therein; or approval of instructor.

PHYS 102 Freshman Physics Orientation II Credit 1.1 Lecture Hour.
Critical thinking skills and problem solving in physics: time management and teaming skills. For physics majors. Registration by non-majors requires approval of instructor.
Prerequisites: PHYS 101, PHYS 208 or registration therein; MATH 172 or registration therein; or approval of instructor.

PHYS 109/ASTR 109 Big Bang and Black Holes Credits 3.3 Lecture Hours.
Designed to give an intuitive understanding of the Big Bang and Black Holes, without mathematics, and de-mystify them for the non-scientist.

PHYS 119/ASTR 119 Big Bang and Black Holes: Laboratory Methods Credit 1.2 Lab Hours.
Hands-on understanding of the concepts surrounding the Big Bang and Black Holes; emphasis on the evidence-based decision making process, methods and presentation; for non-scientists. Companion course for ASTR 109/PHYS 109/PHYS 109/ASTR 109.
Prerequisite: ASTR/PHYS 109/ASTR 109 or registration therein.
Cross Listing: ASTR 119/PHYS 119.
PHYS 123 Physics for Future Presidents
Credits 3. 3 Lecture Hours.
Physics needed to be an effective policy maker or world leader but appropriate for any citizen, since all citizens need to understand the world in which they live and work; fundamental principles of physics made comprehensible and usable by those not in science- or math-related fields.
Prerequisite: Basic math skills.

PHYS 201 College Physics
Credits 4. 3 Lecture Hours. 3 Lab Hours.

PHYS 202 College Physics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
( PHYS 1302 and 1102, 1402) College Physics. Continuation of PHYS 201. Fundamentals of classical electricity and light; introduction to contemporary physics.
Prerequisite: PHYS 201.

PHYS 205 Concepts of Physics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
General survey physics course for K-8 preservice teachers integrating physics content and laboratory activities relevant to physics-related subject matter included in the current Texas and national standards for elementary school science; includes aspects of mechanics, waves, electricity, magnetism and modern physics.
Prerequisite: Major in interdisciplinary studies or interdisciplinary technology or approval of instructor.

PHYS 208 Electricity and Optics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
( PHYS 2326 and PHYS 2126, PHYS 2426) Electricity and Optics. Continuation of PHYS 218. Electricity, magnetism, and introduction to optics. Primarily for students in science and engineering.
Prerequisites: PHYS 218; MATH 152 or MATH 172 or registration therein.

PHYS 218 Mechanics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Prerequisite: MATH 151 or MATH 171 or registration therein.

PHYS 221 Optics and Thermal Physics
Credits 3. 3 Lecture Hours.
Wave motion and sound, geometrical and physical optics, kinetic theory of gases, laws of thermodynamics.
Prerequisites: PHYS 208; MATH 152 or MATH 172; registration in MATH 221, MATH 308.

PHYS 222 Modern Physics for Engineers
Credits 3. 3 Lecture Hours.
Atomic, quantum, relativity and solid state physics.
Prerequisites: PHYS 208 or PHYS 219; MATH 308 or registration therein.

PHYS 225 Electronic Circuits and Applications
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Linear circuit theory and applications of solidstate diodes, bipolar and field-effect transistors, operational amplifiers and digital systems.
Prerequisites: PHYS 208; MATH 308.

PHYS 285 Directed Studies
Credits 1 to 4. 1 to 4 Other Hours.
Special work in laboratory or theory to meet individual requirements in cases not covered by regular curriculum; intended for use as lower-level credit.
Prerequisite: Approval of department head.

PHYS 289 Special Topics in...
Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 6 Lab Hours.
Selected topics in an identified area of physics. May be repeated for credit.
Prerequisite: Approval of instructor.

PHYS 291 Research
Credits 0 to 4. 0 to 4 Other Hours.
Research conducted under the direction of faculty member in physics. May be repeated 2 times for credit.
Prerequisites: Freshman or sophomore classification and approval of instructor.

PHYS 302 Advanced Mechanics I
Credits 3. 3 Lecture Hours.
Classical mechanics of particles and rigid bodies, both by direct application of Newton's equations and by Lagrangian methods; applications to gravity and other central forces, coupled oscillators, non-inertial reference frames, and the statics and dynamics of fluids with and without viscosity; introduction to statics of structures.
Prerequisites: MATH 221 or MATH 251 or MATH 253; MATH 308; PHYS 208, PHYS 218, PHYS 222, and PHYS 331; concurrent enrollment in PHYS 332; for students with other backgrounds, approval of instructor.

PHYS 303 Advanced Mechanics II
Credits 3. 3 Lecture Hours.
Classical mechanics of particles and rigid bodies with an emphasis on Lagrangian and Hamiltonian methods; applications to chaos, scattering, coupled oscillations, and continua, including sound in fluids; mechanical implications of special relativity; introduction to drag and turbulence in fluids; introduction to elasticity in solids; Euler buckling instability.
Prerequisites: PHYS 302 and PHYS 332.

PHYS 304 Advanced Electricity and Magnetism I
Credits 3. 3 Lecture Hours.
Electrostatics; dielectrics; electrical current and circuits; magnetic fields and materials; induction; Maxwell's equations.
Prerequisites: PHYS 221; PHYS 331; concurrent enrollment in PHYS 332; junior or senior classification.

PHYS 305 Advanced Electricity and Magnetism II
Credits 3. 3 Lecture Hours.
Radiation and optics. Electromagnetic waves; radiation; reflection and refraction; interference; diffraction; special relativity applied to electrodynamics.
Prerequisite: PHYS 304.

PHYS 309 Modern Physics
Credits 3. 3 Lecture Hours.
Special relativity; concepts of waves and particles; introductory quantum mechanics.
Prerequisites: PHYS 221; MATH 221; MATH 308.

PHYS 327 Experimental Physics I
Credits 2. 1 Lecture Hour. 2 Lab Hours.
Laboratory experiments in modern physics and physical optics with an introduction to current, state-of-the-art recording techniques.
Prerequisites: PHYS 225; PHYS 309.
PHYS 328 Experimental Physics II  
Credit 1. 1 Lecture Hour. 1 Lab Hour.  
Laboratory experiments in modern physics and physical optics with an introduction to current, state-of-the-art recording techniques.  
Prerequisites: PHYS 225, PHYS 309, PHYS 327.

PHYS 331 Theoretical Methods for Physicists I  
Credits 3. 3 Lecture Hours.  
Applications involving vectors; vector and additional methods for advanced electricity and magnetism; relationship and solutions of classical wave equation, heat equation, and Schrödinger equation; harmonic motion on finite or periodic lattice and in continuum; tensor and matrix notation in classical mechanics and electricity and magnetism.  
Prerequisites: MATH 221 or MATH 251 or MATH 253; MATH 308; PHYS 208 or PHYS 219, PHYS 218, and PHYS 221; restricted to physics majors.

PHYS 332 Theoretical Methods for Physicists II  
Credits 3. 3 Lecture Hours.  
Methods to solve the important equations of theoretical physics, emphasizing the effects of boundary conditions and quantization on their solutions and restricted to the essential physical symmetries associated with free space, spheres, cylinders, and rectangles; if time permits, introduction to symmetries in physics and to asymptotic methods.  
Prerequisites: PHYS 222 or PHYS 309; PHYS 331; restricted to physics majors.

PHYS 401 Computational Physics  
Credits 3. 2 Lecture Hours. 2 Lab Hours.  
Introduction to computational and simulation techniques widely used in physics applications and research, including trajectory integration, wave motion analysis, molecular dynamics, Monte Carlo methods, statistical mechanics of spin systems, phase transitions, quantum evolution, bound state problems, and variational methods.  
Prerequisites: PHYS 302; PHYS 309; PHYS 331; PHYS 332; knowledge of a high level language such as FORTRAN or C (This prerequisite can be obtained by taking CSCE 206 or the equivalent); junior or senior classification.

PHYS 408 Thermodynamics and Statistical Mechanics  
Credits 4. 4 Lecture Hours.  
Statistical method, macroscopic thermodynamics, kinetic theory, black body radiation, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.  
Prerequisites: PHYS 331; PHYS 412; junior or senior classification.

PHYS 412 Quantum Mechanics I  
Credits 3. 3 Lecture Hours.  
Postulates of wave mechanics; wave packets; harmonic oscillator; central field problem; hydrogen atom; approximation methods.  
Prerequisites: PHYS 302; PHYS 309; PHYS 332; junior or senior classification.

PHYS 414 Quantum Mechanics II  
Credits 3. 3 Lecture Hours.  
Continuation of PHYS 412. Electron spin; addition of angular momenta; atomic structure; time dependent perturbations; collision theory; application of quantum mechanics to atomic, solid state, nuclear or high energy physics.  
Prerequisite: PHYS 412.

PHYS 416 Physics of the Solid State  
Credits 3. 3 Lecture Hours.  
A survey of solid state physics; an introduction to crystal structures and the physics of electrons, lattice vibrations and photons; applications to semiconductors; magnetism; superconductivity; physics of nanostructures; brief introduction to selected current topics in condensed matter physics.  
Prerequisites: PHYS 304 and PHYS 412.

PHYS 420 Concepts, Connections, and Communication  
Credit 1. 1 Lecture Hour.  
Stars and atoms; new physics; post-Newtonian universe.  
Prerequisite: Junior or senior classification.

PHYS 425 Physics Laboratory  
Credits 2. 6 Lab Hours.  
Experiments in nuclear, atomic, and molecular physics using modern instrumentation and equipment of current research.  
Prerequisite: PHYS 327 or equivalent.

PHYS 426 Physics Laboratory  
Credits 2. 6 Lab Hours.  
Experiments in solid state and nuclear physics. Modern instrumentation and current research equipment are employed.  
Prerequisite: PHYS 327 or equivalent.

PHYS 444 Art of Communication in Physics I: Communicating Science to Scientists  
Credits 2. 2 Lecture Hours.  
Communication in physics, communicating physics to scientists, scientific presentations; scientific writing; information retrieval; reading technical publications.  
Prerequisite: Knowledge of oral and written English; junior or senior classification.

PHYS 445 Art of Communication in Physics II: Communicating Science to Non-Scientists  
Credit 1. 1 Lecture Hour.  
Communication in physics, communicating physics to scientists, scientific presentations; scientific writing; job and graduate school application; job interview.  
Prerequisites: PHYS 444; knowledge of oral and written English; junior or senior classification.

PHYS 485 Directed Studies  
Credits 1 to 12. 1 to 12 Other Hours.  
Special work in laboratory or theory to meet individual requirements in cases not covered by regular curriculum.  
Prerequisite: Approval of department head.

PHYS 489 Special Topics in...  
Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours.  
Selected topics in an identified field of physics. May be repeated for credit.  
Prerequisite: Approval of instructor.

PHYS 491 Research  
Credits 0 to 4. 0 to 4 Other Hours.  
Research conducted under the direction of faculty member in physics. May be repeated for credit. Registration in multiple sections of this course is possible within a given semester provided that the per semester credit hour limit is not exceeded.  
Prerequisites: Junior or senior classification and approval of instructor.