

# Physical Education and Recreation

See the Department of Health, Physical Education, Recreation, Dance, and Sport for descriptions of course offerings.

## Physics

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Associate Professors P. Harper, M. Walhout  
Assistant Professors D. Haarsma, L. Haarsma

The Physics and Astronomy Department offers programs of concentration for students interested in careers or graduate studies in physics, astrophysics, or related disciplines, and for students interested in high school physics teaching. Students intending to major in physics are advised to enter college with four years of mathematics and to complete their 100- and 200-level courses in mathematics and physics during their first and second years. The Physical World core requirement may be met by Physics 110, 113, 133, 134, 212, 221, or 223. The entire science core requirement (both Physical World and Living World) may be met by the two-course sequence of Physics 133-134 or 133-235.

### PHYSICS MAJOR

#### At least 32 semester hours, including:

Physics 133, 134, 235, 246, and 306 (or higher level substitutes)

Two or more advanced theory courses from Physics 335-376 (excluding 347 and 359)

Two or more upper-level laboratory courses from Physics or Astronomy 380-386 (Engineering 204 is allowed as a substitute for Physics 381)

Departmentally approved electives to bring the total to at least 32 hours

#### Cognates

Computer Science 104 or 108

Mathematics 161

Mathematics 162

Mathematics 231 is also recommended

Mathematics 232 or 261 (Mathematics 261 is recommended)

All physics majors must enroll in Physics 195 at least once and in any combination of 295 or 296 for three additional semesters.

The 32-hour major is intended primarily for students seeking a flexible program, e.g., who are also majoring in another discipline or earning an engineering degree but have an active interest in physics. The major sat-

isfies the college's concentration requirement for graduation with a B.A. degree.

Students wanting a B.S. degree must complete a total of at least 58 semester hours of science and mathematics. Persons interested in a physics-related career who want to earn a B.S. degree based upon a physics major should complete the above minimum requirements plus at least one more upper-level theory course, Physics 395, and Mathematics 231. Students planning to pursue graduate study in physics should take all the upper-level theory courses (Physics 335, 336, 345, 346, 347, 365, 375, and 376), Physics 395, Mathematics 333, and as many as possible of Mathematics 335, 355, and 365. Students are also strongly encouraged to participate in summer research.

Students interested in a career in astronomy or astrophysics should major in Physics, minor in Astronomy, and plan their programs with D. Haarsma or L. Molnar.

### PHYSICS MINOR

#### At least 20 semester hours of physics, including:

Physics 133

Physics 134

Physics 195

Physics 235  
Physics 246  
Physics 306 and 295 or the combination of  
Physics 296 and 335

## **SECONDARY EDUCATION**

### **MAJOR IN PHYSICS**

#### **At least 32 semester hours including:**

Same as the standard physics major, with the following exceptions:

Physics 384 is required as one of the upper-level experimental modules

Physics 380 is recommended as the second experimental module

Cognates required for secondary education major in physics:

Mathematics 161 and 162

SCES 214

One of Astronomy 211, 212

## **SECONDARY EDUCATION**

### **PHYSICS MINOR:**

The secondary education physics minor is the same as the standard physics minor, except that Physics 306 and either Physics 295 or 296 are required. SCES 214 is a required cognate.

## **OPTICS MINOR**

#### **At least 21 hours, including:**

Physics 133

Physics 235

Physics 246

Physics 345 or Engineering 302

Physics 346

Physics 386

Students pursuing a Physics Major and Optics Minor must follow college guidelines for overlap between a major and a minor; this is facilitated by the option in the Physics Major of substituting upper-level courses for introductory ones.

## **HONORS**

The requirements for graduation with honors in physics are:

1. Minimum cumulative GPA of 3.3 and total of six honors courses (18 hours minimum) overall, including two honors courses outside the major;
2. At least three honors courses (of 3 or more semester hours each) in physics

or astronomy; at least one of the three must be an advanced theory course from 335-376, excluding 347 and 359;

3. Cumulative GPA of at least 3.3 in physics, astronomy, and mathematics collectively;
4. Completion of an approved physics major, with at least 40 semester hours of physics or the secondary education physics major;
5. Regular participation in the departmental seminar program; and
6. Successful completion of a departmentally approved research project in physics or astronomy (typically through summer research) and Physics or Astronomy 395.

To obtain honors credit in any physics or astronomy course, a student can make a contract with the course instructor regarding a special project. Alternatively, a student in an Introductory level physics course up through Physics 235 or in a 100 - 200 level astronomy course may earn honors in that course by concurrently taking the seminar course, Physics 195, and completing its requirements. A student must earn a grade of "B" or better in a course to receive honors designation for that course.

## **ELEMENTARY AND SECONDARY INTEGRATED SCIENCE STUDIES MINOR AND MAJOR**

Students in the Elementary or Secondary Education Program wishing to major or minor in science should consult the Science Education Studies section of the catalog.

## **PHYSICS/COMPUTER SCIENCE GROUP MAJOR**

Physics 133

Physics 134

Physics 235

Physics 381

Computer Science 108

Computer Science 112

Computer Science 214

One from Computer Science 212, Engineering 220, or an upper division computer-science elective

Physics or Computer Science electives (to provide a minimum of 24 semester hours in either physics or computer science)

**Cognates**

Mathematics 161  
 Mathematics 162  
 Mathematics 231 or 256  
 Mathematics 261 or 232

**COURSES****Introductory Courses**

**133 Introductory Physics: Mechanics and Gravity** (4). F and S. An introduction to classical Newtonian mechanics applied to linear and rotational motion; a study of energy and momentum and their associated conservation laws; introductions to oscillations and to gravitation. Attention is given throughout to the assumptions and methodologies of the physical sciences. Laboratory. Prerequisite: Concurrent registration in Mathematics 162. Students currently enrolled in Mathematics 161 may enroll in Physics 133 with permission of the instructor.

**134 Matter, Space, and Energy** (4). S. Theories of the fundamental character of matter, interactions, and space, including historical perspectives. Observational astronomy, Greek science, and the five essences. The Copernican revolution and the Newtonian synthesis. Gravity and force at a distance. The atomic model of matter, including the states of matter. Introductory thermodynamics and the arrow of time. Blackbody radiation and energy quantization. Electromagnetic and nuclear forces. Radioactivity, nuclear processes, and the weak force.  $E=mc^2$ . Quarks, gluons, and the Standard Model. Relativity and Spacetime. Modern Cosmology. Perspectives on the character of scientific inquiry, models, and humans' quest for understanding. Laboratory. Prerequisite: Mathematics 132, 161, or permission of the instructor.

**195 Physics and Astronomy Student Seminar** (0). F and S. This course gives students a broad overview of the fields of physics and astronomy through guest lectures by active researchers, focused readings and discussions of Science, Technology, and Society issues, and presentations by students enrolled in Physics 295 & 296. A student may earn honors credit in an approved introductory physics course by completing a

paper and, at the instructor's option, a class presentation on an approved topic. This course may be taken multiple times.

**212 Inquiry-Based Physics** (4). \* F. This course provides a hands-on study of important concepts in physics. The course is designed specifically to meet the needs of teacher-education students who wish to be elementary- or middle-school science specialists, but is open to other students who satisfy the prerequisites. Topics covered include mechanics (energy, force, friction, work, torque, momentum, and simple machines), pressure, waves, sound, light, resonance, electricity, magnetism, and radioactivity. Reflections on the nature of physical science and the physical world are included; connections to everyday experience and to technology are discussed. Prerequisite: Phys 112 or SCES 112 or high-school physics.

**221 General Physics** (4). F. This course is designed for those who do not intend to do further work in physics. Topics covered in the two-semester sequence (Physics 221-222) include Newtonian mechanics, fluids, waves, thermodynamics, electricity, magnetism, light, optics, atomic physics, and nuclear radiation. Attention is given throughout to quantitative analysis, empirical methods, experimental uncertainties, perspectives on the assumptions and methodologies of the physical sciences, and the use of physics in the life sciences. Laboratory. Prerequisites: High-school algebra and trigonometry.

**222 General Physics** (4). S. A continuation of Physics 221, which is a prerequisite. Laboratory.

**223 Physics for the Health Sciences** (4). F. An introduction to those topics in physics that are applicable to a variety of health science fields, with special emphasis on understanding various physical aspects of the human body. Topics include basic laboratory techniques and instruments for physical measurements, data analysis, basic mechanics, fluids, heat, electrical circuits, sound, optics, radioactivity and x-rays, a discussion of the nature of physical science, and a Christian approach to science. Laboratory. Prerequisites: High school ge-

ometry and algebra. Not open to those who have taken or plan to take Physics 221.

**235 Introductory Physics: Electricity and Magnetism (4).** F and S. A study of electric and magnetic forces, fields, and energy, and of the integral form of Maxwell's equations, which describe these fields; electric circuits. Laboratory. Prerequisites: Physics 133 and Mathematics 162. Students who took Mathematics 162 prior to Fall 2002 have the additional prerequisite of concurrent registration or completion of Mathematics 261 or 232.

**246 Waves, Optics, and Optical Technology (4).** S. Introduction to the basic properties of waves and light, with applications to optical technology. Development of wave and particle models for light. Interactions between light and matter. Reflection, refraction, interference, and diffraction. Devices and applications, including lasers and other light sources, detectors, lenses, thin films, gratings, interferometers, polarizers, phase retarders, fiber optics, nonlinear crystals, and electro-optical technologies. Laboratory. Prerequisites: Physics 235 or Physics 222 and Mathematics 162.

**295 Seminar in Physics, Technology and Society (0).** F and S. This course gives students a broad overview of the fields of physics and astronomy through guest lectures by active researchers, focused readings and discussions of Science, Technology, and Society issues, and student presentations. Each student is required to make a presentation on an approved topic. Meets concurrently with Physics 195. Prerequisite: Physics 235 and at least one semester of Physics 195. This course may be taken multiple times. Concurrent enrollment in 296 is not allowed.

**296 Studies in Physics, Technology and Society (1).** F and S. This course is identical to Physics 295, except that each student must pursue an instructor-approved project that will produce an in-depth paper as well as an oral presentation. Prerequisite: Physics 235 and at least one semester of Physics 195. This course may be taken multiple times. Concurrent enrollment in 295 is not allowed.

### Advanced Theory Courses

**306 Introduction to Quantum Physics (4).**

\* S. An introduction to non-classical phenomena and their explanation in quantum mechanics. Wave-particle duality of matter and light; the Heisenberg uncertainty principle; Schroedinger's wave mechanics; spin; quantum mechanical treatment of atoms; introduction to statistical mechanics; the quantum mechanical description of solids; introduction to nuclear physics. Prerequisites: Physics 134 or 235, and Mathematics 162. Mathematics 231 is recommended.

**335 Classical Mechanics (3).** \* F, alternate years. The motion of particles and systems in Newtonian terms, covering the assumptions, goals, and methods of Newtonian mechanics, and describing some of its notable successes. Areas of coverage include systems of particles, conservation laws, harmonic motion, central-force motion, rotational motion, and motion in non-inertial reference frames. The status of Newtonian determinism and the question of predictability are also addressed. Prerequisites: Mathematics 162 and at least concurrent enrollment in Physics 235. Mathematics 261 or 232 is recommended.

**336 Classical Mechanics II (3).** \* S, alternate years. Continuation of Physics 335, which is a prerequisite. Coupled oscillators, moment of inertia tensors and extended bodies in rotation. Lagrangian mechanics, the principle of least action, and the Hamiltonian formulation of mechanics. Non-linear systems and chaotic motion.

**345 Electromagnetism (4).** \* F, alternate years. The basic equations of electromagnetism are developed and applied to simple charge and current distributions. Further applications are made to electromagnetic energy and electromagnetic properties of matter. Prerequisite: Physics 235 and Mathematics 261 or 232. Mathematics 231 is also recommended. Not offered 2005-2006.

**346 Advanced Optics (3).** \* S, alternate years. The systematic application of Maxwell's Equations to electromagnetic radiation, including the interaction of light with matter, electromagnetic wave propagation, polarization, interference and diffraction.

Includes a study of technologically significant systems such as waveguides, optical filters and fibers, laser cavities, and some electro-optical technologies. Prerequisites: Physics 246 and Physics 345 or Engineering 302. Not offered 2005-2006.

**347 Relativistic Electrodynamics (1).** \* S, alternate years. Special relativity is reformulated in terms of 4-vectors and this new understanding is used to explicitly articulate the relativistic nature of Maxwell's equations. An introductory understanding of special relativity is assumed. Prerequisites: Physics 134 and concurrent registration in Physics 346. Not offered 2005-2006.

**359 Seminar in Secondary Teaching of Physics (3).** S. A course in perspectives on, principles of, and practices in the teaching of physics and the other natural sciences at the secondary level. Included are teaching strategies, curriculum studies, readings regarding new developments in science education, and considerations of educational uses of statistics and computers. This course should be taken concurrently with Education 346, and provides a forum for the discussion of concerns that develop during directed teaching. This course is part of the professional education program and may not be included in the major or minor in physics.

**365 Thermodynamics and Statistical Mechanics (4).** \* F alternate years. Equations of state, heat capacities, and the laws of thermodynamics. The thermodynamic potentials. Application to some simple systems and changes of phase. Kinetic theory. Statistical mechanics with emphasis on the canonical ensemble. Determination of entropy and the thermodynamic potentials with application to crystals and gases. Introduction to quantum statistical mechanics. Prerequisite: Mathematics 231, Physics 306, and either Physics 134 or Engineering 209. Not offered 2005-2006.

**375 Quantum Mechanics (3).** \* F, alternate years. The main emphasis is on wave mechanics and its application to atoms and molecules. One-electron atoms are discussed in detail. Additional topics discussed are electronic spin and atomic spec-

tra and structure. Nuclei, the solid state, and fundamental particles are also considered. Prerequisite: Physics 306 and Mathematics 231. (Concurrent registration in Mathematics 231 is allowed with permission of the Instructor.) A course including linear algebra is recommended. .

**376 Quantum Mechanics (3).** \* S, alternate years. A continuation of Physics 375, which is a prerequisite.

**390 Independent Study in Physics.** F, I, and S. Independent readings and research in physics under the supervision of a member of the departmental staff. Prerequisite: permission of the chair and supervising professor.

### Laboratory Courses

**380 Great Experiments in Physics (2).** \* F, alternate years. Students recreate several historic experiments that originally led to the development or confirmation of physical theories related to quantum mechanics, nuclear physics, wave-particle duality, relativity, and gravity. Prerequisite: Physics 306.

**381 Electronic Instrumentation (2).** F, alternate years. An introduction to electronic circuits and devices and to their use in scientific measurements. Topics include a review of DC and AC circuits, introductions to diode and transistor characteristics, operational amplifiers, digital logic, and the use of specialized instruments in laboratory measurements. Prerequisite: Physics 235 or permission of the instructor. Not offered 2005-2006.

**384 Laboratory Investigations in Physics (2).** \* S, alternate years. A laboratory-based course in which students choose and complete investigative projects under the supervision of the instructor. The projects are relatively open-ended, with students being responsible for learning background information regarding their topics and becoming familiar with relevant equipment, then designing and conducting open-ended investigations, interpreting their results, and presenting their conclusions. Prerequisite: concurrent registration in Physics 306. Students may concurrently enroll in Physics 395 and use Physics 384 and 395 as a single package.

386 **Advanced Optics Laboratory** (2). \* S, alternate years. This course builds upon the conceptual and laboratory skills developed in Physics 246 by giving students the opportunity to investigate optical phenomena and applications using advanced instrumentation. Each student selects from a list of several multi-week projects in the fields of laser technology, spectroscopy, interferometry, electro-optical devices, non-linear optics, and quantum optics. Prerequisite: Physics 246. Not offered 2005-2006.

395 **Physics Research, Writing, and Presentation** (0-3). \* F, I, and S. Completion

of an approved experimental or theoretical research with presentation of results. The research may be done entirely as part of this course or through another avenue (e.g., summer research with a faculty member or Physics 384). Normally, each student is required to submit a formal, written report and to present results in a department seminar and/or poster presentation. This course may be repeated twice. Prerequisites: A faculty sponsor and approval of the department.

### Graduate Courses

590 **Independent Study**. F, I, and S.

## Political Science

*Professors \*\*R. De Vries, †D. Koopman, J. Penning, C. Smidt, W. Stevenson (chair)*  
*Associate Professors S. Goi, S. Thomas*  
*Assistant Professor A. Patterson*  
*Instructors M. Roberts, R. Vanderhill*

The department offers a variety of courses in the areas of American politics, international relations, comparative politics, and political theory. Students may major in political science or international relations. Those who major in political science may also follow a program of concentration in public administration.

### POLITICAL SCIENCE MAJOR:

#### 33 semester hours

Political Science 101  
 Political Science 207  
 Political Science 240  
 Political Science 251  
 One from Political Science 102, 271, 275, 276, 277, or 279  
 Eighteen additional semester hours from the department, which may include one interim course

### POLITICAL SCIENCE MAJOR: PUBLIC ADMINISTRATION CONCENTRATION (33 semester hours plus four approved cognate courses)

Political Science 101  
 Political Science 202  
 Political Science 207  
 Political Science 209  
 Political Science 212

Political Science 240  
 Political Science 251  
 One from Political Science 102, 271, 275, 276, 277, or 279  
 One from Political Science 208, 310, 314, 317, or 318  
 One internship in either State/Local Government or Washington, D.C. (minimum 6 hours)  
 One Political Science elective (if needed to fulfill 33 hr. major requirement)  
 Four approved cognate courses in Business/Economics (Recommended: Business 160, 203, 204, Economics 151, 221, 222, or 339)

### POLITICAL SCIENCE MINOR:

#### 21 semester hours

One from Political Science 101, 202, 208, 209, 212, 310, 314, 317, or 318  
 One from Political Science 102, 207, 271, 275, 276, 277, 279, 308, or 309