Physics

***Professors* HILT, VEIRS, WHITTEN*; Adjunct Professor* DICENZO; *Associate Professor* BURNS (Chair); *Assistant Professors* CERVANTES, LANG, PURDUE; *Visiting Professor* STEELE; *Emeritus Professors* BORDNER, BRADLEY.**

First-year students who think they might major in Physics should plan to take Physics 241 and 242 in Blocks 6 and 7 of their first year. Physics majors must ordinarily also complete 251, 261, 361 or 461–462, and three units of physics numbered 262 or above together with their prerequisites. One block of Investigations in Physics may be included but Readings in Physics may not. In addition, all majors must participate actively in the departmental colloquium program. Additional advanced courses in physics and mathematics are strongly recommended, especially for those who intend to pursue a career in Physics, Astronomy or Applied Science. An Investigations course is also recommended.

Courses 123 and 124 (Scientific Revolutions I and II) through 137 (Conceptual Physics) are intended particularly for people with no professional interest in the sciences, but a curiosity about what physicists and astronomers know about various aspects of the world and how they found out.

Minor in Physics
Requirements: Physics 241–242 (Introductory Classical Physics I, II), Physics 251 (Modern Physics), Physics 261 (Electronics I), plus one other course numbered 200 or above.

Topical Courses

120, 220, 320 Topics in Physics: Experimental or occasional courses taught by visiting professors or permanent faculty. Courses offered under this rubric will vary year to year. 1 unit—department.

120 Topics in Physics: Cultural Astronomy of the Southwest. Surveys the history and concepts of Western astronomy as background for other cultural approaches to astronomy. Focuses on archaeoastronomy and ethnoastronomy of native Southwestern peoples, including Ancestral Puebloans as well as modern Pueblo and Athabascan tribes. Explores relationships among astronomy, rock art, ritual, oral narratives, social patterns and belief systems. (Meets the Alternative Perspectives:B requirement and the laboratory/field requirement in the Natural Sciences.) Also listed as AN 210 and SW 200. 1 unit—Hilt.

123 Scientific Revolutions: The Copernican Revolution. Planetary astronomy from the Greeks to the age of Newton. This course is a blend of history and science, and it explores the role of planetary astronomy in the development of Western thought. Readings from Aristotle, Ptolemy, Copernicus, Galileo, Kepler and Newton. Astronomical observations and laboratory work. Also listed as FE 143.) (Satisfies the laboratory/field requirement for natural sciences.) (123 and 124, taken in the same year with no more than two blocks intervening, satisfy the Alternative Perspectives: A requirement.) 1 unit — Whitten.

124 Scientific Revolutions: Relativity. This course examines 19th and 20th-century modifications of Newtonian ideas of space, time and interactions. We focus on the concepts and consequences of the theory of relativity: length contraction, time dilation, the relativity of simultaneity, the equivalence of mass and energy, new approaches to gravitation, and black holes. We also explore the impact of relativity outside science. Readings from Einstein, Minkowski, Holton, Kuhn and others. (Also listed as FE 144.) (123 and 124, taken in the same year with no more than two blocks intervening, satisfy the Alternative Perspectives: A requirement.) 1 unit — DiCenzo.

126 Atoms, Nuclei, and Quarks. The search for the fundamental constituents of matter from Greek atoms to charmed quarks. Emphasis on what physicists now know about elementary particles — and how they found out. Atoms, the nuclei of atoms, fission, fusion, accelerators, elementary particles, anti-particles, strange particles, quarks-charmed and otherwise — and whatever turns up next. (Offered in some years for 2 units with Emphasis on Writing.) (Not offered in 2003-04.) 1 unit -- department.

129 Acoustics. Physics of motion, vibrations and waves, with application to hearing, music and architectural acoustics. (Meets the laboratory/field requirement for natural sciences.) (not offered in 2003-04) 1 unit — department.

132 Energy Systems in Technological Society. Physics of energy and power with applications to nuclear, coal and solar energy systems. Availability of resources, techniques of energy conversion, characteristics of nuclear, electric, electromagnetic and thermal energy, environmental consequences of energy conversion. Special emphasis will be placed on case studies of energy systems in the American Southwest. (Also listed as Environmental Science 120.) (Not offered 2003-04.) 1 unit -- department.

133 Astronomy. Our solar system, our galaxy, the expanding universe of galaxies. Methods for obtaining astronomical data; fundamental properties of planets, stars, interstellar matter and galaxies; their origin and evolution; unusual objects like pulsars, quasars and black holes; life in the universe. (Meets the laboratory/field requirement for natural sciences.) 1 unit — Burns, Cervantes. Lang.

135 Meteorology. Basic physics principles are introduced and used to study dynamic processes in the atmosphere: atmospheric energy flow, solar radiation, green-house effect, large-scale circulation of the atmosphere, small-scale processes including clouds and storms, weather forecasting, man's impact on weather and climate. Laboratory and field

experiments and field trips will be utilized. (Also listed as Environmental Science 120.) (Not offered 2003-04.) 1 unit — Veirs.

137 Conceptual Physics. A nonmathematical introduction to some of the important concepts in physics such as inertia, gravity, energy, relativity, and quanta. Some examples of phenomena and devices that might be covered include falling and floating bodies, rocket action, tides, waves of many kinds, the behavior of atoms, fission and fusion, lasers, the twin paradox, and black holes. (Meets the laboratory/field requirement for natural sciences.) (Not offered 2003–04.) 1 unit -- department.

141, 142 Introductory Physics I, II. An introduction to scientific thought and method through a study of the major theories in physics and the phenomena that provoked them from their origins in Greek civilization through the 20th century. The first block: mechanics, heat and relativity; the second block: electricity, magnetism, waves, and quantum physics. (Primarily for students who do not intend to major in the physical sciences). Calculus 1 (MA 126) is recommended. Ideas from calculus will be used in the development of the subject, but formal training in calculus is not required. ***Prerequisite:*** 141 required for 142. (Meets the laboratory/field requirement for natural sciences.) (Meets the Alternative Perspectives: A requirement *when no more than* two blocks intervene between 141 and 142, taken in the same academic year.) 1 unit each — Cervantes, Lang, Purdue, Steele, Whitten.

151 Biophysics: Physics and Living Things. How physical principles apply to living things. Some examples of the kinds of topics to be discussed are muscle action, running, jumping, flying, circulation of blood, keeping warm, keeping cool, nerve action, hearing, and seeing. 1 unit -- DiCenzo.

224 Spacetime Physics. An introductory examination of some of the physics of spacetime. Flat spacetime geometry, momentum and energy, gravity and curved spacetime. Effects of relativity in mechanics, optics and particle physics. More mathematical than 124. ***Prerequisite:*** High school mathematics and science. 1/2 unit — DiCenzo.

241, 242 Introductory Classical Physics I, II. These courses provide an introduction to the theories of classical physics at a mathematical level that involves the use of calculus where appropriate. It is similar in content to 141, 142 except that relativity and quantum physics are not covered and the material is treated with more advanced mathematics. The first block includes the areas of mechanics, waves, thermodynamics and kinetic theory; the second continues with electricity, magnetism and optics. This sequence of courses is designed to meet the needs of students planning to major in the physical sciences or enter an engineering program. ***Prerequisite:*** Mathematics 128 or equivalent, and high school physics or consent of instructor required for 241; 241 or consent of instructor required for 242. (Meets the laboratory/field requirement for natural sciences.) 1 unit each — Burns, DiCenzo, Hilt, Lang, Veirs.

251 Introductory Modern Physics. A continuation of introductory physics using calculus begun in 241 and carried forward in 242. Special relativity and quantum theory are introduced and then used to understand such things as atomic structure, statistical mechanics, and radioactive decay. Includes a laboratory component. ***Prerequisite:*** 242 or equivalent. 1 unit — Hilt, Purdue.

Laboratory Courses

161 Introduction to Modern Electronics. This course covers analog and digital electronics. It is primarily a laboratory course which emphasizes building circuits and understanding how they work. No background in physics is required, although experience in physics or electronics is helpful. (Meets the laboratory/field requirement for natural sciences.) (Not offered 2002-03.) 1 unit -- department.

261 Electronics I. The block begins with basic circuit theory and discrete circuit elements. We then go on to a study of analog and digital electronics. The emphasis is on experimental work. ***Prerequisite:*** 242 or equivalent. 1 unit — Hilt, Veirs.

361 Techniques of Experimental Physics. The design, execution, and analysis of experiments in physics. Data analysis, probability and statistics. One or more laboratory projects to be completed. ***Prerequisite:*** 251, 261 or consent of instructor. 1 unit — Cervantes.

461, 462 — Field Research in Physics. The design, execution, and evaluation of field research in physics. Use of instrumentation including computerized data acquisition, construction and testing of equipment for fieldwork, planning a field program and carrying out field research, analyzing and reporting results. PC 461 is a 1/2 unit extended format course, and must be completed prior to PC 462, the 1 unit block course devoted to field research. ***Prerequisite:*** 251, 261 or COI. 1/2 unit (461) and 1 unit (462) — Veirs.

Core Theory Courses for Majors

311 Vector Analysis. Vector functions, divergence and curl. Green's and Stokes's theorems, and the properties of three-dimensional curves and surfaces. Related topics from linear algebra and differential equations. ***Prerequisite:*** Mathematics 203. (Also listed as Mathematics 311.) 1 unit — DiCenzo.

312 Fourier Analysis. The theory of Fourier series, the Fourier transform, and orthogonal polynomials. Applications to the classical partial differential equations of physics and to theoretical mathematics. ***Prerequisite:*** Mathematics 220 or 311. 1 unit — Tinsley (Mathematics).

341 Mechanics I. Forces and Motion According to Newton: Topics such as motion of a particle in one dimension, oscillations, motion in two and three dimensions, Newton's gravitation, systems of particles and conservation laws, the laws of motion in moving co-ordinate systems. ***Prerequisite:*** 251 and Mathematics 203 or consent of instructor. 1 unit — Hilt.

349 Thermal Physics. First and second laws of thermodynamics and their applications. Statistical mechanics, kinetic theory, elementary transport processes. Maxwell-Bolzman, Fermi Dirac, and Bose-Einstein statistics and their applications in solid state, nuclear and molecular physics. ***Prerequisite:*** 251 and Mathematics 203 or consent of instructor. 1 unit — Lang.

353 Electromagnetic Theory. The theory of electricity and magnetism: electric charges, forces, fields and potentials; electric currents, magnetic forces, fields and potentials. Electromagnetic induction. Maxwell's equations, plane waves in vacuum. ***Prerequisite:*** 251, 311 or consent of instructor. 1 unit — Whitten.

354 Electromagnetic Waves and Optics. The continuation of 353. Electromagnetic fields in matter: conduction, polarization, magnetization; a brief introduction to condensed matter physics. Plane waves in linear media, boundary conditions, interference, diffraction. Radiation from simple sources, coherence. ***Prerequisite:*** 353. 1 unit — Purdue.

441 Quantum Mechanics and Relativity I. General formulation of quantum mechanics: hermitian operators, eigenfunctions and eigenvalues, physical content of the wave function, indeterminacy relations and simultaneous observables, angular momentum and spin. Solutions of the Schrödinger equation in one and several dimensions, the hydrogen atom. ***Prerequisite:*** 341, 311, Mathematics 312 or consent of instructor. 1 unit — Burns.

442 Quantum Mechanics and Relativity II. An introduction to the special theory of relativity: flat spacetime, four-vectors and four-tensors, Lorentz transformations. Approximation methods in Quantum Mechanics, Electromagnetic radiation, scattering theory. ***Prerequisite:*** 441. 1 unit — Burns.

Electives for Majors (not offered every year)

262 Electronics II. The block begins with more analog and digital electronics using integrated circuits. The applications are to physics instrumentation. An introduction to micro-processors may be included. The emphasis is again on experimental work. ***Prerequisite:*** 261. (Not offered 2003-04.) 1 unit -- department.

335 Atmospheric Physics and Climate Change. Introduction to atmospheric circulation, radiation transfer and the resulting climates of the world: thermodynamics and radiation balance as they determine the vertical structure of the atmosphere and regulate the surface temperature, role of water vapor and trace gasses in the global greenhouse effect, dynamics of the troposphere, evidence for climate change. (Also listed as EV 431.) ***Prerequisite:*** 251. 1 unit — Veirs.

342 Mechanics II. Topics such as generalized co-ordinates, the Lagrangian & Hamiltonian formulation of classical mechanics, small oscillations, rotation and angular momentum, rigid body motion and the inertia tensor. ***Prerequisite:*** 311, 341 or consent of instructor. (Not offered 2003-04.) 1 unit -- department.

357 Astrophysics. An introduction to stellar structure and physical cosmology: the observed properties of stars, the physics of stellar interiors, mathematical models for stars, how stars evolve, the origin of the chemical elements, the expanding universe, cosmological models, the age of the universe. ***Prerequisite:*** 251. (Not offered 2003-04) 1 unit — Burns.

443 Quantum Mechanics of Atoms, Molecules and Solids. The methods of quantum mechanics are applied to the problem of understanding the structure of complex atomic systems. Approximation methods are used to describe the multi-electron atom and its interaction with radiation. The Born-Oppenheimer approximation is used to derive the electronic, vibrational, and rotational structure of diatomic molecules. Models for the structure of a crystalline solid are developed. ***Prerequisite:*** 441 and 442 or consent of instructor. (Not offered 2003-04.) 1 unit -- department.

444 Elementary Particle Physics. This course applies the principles of quantum mechanics to elementary particle physics. A review of non-relativistic quantum mechanics is followed by a brief introduction to relativistic quantum theory. The connection between symmetry or invariance principles and conservation laws in quantum mechanics is discussed and then applied to the classification of elementary particles. The standard electro-weak and strong models are introduced as a means of describing the interactions of these particles. ***Prerequisite:*** 441 and 442 or consent of instructor. (Not offered 2003-04.) 1 unit -- department.

451 Relativity. Concepts and consequences of the special and general theories of relativity. Flat spacetime, four-vectors and four-tensors, Lorentz transformations, differential geometry, curved spacetime, weak gravitational fields, relativistic stars, Schwarzschild geometry, gravitational collapse, black holes, gravitational waves. ***Prerequisite:*** 251, 311, or consent of instructor. 1 unit -- Purdue.

Independent Study

270, 370, 470 Readings in Physics. Directed readings in selected areas of physics with discussions and written reports. ***Prerequisite:*** consent of instructor. 1 unit each — department.

391, 392 Investigations in Physics. Independent experimental and/or theoretical practice-research in areas such as nuclear magnetic resonance, geophysics, atomic physics, non-linear dynamics, and astrophysics. Affiliation with a staff member for work as an apprentice researcher in the area of his or her interest. As many as four units of Investigations may be taken for credit. ***Prerequisite:*** 251, 261 and consent of instructor. 1 unit each — Lang.

491 Advanced Investigations in Physics. Yearlong independent experimental and/or theoretical research in areas such as nuclear magnetic resonance, geophysics, atomic physics, non-linear dynamics, and astrophysics. Affiliation with a staff member for work as an apprentice researcher in an area of the faculty member's interest. Combines an extended format course (one-half unit of credit) working with a faculty member to plan and begin research with a block of

intensive work (one unit of credit) resulting in a formal written report and an oral seminar presentation before the Physics Department faculty and students. ***Prerequisite:*** 251, 261 and consent of instructor. (Not offered 2003-04.) 1 and 1/2 units - department.