The School of Science and Engineering

Physics and Astronomy

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Professors

Ulrike Diebold, Ph.D., Technische Universitaet Wien, Vienna

James M. MacLaren, Ph.D., Imperial College, London (Interim Dean)

James H. McGuire, Ph.D., Northeastern (Murchison-Mallory Professor of Physics) (Chair)

John P. Perdew, Ph.D., Cornell

Robert D. Purrington, Ph.D., Texas A&M

Wayne F. Reed, Ph.D., Clarkson

George T. Rosensteel, Ph.D., Toronto

Frank J. Tipler, Ph.D., Maryland

Associate Professors

Zhiqiang Mao, Ph.D., Univ. of Science & Technology, China

Fred Wietfeldt, Ph.D., California, Berkeley

Assistant Professors

Lev Kaplan, Ph.D., Harvard

Emeritus

David L. Ederer, Ph.D., Cornell

PHYSICS

INTRODUCTORY COURSES

The department offers both calculus-based general physics (131 and 132) and non-calculus general physics (121 and 122). Premedical students may elect either 121-122 or 131-132. Physics 131 and 132 are designed primarily for majors in the sciences, mathematics, and engineering.

COURSES FOR NON-SCIENTISTS

The department offers a broad range of non-traditional courses which may be used to satisfy the science requirement. These courses are non-mathematical; testing emphasizes verbal techniques (papers, book reports, projects, essays, etc.), rather than quantitative skills. There are no mathematics or other prerequisites for any of these courses.

MAJOR

The intention of the liberalized physics major program is to encourage cross-disciplinary preparation for students interested in public interest science or in physics as a preparation for medical or other professional schools. Dual majors are encouraged. Students pursuing a career in physics are advised to follow the "Pre-graduate Training" sequence. The basic requirements for a physics major are as follows. The minimum requirements are seven courses in Physics, four in Mathematics, and an additional four in any Mathematics, Physics, or other Science courses at the two hundred level and above, and approved by the Physics Department. Six credits of upper level courses must be chosen from among contemporary topics (235, 236, 321, 327, 447, 607, 608, 621, 625, 627, 630, 675) and six credits from classical topics (363, 374, 423, 465, 601, 602). Three credits of Advanced Laboratory 353 are also required. Satisfactory completion of one semester of Seminar 380 is required for degree certification (one credit). At least 13 credits (four courses) of mathematics are required including MATH 221 or one of MATH 224 or 424, or both MATH 221 and MATH 224/424. No more than two of the four mathematics courses may be at the 100 level. Twelve additional credits above the 100 level of physics, engineering physics, chemistry, biology, geology or mathematics must be selected with the approval of the major advisor. This approval will normally be given only for courses that have disciplinary prerequisites at the 100 level. It is recommended that a course in computer science be taken early in a student's undergraduate career.

Students are encouraged to consider a bachelor of science in physics as preparation for graduate study in disciplinary and interdisciplinary sciences (physics, astrophysics, biophysics, chemistry, neuroscience, materials science, geophysics, meteorology, oceanography, and applied physics), for professional study in medicine, in patent law, or in engineering, and for careers in environmental science, in mathematical or computer modeling, in science writing, or in science and public policy. Within the requirements above, programs can be tailored to suit the needs of students who elect these career options.

In addition, we have a 4+1 program that allows students to obtain a Master's Degree in five years, by enabling them to take graduate level courses as an undergraduate.

Tulane University is a member of the Oak Ridge Associated Universities (ORAU) consortium.

MINOR

A minor in physics consists of eight credits of general physics (normally 131, 132) plus twelve credits of physics courses at the 200 level or above. At least three credits of the upper-level courses must be chosen from classical topics in physics (363, 374, 423, 465). It should be noted that some of the upper-level physics courses have certain mathematics prerequisites.

PRE-GRADUATE TRAINING

The student who intends to continue graduate work in physics should complete at least 32 credits in physics including general physics, 363, 374, 423, 447, 465. Students are encouraged to undertake a research project and write a senior honors thesis under the supervision of a physics faculty member. The student should also take Mathematics 347 or its equivalent. Other recommended mathematics courses include 305, 309, 406, 421, and 430. Courses in scientific computing, e.g., Mathematics 331 are also recommended.

COURSES FOR NON-SCIENTISTS

PHYS 101 Great Ideas in Science (4)
Prof. McGuire. Basic principles of science and their relevance to our world. The universe, Newtonian mechanics, energy conservation, symmetry in nature, order and disorder, electricity, quantum mechanics, atoms and molecules, DNA, computer technology, and ethical issues. Laboratory.

PHYS 201 The Omega Point Theory: Integrating Science and Religion (3)
Prof. Tipler. The future evolution and final state of the universe in modern cosmology. The Mind-as-Computer-Program idea and

the Turing Test of personhood. The universe as a computer simulation. Why is there something rather than nothing? What is "free will" and is it consistent with physics? Resurrection vs. soul immortality in religious eschatology. Heaven, Hell, and Purgatory as a "virtual reality" in the computers of the far future. Why the most fundamental laws of physics require the Final State of the universe—Omega Point—to be omniscient, omnipotent, omnipresent, and transcendent to space and time. A personal God and individual immortality as implications of reductionist scientific materialism.

PHYS 304 Approaches to the Scientific Revolution (3)
Prof. Purrington, Prof. Tipler. The origins of quantitative science in the "Newtonian Revolution" have been the subject of much recent scholarship. The course examines a variety of often conflicting insights about this crucial period and its heritage in contemporary science, without assuming that consensus is any longer possible. Sources and techniques from history of science, biography, sociology of science, and cultural studies of science are employed. Case studies from Isaac Newton's work provide the context for the development of the multiple points of view.

SEQUENCE OF COURSES FOR MAJORS

PHYS 121 Introductory Physics I (4)
Staff. A non-calculus course in classical physics stressing the fundamental physical laws. Newtonian mechanics, thermal phenomena, electricity and magnetism, and classical waves normally are treated in 121. A weekly laboratory is included; the laboratory includes a review of techniques of problem solving, as well as experiments in classical physics. Not open for credit to students who have completed 131.

PHYS 122 Introductory Physics II (4)
Staff. A continuation of 121. Electricity and magnetism, and optics. Emphasis is given to topics in modern physics, including the quantum theory of the atom and special relativity. A weekly laboratory is included. Not open for credit to students who have completed 132.

PHYS 131 General Physics I (4)
Staff. Prior or concurrent study in calculus, or approval of instructor is strongly recommended. A calculus-based course in classical physics designed primarily for physical science majors. Newtonian mechanics, thermodynamics, and classical wave

motion are studied. Emphasis is on understanding basic principles and solving problems. A weekly laboratory is included. The laboratory includes a review of techniques for problem solving, as well as experiments in classical physics. Not open to students who have completed 121.

PHYS 132 General Physics II (4)
Staff. A continuation of 131. Electricity and magnetism, optics, and topics in modern physics, including the quantum theory of the atom and special relativity. Weekly laboratory. Not open to students who have completed 121 and 122.

PHYS 235 Modern Physics I (3)
Staff. Prerequisites: PHYS 121 and 122 or 131 and 132, MATH 121 and 122 or equivalent. Quantitative treatment of important topics of 20th-century physics: special relativity, kinetic theory and Planck's hypothesis, photons, deBroglie wavelength, the nuclear atom, the Bohr model, introduction to wave mechanics, multi-electron atoms.

PHYS 236 Modern Physics II (3)
Staff. Prerequisite: PHYS 235. Properties of nuclei, radioactivity, nuclear reactions, interaction of particles with matter. Diatomic molecules, electrons in metals, band theory of solids, superconductivity. Atomic physics, elementary particles, the standard model, quarks, and cosmology.

PHYS 291 Introduction to Physics Pedagogy (1)
Staff. Prerequisites: PHYS 121 and 122 or 131 and 132. Introduction to the theory and practice of teaching physics courses through workshops, observations and assisting teachers at local schools with lectures and/or classroom demonstrations.

PHYS 301 Theoretical and Computational Physics (3)
Staff. Prerequisites: PHYS 235 and 11 credits of mathematics, or approval of instructor. An introduction to the methods of theoretical physics emphasizing modern mathematical techniques, numerical methods using computers, and computer algebra.

PHYS 305 Spectroscopy of Solids and Atoms (3)
Prof. Ederer. Prerequisites: PHYS 131, 132, 235, 236, or consent of instructor. This course deals with the interaction of photons with matter. Topics will include some of the ideas of quantum electrodynamics that form the basic underpinning of all forms of electromagnetic interactions with matter. Absorption, reflection,

and scattering of radiation in the spectral region extending from the infrared to the x-ray region of the spectrum will be described and will include experimental methods used to study gases and condensed matter materials. Emphasis will be given to photoionization, autoionization, Raman, Compton, Bragg, and Rayleigh scattering, and how these phenomena are used to study the electronic properties of matter. Sources, including lasers and synchrotron radiation, and instrumentation for their use will be discussed.

PHYS 317 Computational Physics and Engineering (3)
Prof. Kaplan. Prerequisites: PHYS 235 and MATH 221 or 224. An introduction to the use of computational methods in physics and engineering. Writing computer code and using data visualization techniques to help solve experimental and theoretical problems. Data analysis and modeling, Monte Carlo simulations, numerical differentiation and integration, ordinary and partial differential equations, electrostatic nonlinear dynamics and chaos, fast Fourier transform, noisy signal processing, quantum spectra, thermodynamics. Same as ENGP 317.

PHYS 321 Molecular Biophysics and Polymer Physics (3)
Prof. Reed. Prerequisites: PHYS 235 or equivalent, CHEM 107 or equivalent, and MATH 122 or equivalent. An introduction to the physics of polymers and the physical bases underlying the biofunctionality of macromolecules in living systems. Themes of molecular self-organization, conformation, complementarity, and information content are emphasized and related to protein, lipid, and nucleic acid structure and processes. Introduction to scattering, NMR, and other spectroscopic techniques. Same as PHYS 621.

PHYS 327 Biophysics of the Living Cell (3)
Staff. This course explores the fundamental physics of several important processes in living systems at the cellular level. The emphasis throughout will be on how physical theory can be used to achieve a deeper level of understanding of biological processes. Topics covered include the relevant aspects of equilibrium and nonequilibrium statistical mechanics, diffusion, cellular electrochemistry and transport, energy transduction, protein pumps, motor proteins, enzyme biophysics and kinetics, and the composition and behavior of neurons. Same as PHYS 627.

PHYS 353 Advanced Laboratory I (3)
Staff. Prerequisite: PHYS 235 or approval of instructor. Advanced experiments in modern physics, particularly nuclear physics, emphasizing research techniques and analysis of data using computers.

PHYS 360 Nanoscience and Technology (3)
Prof. Diebold. Prerequisite: PHYS 235. Nanoscience and technology is often branded the science of the 21st century. It has been promised that nanotechnology will have similar stimulating effects on the world's economy and society as the industrial-and microelectronics- revolution. Nanoscience is an interdisciplinary effort with the aim to manipulate and control matter at length scales down to single molecules and atoms and thus to create materials and devices with novel properties. With diminishing dimensions material properties are being governed by quantum mechanics. The description and exploitation of quantum phenomena in novel devices is the quintessence of nanophysics. Consequently, the main emphasis of this course is to give an overview of the physics of low dimensional solid state systems. This course is supplementary to courses in solid state physics and surface science but can be taken independently. Same as ENGP 360.

PHYS 363 Electromagnetic Theory I (3)
Staff. Prerequisites: PHYS 131, 132, and Mathematics 221 or equivalent. Three lecture hours and one conference hour a week. Electrostatic fields in a vacuum, dielectric materials, solutions to Laplace's and Poisson's equations, steady current and non-magnetic materials, low frequency circuit theory, Maxwell's equations.

PHYS 374 Classical Mechanics (3)
Staff. Prerequisites: PHYS 131, 132, and MATH 221. Three lecture hours and one conference hour a week. Newtonian mechanics, oscillations, central force motion, special theory of relativity, dynamics of rigid bodies, and the Lagrangian formulation of classical mechanics.

PHYS 380 Seminar (1)
Staff. Prerequisite: junior standing or departmental approval. A series of undergraduate and faculty seminars emphasizing topics and points of view not covered in the standard curriculum, but which are nonetheless important to the education of a physicist. Required of all majors.

PHYS 388 Writing Practicum (1)
Staff. Corequisite: three-credit departmental course. Prerequisite: successful completion of the First-Year Writing Requirement. Fulfills the college intensive-writing requirement.

PHYS 391 Special Topics in Physics (3)
Staff. Special topics in physics depending upon faculty and student interest.

PHYS 423 Thermal Physics (3)
Staff. Prerequisites: PHYS 121 and 122, or 131 and 132. A study of the physical properties of matter where temperature is an important variable. The laws of thermodynamics, equations of state, thermodynamic potentials. Kinetic theory of gases. Elementary statistical postulates. Ensembles, the partition function. Entropy, phase transitions.

PHYS 447 Introductory Quantum Mechanics (3)
Prof. Rosensteel. Prerequisites: PHYS 235 and Mathematics 221. The postulates of quantum mechanics, Schroedinger equation, operator methods, angular momentum, fermion and boson systems, and Heisenberg formulations, applications to simple physical systems.

PHYS 465 Optics (3)
Staff. Prerequisites: PHYS 121 and 122, or 131 and 132, and eight credits of mathematics. Geometrical, physical, and quantum optics. Applications to optical instruments, spectroscopy, and interferometry, Fourier optics, lasers, and holography.

PHYS H491, H492 Independent Studies (1-3, 1-3)
Staff. Prerequisite: approval of instructor and chair of department.

PHYS H499-H500 Honors Thesis (3, 4)
Staff. Open only to candidates for honors degrees with department approval.

PHYS 601 Techniques of Theoretical Physics I (3)
Prof. MacLaren, Prof. McGuire. Prerequisite: approval of instructor. Mathematical techniques used in theoretical physics. Topics include partial differential equations, orthogonal coordinate systems, separation of variables, introduction to ordinary differential equations, series solutions and convergence; Sturm Liouville theory, eigensystems and orthogonal functions; complex variables, Taylor and Laurent series, contour

integration, integration by steepest descents, and conformal mappings.

PHYS 602 Techniques of Theoretical Physics II (3)
Prof. MacLaren, Prof. McGuire. A continuation of Physics 601. Calculus of variations, Rayleigh Ritz technique, Bessel and Legendre functions, Fourier series, Fourier and Laplace transforms, Green functions. An introduction to group theory and symmetry.

PHYS 607 Astrophysics (3)
Prof. Purrington, Prof. Tipler. Fundamentals of stellar atmospheres and interiors: nuclear astrophysics, energy generation in stars, stellar evolution, nucleo-synthesis, and theories of supernovae. Gravitational collapse and properties of superdense stars. Galactic structure and evolution, elements of cosmology.

PHYS 608 Surface Science (3)
Prof. Diebold. Prerequisite: approval of instructor. Introduction to current topics of surface and interface physics and applications. Methods and techniques of modern surface science, experimental requirements and applications. Concepts of two-dimensional physics and chemistry, properties of surfaces and model systems.

PHYS 621 Molecular Biophysics and Polymer Physics (3)
See Physics 321 for description.

PHYS 625 The Standard Model (3)
Prof. Purrington, Prof. Tipler. Prerequisite: PHYS 447. Unification of the strong, weak, and electro-magnetic interactions, based on the U(1) x SU(2) x SU(3) gauge group. Introduction to quantum field theory and the Feynman rules. Gauge invariance and non-Abelian Gauge Theories. The Standard Model Lagrangian. Electroweak theory and quantum chromodynamics. Masses and the Higgs mechanism. W and Z boson widths and decay channels. Quarks, gluons, confinement, and jets. Mesons, baryons, and glueballs. The Higgs boson. Running coupling constants in QED and QCD. Quark mixing angles, CP violation, and KM matrix. Beyond the Standard Model: grand unification, supersymmetry, supergravity, and superstrings.

PHYS 627 Biophysics of the Living Cell (3)
See Physics 327 for description.

PHYS 630 General Relativity (3)
Prof. Tipler. Prerequisites: PHYS 602 or MATH 221 and 235 or MATH 374. Review of special relativity. Tensor analysis. Differential forms and manifolds. Geodesics and curvature two-forms. The metric tensor. The stress-energy tensor and the Einstein equations. The initial data problem. The Schwarzschild and Kerr solutions: classical black holes. Elementary relativistic cosmology. Generation and detection of gravitational waves. Experimental tests of general relativity: the PPN formalism. Global techniques and the Hawking-Penrose singularity theorems. Hawking radiation and the Bekenstein bound.

PHYS 660 Nanoscience and Technology (3)
Prof. Diebold. Prerequisite: PHYS 235. Nanoscience and technology is often branded the science of the 21st century. It has been promised that nanotechnology will have similar stimulating effects on the world's economy and society as the industrial-and microelectronics- revolution. Nanoscience is an interdisciplinary effort with the aim to manipulate and control matter at length scales down to single molecules and atoms and thus to create materials and devices with novel properties. With diminishing dimensions material properties are being governed by quantum mechanics. The description and exploitation of quantum phenomena in novel devices is the quintessence of nanophysics. Consequently, the main emphasis of this course is to give an overview of the physics of low dimensional solid state systems. This course is supplementary to courses in solid state physics and surface science but can be taken independently.

PHYS 675 Modern Cosmology (3)
Prof. Tipler. Prerequisites: PHYS 423, 625, and 630. The Friedmann cosmological models: open, flat, and closed; matter and radiation dominated. The cosmological constant. Three degree blackbody radiation and its theoretical implications. Experimental tests in cosmology. Nucleosynthesis and galaxy formation. Anisotropic and inhomogeneous cosmologies: the Bianchi models, primarily Kasner and Type IX. GUTs in the very early universe: baryogenesis and phase transitions. Dark matter. Cosmic strings and magnetic monopoles. Inflationary models. Chaotic inflation. Future history and final state of the universe.

ASTRONOMY COURSES

The student who wants a one-semester survey of astronomy should take Astronomy 100. Students who complete Astronomy 100 may not take Astronomy 101 or 102 for credit. The solar system is treated in more depth in 101. Similarly, 102 treats stellar astronomy in depth.

ASTR 100 Descriptive Astronomy (3)
Staff. A one-semester survey of astronomy for the liberal arts student. The solar system, properties and evolution of stars and galaxies, and cosmology. Recent discoveries in astronomy are emphasized. Students who take 100 may not take 101 or 102.

ASTR 101 The Solar System (3)
Staff. The organization and origin of the solar system, the earth in motion, the sun, the moon, the planets, comets, and meteors. Not open for credit to students who have completed 100.

ASTR 102 Stellar Astronomy (3)
Staff. The stars, their distances, spectra, magnitudes. Stellar atmospheres and interiors, stellar evolution. Variable and collapsing stars, nebulae, galaxies and cosmology. Not open for credit to students who have completed 100.

ASTR 110 Observational Astronomy (4)
Staff. Prerequisite: ASTR 100 or approval of instructor. Activities, readings, and projects in observational astronomy. This course provides students with practical experience in observational techniques, while guiding them to an understanding of the role of measurement in the scientific method.

ASTR 301 Archaeoastronomy (3)
Prof. Purrington. A study of ancient Old- and New-World astronomy as exhibited in archaic myth, megalithic monuments, Mesoamerican buildings, stelae and manuscripts, and alignments of archaeological sites. The fundamentals of spherical astronomy will he presented, with emphasis on horizon phenomena, making it possible to explore the implications of possible astronomical alignments, astronomical content of Mesoamerican codices, and the sky-lore of a variety of cultures. Special attention will be given to early Bronze Age megalith monuments in Britain, to Middle American astronomy, and to astronomy of the Native American Indians.

See also Physics 607, Physics 675.