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William Nettles (2006). University Professor of Physics, Department Chair, and Associate Dean of the College of Arts and Sciences. B.S., Mississippi College; M.S., and Ph.D., Vanderbilt University.

Ildefonso Guilaran (2008). Professor of Physics. B.S., Western Kentucky University; M.S. and Ph.D., Florida State University.

Geoffrey Poore (2010). Associate Professor of Physics. B.A., Wheaton College; M.S. and Ph.D., University of Illinois.

David A. Ward (1992, 1999). Professor of Physics, B.S. and M.A., University of South Florida; Ph.D., North Carolina State University.

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Christine Rowland (2006). Academic Secretary—Engineering, Physics, Math, and Computer Science.

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The programs offered by the Department of Physics are designed to help students understand the physical world by examining the laws which describe the interactions throughout the universe, the methods by which the cosmos can be studied, and the relationship of physics to other aspects of human experience. The department offers courses that effectively serve all students within the institution, recognizing that each student's needs and career goals may be different. The curriculum is designed to provide content of the appropriate level and diversity for students classified as physics majors/minors, non-science majors, engineers, pre-professionals, and those preparing for a teaching career in secondary school. The faculty endeavor to create an atmosphere in which students are challenged to acquire problem-solving skills using advanced mathematics and modern methods in science. Students are encouraged to develop in-depth analytical skills and an attitude of scientific curiosity while maintaining a Christian worldview. In summary, the physics curriculum provides liberal arts students with a working knowledge of science and meets the career needs of students who wish to:

- pursue a teaching career in elementary or secondary school;
- enter engineering, one of the health professions, or an allied health field;
- become a professional/industrial physicist; or
- continue study of physics or a related field at the graduate level.

- I. Major in Physics—38 hours
 - A. Physics 231-232, 311, 313, 314, 420, 424(1-3 hours), 430, 498—28–30 hours
 - B. Select three or more courses: PHY 262, 325, 350, 360, 395-6-7*, 400, 410, 417, 425 (1-2 hours**), 495*
 - C. Prerequisites: MAT 211, 212, 213, 314
 - *Must be approved Special/Independent Studies
 - **Maximum 3 hours from 424 and 425 apply to major.
- II. Major in Physical Science—44 hours
 - A. CHE 111, 112, 113, 211, 221—15 hours
 - B. PHY 112, 231-32, 311, 310 or 301—22 hours
 - C. Upper Level Electives from CHE and PHY—7 hours; maximum 1 hour from 424 and 1 from 498

- III. Major in Physics with Discipline-Specific Honors

Students who are pursuing a major in physics have the option of completing an honors program in the discipline. Students who are interested in this Honors program should refer to the general requirements for Discipline-Specific Honors (DSH) as well as the requirements for the program in physics below:

 - To apply for admission to the Physics DSH program students must
 - have at least a sophomore standing,
 - have a cumulative 3.5 GPA on 15 or more credit hours,
 - be enrolled in or have completed PHY 311, and
 - have at least three, and preferably four, semesters remaining in their undergraduate career.
 - Application should be made to the Chair of the Department of Physics and must be approved by the Department of Physics. Upon departmental approval, the application will be sent to the Honors Community leadership for final approval.
 - Physics DSH Students must complete all requirements for the major in physics. In addition, the student must complete DSH requirements established by the Honors Community.
 - Physics DSH students must complete 12 credit hours of honors-contract courses in physics: Physics Research (PHY 424-425) plus three additional upper-division courses:
 - Three credit hours total must be obtained under an honors contract in the physics research courses (PHY 424 and/or 425). The research must be done within an ongoing research project either at Union or at an off-campus research site. Research Experience for Undergraduates (REUs) are ideal for this requirement. Students must present a paper and a talk which will be evaluated by departmental faculty and must meet high standards of excellence. The department maintains a rubric for evaluating these. The research must be presented at the Union University Scholarship Symposium or its successor. The student must make a good faith effort to present the research at a regional or national meeting.

- The remaining nine credit hours of upper-division honors contract must be above PHY 311 and have a minimum prerequisite of PHY 232.
- Honors contract work will consist of writing a review article on a relevant topic, preparing and giving one or more presentations on relevant topics, completing additional homework of a particularly advanced and challenging nature, designing a physical or computational experiment for a course that does not include a lab component, or a similarly demanding project approved by the department.
- PHY 498 (Seminar) may be taken for 3 hours of honors contact. Only honors students may take this course for more than 1 credit hour.
- Physics DSH students must attend at least four regularly scheduled honors colloquia during each of the student's junior and senior years. Students who are only in Physics DSH for three semesters must attend two colloquia per semester for an overall total of at least six colloquia. Within one week of attending a colloquium, the student will submit a short written summary and reflection paper to the student's honors advisor.
- A grade of C or below in any honors contract course will result in a student's re-evaluation by the department. In the absence of extenuating circumstances, the department will typically dismiss the student from the program. If a student receives more than one B for honors contract classes, the department will assess whether the student should be allowed to continue the program.
- To graduate with Discipline-Specific Honors in Physics, the student must have both a 3.5 cumulative GPA and a 3.5 Physics GPA.

M. Minor in Physics—24 semester hours

Physics 231-232, 311, + 10 hours of Physics electives except PHY 111, 112, 301, 310

V. Teacher Licensure in Physics (Grades 6–12)

A. Complete the requirements shown above for the Physics or Physical Science major.

1. Physics majors must select PHY 262 and 325 from the elective list and must also take CHE 105 or



() Hours Credit; F-Fall; W-Winter; S-Spring; Su-Summer

111. Principles of the Physical Sciences (4) F, W, S

Introduction to physics and chemistry for non-science majors including their historical, philosophical, and social significance. Exercises are indicative of various scientific methods. Knowledge of basic algebra is assumed. Science credit will not be given after completion of a course in CHE or a PHY course numbered 200 or higher. Three lectures, one 2-hour laboratory/week.

112. Earth and Space Science (4) F, W, Su—As Needed
Reciprocal credit: GEO 112.

Earth science and astronomy: their nature, history, divisions, and relation to other sciences. The physical laws of nature will be examined as they apply to physical geography, meteorology, and astronomy. Three lectures, one 2-hour laboratory/week.

213-4. Introduction to Physics (4) 213—F, Su; 214—S, Su
Prerequisite: MAT 111 and 112, or 116.

The first semester involves the study of classical mechanics wave motion, fluid flow, sound, temperature, and heat. The second involves the study of electricity, magnetism, light, optics, and modern physics. Cannot be used as a PHY Elective toward majors/minors. Three lectures, one 3-hour laboratory/week.

231-2. University Physics I, II with Calculus (5)
231—F, S; 232—F, S

Prerequisite to 231: MAT 211. Pre- or Corequisite to 232: MAT 212.

The first semester involves the study of classical mechanics, wave motion, fluid flow and sound. The second involves the study of temperature and heat, electricity, magnetism, light and optics. Four lectures, one laboratory/week.

262. Electrical and Electronic Circuits (4)

Prerequisite: PHY 232 and MAT 212. Reciprocal credit: EGR 262. See EGR 262 for description.

301. Perspectives in Science (4)

Prerequisite: PHY 111-2. Reciprocal credit: CHE 301.

The study of science from a historical and philosophical perspective in an interdisciplinary manner, exploring the complementarity of physical and biological sciences, while addressing relationships to other disciplines such as art, religion, and politics. Examines the role of science in global issues and life issues. Three lecture, 2 lab hours/week.

310. Energy, Environment, and Society (4)

Prerequisite: PHY 111.

A non-technical course for the general student presenting a broad view of energy and its relationship to man and the environment. Topics: past and future demands, energy sources, storage and transportation of energy, environmental considerations, conservation, politics, economics, and national policy. Three lectures, 3 lab hours/week.

311. University Physics: Modern Physics (4)

Prerequisite: MAT 212 and PHY 232.

An introduction to special relativity, quantum mechanics, atomic, and nuclear physics. The laboratory involves investigations in radioactivity, as well as performing some of the classic experiments of modern physics. Three lectures, one 3-hour lab/week.

312. The World of Water (2) S

Prerequisites: PHY 111 or CHE 105

This course is a survey of water, its nature and properties, its role in the physical world, and its role in human society. The uses of water by individuals and societies will be addressed. Ramifications and applications range from international geopolitics to designing a water pump system for a well. Cannot be used as an elective toward PHY major/minor.

313. Intermediate Mechanics (3)

Prerequisite: PHY 232 and MAT 212.

Introduction to rectilinear and curvilinear dynamics of particles and rigid bodies; both Lagrangian and Hamiltonian formulations of mechanics will be developed and applied.

314. Intermediate Electricity and Magnetism (3)

Prerequisites: MAT 212 and PHY 232.

Electric and magnetic fields both in media and a vacuum. Maxwell's equations are used to determine electromagnetic fields produced by a variety of charge and current distributions.

325. Thermodynamics and Statistical Mechanics (3)

Prerequisites: MAT 212 and PHY 232.

An intermediate survey of heat and thermodynamics including the concepts of temperature and heat, the laws of thermodynamics, thermodynamics potentials, the Maxwell relations and statistical methods applied to the thermodynamics of various states of matter, including gases, liquids, and quantum fluids.

350. Introduction to Astrophysics (3)

Pre-requisite: PHY 232

An introduction to the behaviors of solar systems, stars, and galaxies. Newtonian celestial mechanics, gravitation, simple nuclear physics, and introductory cosmology will be included.

360. Mathematical Methods in Physics (3)

Prerequisites: MAT 213, PHY 232.

Special differential equations, complex number analysis, linear algebra, group theory and Fourier analysis applied to advanced topics in physics.

400. Optics and Lasers (3)

Prerequisites: MAT 213, PHY 232.

Analyzes the behavior of electromagnetic radiation, emphasizing geometrical optics and instrumentation. The role of optics in spectroscopic measurements will be highlighted by discussing polarization and diffraction. Includes an introduction to laser physics and operations using systems, including excimer and neodymium-YAG lasers.

<p>410. Nuclear Physics (3) Prerequisites: MAT 213 and PHY 311. A study of the atomic nucleus, including its constituents, interactions and energies. Radiative processes, angular momentum, and practical applications such as astrophysics, medical physics, energy production, and environmental physics.</p>	<p>424-425. Physics Research (1-3) F, S Prerequisite: PHY 311. Application of a simple piece of original work to include a literature search and summary paper on a topic of current interest in physics. Under faculty supervision, this work may be done off site at a national laboratory or comparable research facility.</p>
<p>417. Introduction to Condensed Matter Physics (3) Pre-requisite: PHY 311 An introduction to properties of various phases of matter from the macroscopic scale down to the atomic. The topics covered in this course will include crystal structure, the reciprocal lattice, structural analysis techniques (wave diffraction), the historical progression and theories of various models of electrical conduction, energy bands, semiconductors, metals, and Fermi surfaces.</p>	<p>430. Experimental Physics Laboratory (3) Prerequisites: PHY 311 and MAT 213. Modern experimentation, research, data acquisition and analysis. The theory, practice and reporting of research in a scientific format are demonstrated through experiments in atomic, nuclear, solid state, thermodynamics, and optics. One lecture, 4 lab hours/week.</p>
<p>420. Quantum Mechanics (3) Prerequisites: PHY 311 and MAT 314. Fundamental principles of quantum mechanics, methods of calculation, and solutions to Schrodinger's equation. Applications to atomic, molecular, and nuclear physics with an introduction to operator notation. Three lecture hours/week.</p>	<p>498. Seminar (1-3) S Prerequisite: 20 hours of physics and junior/senior standing. Skills in scientific and technical presentations, written and oral, will be polished. To be used at the discretion of the department for majors/minors only.</p>

<p>179-279-379-479. External Domestic Study Programs (1-3) As Needed All courses and their applications must be defined and approved prior to registering.</p>	<p>195-6-7. Special Studies (1-4) On Demand 295-6-7. Special Studies (1-4) On Demand Lower-level group studies which do not appear in the regular departmental offerings.</p>
<p>179PF-279PF-379PF-479PF. External Domestic Study Programs (Pass/Fail) As Needed All courses and their applications must be defined and approved prior to registering.</p>	<p>395-6-7. Special Studies (1-4) On Demand Upper-level group studies which do not appear in the regular departmental offerings.</p>
<p>180-280-380-480. Study Abroad Programs (1-4) As Needed All courses and their application must be defined and approved prior to travel.</p>	<p>495-6-7. Independent Study (1-4) On Demand Individual study under the guidance of a faculty member(s).</p>
<p>180PF-280PF-380PF-480PF. Study Abroad Programs (Pass/Fail) As Needed All courses and their applications must be defined and approved prior to travel.</p>	<p>498-9. Seminar (1-3) As Needed To be used at the discretion of the department.</p>