Physics

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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 133, 134, 212, 221, or 223. Science Education Studies 113, formerly Physics 113, also meets the requirement. The entire science core requirement (both physical world and living world) may be met by the two-course sequences of Physics 133-134 or 133-235.

PHYSICS MAJOR

(At least 32 semester hours)
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 170 or 171
Mathematics 172
Mathematics 231 is also recommended
Mathematics 232, 261 or 271 (Mathematics 261 or 271 are 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 satisfies the college's concentration requirement for graduation with a BA degree.

Students wanting a BS 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 BS 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)
Physics 133
Physics 134
Physics 195
Physics 235
Physics 246
Physics 306 and 295 or the combination of Physics 296 and 335

SECONDARY EDUCATION PHYSICS MAJOR

(At least 30 semester hours)

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

The two required upper-level theory courses must be Physics 335 and 345

Only one upper-level experimental module, Physics 384, is required.

Cognates

Mathematics 171 (or 170), 172 and 271 (161, 162 and 261 may substitute)

Science Education Studies 214 and 314

Physics 359 (also listed as Science Education Studies 359)

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. Science education studies 214 and 314 are required cognates.

OPTICS MINOR

(At least 21 hours)

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 (Astronomy 384 and Astronomy 395 may be counted in the 40 hours.);
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 170 or 171
Mathematics 172
Mathematics 231 or 256
Mathematics 261, 271 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: Mathematics 162 or concurrent registration in Mathematics 172. Students currently enrolled in Mathematics 170 or 171 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=mc2. 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: any of Mathematics 132,161, 170 or 171 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: Science Education Studies 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 geometry and algebra. Not open to those who have taken or plan to take Physics 221.

235 **Introductory Physics: Electricity and Magnetism** (4). F. 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 or 172.

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 or 172.

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 or 172.

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 172 (or 162) and at least concurrent enrollment in Physics 235. Mathematics 261, 271 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, 271 or 232. Mathematics 231 is also recommended. Not offered 2009-2010.

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 2009-2010.

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 2009-2010.

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 solids and gases. Introduction to quantum statistical mechanics. Prerequisite: Mathematics 231, Physics 306, and either Physics 134 or Engineering 209. Not offered 2009-2010.

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 spectra 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 2009-2010.

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 2009-2010.

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.