Physics and Astronomy

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Physics is the study of natural phenomena in an attempt to explain the interactions of matter and energy in terms of a limited number of fundamental laws. This study is predicated on careful observation and experimentation, thoughtful analysis, and creative insights. It is both descriptive and prescriptive and encompasses a realm from the submicroscopic particles of the atomic nucleus to the distant constituents of the universe.

In this context, the Physics and Astronomy Department offers a program of study to prepare students for graduate study and for entry-level work as a physicist in government or industry. Fields of study and employment include, but are not limited to, atomic physics, nuclear physics, elementary particle physics, molecular physics, condensed matter physics, quantum electronics, laser optics, astronomy, astrophysics, geophysics, biophysics, medical physics, computational physics, electrical engineering, nuclear engineering, scientific writing and reporting, high school physics teaching, patent law, and scientific equipment sales.

The Department is well equipped, having a particle accelerator, an astronomical observatory, and extensive computer resources. Students pursue research projects under the direction of members of the faculty.

The Department sponsors a local chapter of the national Society of Physics Students. Qualified students are elected to membership in the national honor society, Sigma Pi Sigma. More information about the department can be found on the internet at <http://www.physics.valpo.edu/>.

Qualified students may obtain cooperative education experiences in a variety of employment situations, including research laboratories and industrial and engineering companies. Up to four credits may be counted towards the minimum 28 credit hours needed for a physics major. With departmental approval, PHYS 481-483 or 497 may be substituted for PHYS 445. For further information, refer to Cooperative Education, College of Arts and Sciences, page 56.

Major. A minimum of 28 credit hours in physics and astronomy (32 credits for a Bachelor of Science degree) constitutes a major. Courses must include the core courses PHYS 243, 245, 250, 281, 310, 345, 371, 445 and 499.

Four concentrations within the physics major have been designed to meet students' educational and career goals. The departmental advisor will assist students in selecting the most appropriate physics major emphasis and the courses which apply within the emphasis.

One year of chemistry is recommended. It is assumed that students majoring in physics will acquire competency in at least one computer programming language (FORTRAN, C, C++). Courses in astronomy may be taken as electives.

The Fundamental Physics Concentration is intended for students primarily interested in pursuing a career in physics and who may anticipate graduate study in physics. In addition to the core courses, the following courses may be used to complete the major: PHYS 360, 372, 381, 421, 422, 430, 440. MATH 430 and 434 are also recommended.

The Astronomy and Space Science Concentration is intended for students interested in careers in astronomy and related fields and who might pursue graduate studies in astronomy or space science. In addition to the core courses, the following courses may be used to complete the major: ASTR 101, 190, 221, 252, 390, and 445, the latter substituted for PHYS 445.

The High School Physics Teaching Concentration is intended for students planning to teach physics at the secondary school level. This emphasis combines the physics major with education courses and professional field experience, and includes Physics 489. See the description of the Secondary Education program on page 87 for further details. In addition to the core courses, ASTR 101, 101L, and 221 are recommended.

The Applied Physics Concentration is intended for students interested in the application of physics to problems in a business or industrial environment. In addition to the core courses, students are advised to complete the major by electing courses most closely associated with the physics application intended. Participation in the University's Cooperative Education program (see page 56) is strongly recommended to give the student practical work experience. The Applied Physics option is most useful to students who will seek employment immediately after graduation.

Mechanics and Materials—for careers in research and development fields involving mechanics and materials science. In addition to the major, students are encouraged to complete the Mechanics and Materials minor described below.

Electronics—for careers in research and development fields involving electronic devices. In addition to the major, students are encouraged to complete the Electronics minor described below.

Computational Physics—for computer-related applications of physics and computational problem solving. In addition to the major, students are encouraged to complete the Computer Science minor (page 136).

Industrial Project Management—for management and project leadership in technological and scientific environments in business and industry. In addition to the major, students are encouraged to complete the Liberal Arts Business Minor (page 238).

Physics Minor. A minimum of 16 credit hours in physics and astronomy constitutes a minor. PHYS 142L, 243 and one of ASTR 221, PHYS 245, or PHYS 246 must be included.

Mechanics and Materials Minor. A minimum of 16 credit hours which must include PHYS 109, 252, and 440. Other courses should be selected from PHYS 215, 333, ME 252 and 462.

Electronics Minor. A minimum of 16 credit hours which must include PHYS 342, 372, and 440. Other courses should be selected from PHYS 320, ECE 221, 222, 263, 264, and 315.

Degrees. Completion of the degree requirements of the College of Arts and Sciences with a major in physics leads to the Bachelor of Arts degree or the Bachelor of Science degree.

Credit by Examination. Credit for PHYS 111, 112, 141, or 142 may be earned through the Advanced Placement examinations offered by the College Entrance Examination Board.

Approval of Schedules. All students taking a major or minor in physics and all students planning to teach physics must have their schedules approved by the department advisor.

ASTRONOMY

ASTR 101. Astronomy.
3+0, Cr. 3. A study of the history of mankind's view of the universe including our contemporary understanding of the physical universe. The tools and techniques employed by contemporary astronomers to probe the universe are studied. Topics include the structure of the solar system as revealed by modern space probes, the sun, stellar systems and classification, and the structure and evolution of stars, galaxies and the universe. Special topics such as neutron stars, black holes and the big bang model may also be examined. Only elementary mathematics is required. This course, along with ASTR 101L, may be used to fulfill the Natural Science component of the General Education Requirements. Prerequisite: MATH 110 or placement higher than MATH 110 on the math placement examination.

ASTR 101L. Astronomy Laboratory.
0+3, Cr. 1. Laboratory experiences designed to give students personal experience with astronomical equipment, including the astronomical observatory, and with the analysis of astronomical data. Techniques and skills appropriate to physical sciences will also be stressed. Prerequisite: MATH 110 or placement higher than MATH 110 on the math placement examination. Prerequisite or concurrent registration: ASTR 101 or 252.

ASTR 190. Topics in Astronomy and Space Science.
Cr. 1-2. The study of various topics of current interest in astronomy and space science, on an introductory level. Prerequisites are dependent on the topic. Interested students are urged to consult the instructor or the Department Chair for specific information.

ASTR 221. Observational Astronomy.
0+3, Cr. 1. Practical observational experience using the 16 inch reflecting telescope and astronomical instrumentation including photographic cameras, spectograph and CCD camera and computer. Normally offered in the spring semester of odd numbered years. Prerequisite: ASTR 101 and 101L or 252 or consent of the instructor.

ASTR 252. Introduction to Astrophysics.
3+0, Cr. 3. A study of modern astronomy and the physical principles involved. Topics to be studied include the properties and evolution of stars and galaxies. Problems illustrating the quantitative nature of modern astronomy will be solved. This course along with ASTR 101L may be used to fulfill the Natural Science component of the General Education Requirements. Normally offered in the spring semester of even numbered years. Prerequisite or concurrent registration: MATH 131 or 151 and PHYS 243. Students who have taken ASTR 101 need permission from the Department Chair to also take ASTR 252.

ASTR 390. Topics in Astronomy.
Cr. 1-4. The study of various topics of current interest in astronomy and space science. Prerequisites are dependent on the topic. Interested students are urged to consult the instructor or the Department Chair for specific information.

ASTR 445. Senior Research in Astronomy.
0+3, Cr. 1-2. This course is identical to PHYS 445 but with a specific focus on problems in astronomy. See PHYS 445 for details. Prerequisites: ASTR 221 and 252.

ASTR 492. Research or Reading in Astronomy.
Cr. 0.5-3. Research or reading in astronomy, under the supervision of a faculty member. Prerequisite: consent of the Chair of the Department.

PHYSICS

PHYS 109. Mechanics--Statics.
Cr. 3. (Also offered as GE 109.) A course in the resolution and composition of forces and moments as applied to the free body diagram. Topics include principles of equilibrium, first and second moments of areas, study of trusses, frames and machines, friction. Prerequisite: MATH 131 or 151, and PHYS 141.

PHYS 111. Essentials of Physics.
3+0, Cr. 3. The development of basic concepts of physics emphasizes intuition, logic and experiment rather than complex mathematical analysis. Specific topics included are space, time, motion, energy, conservation laws, fluids, sound and heat. Not open to students who have taken PHYS 141. This course along with PHYS 111L may be used in fulfillment of the Natural Science component of the General Education Requirements. Prerequisite: MATH 110 or placement higher than MATH 110 on the math placement examination.

PHYS 111L. Essentials of Physics Laboratory.
0+3, Cr. 1. Laboratory experiments test and illustrate fundamental physics concepts and laws closely related to those studied in PHYS 111. Emphases are placed on experiential learning and on the development of laboratory skills in physical science. Prerequisite: MATH 110 or placement higher than MATH 110 on the math placement examination. Prerequisite or concurrent registration: PHYS 111. Not open to students who have taken PHYS 141L.

PHYS 112. Essentials of Physics.
3+0, Cr. 3. This course is a continuation of PHYS 111. Specific topics include the study of electricity and magnetism, wave phenomena, optics, relativity, atomic and nuclear physics. Prerequisites: PHYS 111 and 111L or consent of the instructor. This course along with PHYS 112L may be used in fulfillment of the Natural Science component of the General Education Requirements.

PHYS 112L. Essentials of Physics Laboratory.
0+3, Cr. 1. Laboratory experiments test and illustrate fundamental physics concepts and laws closely related to those studied in PHYS 112. Emphases are placed on experiential learning and on the continued development of laboratory skills in physical science. Prerequisite: PHYS 111L. Prerequisite or concurrent registration: PHYS 112. Not open to students who have taken PHYS 142L.

PHYS 141. Physics: Mechanics and Heat.
3+0, Cr. 3. A study of classical mechanics, including static and dynamic systems, and of thermal physics for students of physics, engineering, chemistry and meteorology. Applications of calculus are made as appropriate. This course along with PHYS 141L may be used in fulfillment of the Natural Science component of the General Education Requirements. Prerequisite or concurrent registration: MATH 131 or 151.

PHYS 141L. Experimental Physics I.
0+3, Cr. 1. Laboratory experiments test and illustrate fundamental physics concepts and laws closely related to those studied in PHYS 141. Emphasis is placed on the development of laboratory skills in physics. Prerequisite or concurrent registration: PHYS 141. Not open to students who have taken PHYS 111L.

PHYS 142. Physics: Electricity, Magnetism and Waves.
3+0, Cr. 3. A continuation of PHYS 141 which treats electricity, magnetism, wave motion and optics. Prerequisite: PHYS 141 and 141L or advanced placement by permission of the Chair of the Department, MATH 132 or 152 or concurrent registration. This course along with PHYS 142L may be used in fulfillment of the Natural Science component of the General Education Requirements.

PHYS 142L. Experimental Physics II.
0+3, Cr. 1. Laboratory experiments test and illustrate fundamental physics concepts and

laws closely related to those studied in PHYS 142. Emphasis is placed on the development of laboratory skills in physics. Prerequisite: PHYS 141L. Prerequisite or concurrent registration: PHYS 142. Not open to students who have taken PHYS 112L.

PHYS 151. Physics: Mechanics and Heat - Honors.
3+0, Cr. 3. A study of classical mechanics, including static and dynamic systems, and of thermal physics for students of physics, engineering, chemistry, and meteorology. The pace of this course and the subject matter will be similar to that in PHYS 141. However, students are assumed to be proficient in differential and integral calculus at the outset, and applications of calculus are made throughout the course. This course along with PHYS 141L may be used in fulfillment of the Natural Science component of the General Education Requirements. Prerequisite: MATH 132 or 152 or concurrent registration, equivalent AP credit, or the permission of the instructor.

PHYS 152. Physics: Electricity, Magnetism and Waves - Honors.
3+0, Cr. 3. A continuation of PHYS 151 which treats electricity, magnetism, wave motion and optics. This course along with PHYS 142L may be used in fulfillment of the Natural Science component of the General Education Requirements. Prerequisite: PHYS 151 or consent of the instructor. Corequisite: MATH 132 or 152.

PHYS 215. Mechanics of Materials.
Cr. 3. (Also offered as CE 215.) Concepts of stress and strain, stress-strain relationships, states of plane stress and strain at a point; elementary analysis of stress distributions and deformations for axial loading of prismatic members, torsional loading of circular shafts and bending of beams, combined loading; plastic elastic action, and an introduction to statically indeterminate problems. Prerequisite: MATH 132 and PHYS 109.

PHYS 243. Physics: Atoms and Nuclei.
Cr. 3. An introduction to the special theory of relativity, physics of the atom, the Schroedinger wave equation, physics of condensed matter, physics of the nucleus including radioactivity, and elementary particles. Prerequisites: PHYS 142 and MATH 132 or 152 (may be taken concurrently).

PHYS 245. Experimental Physics III.
0+3, Cr. 1. Selected experiments include both the measurement of fundamental constants such as the speed of light, Planck's constant, the gravitational coupling constant, as well as investigations of fundamental physical processes. The further development of laboratory skills and methods of data analysis are emphasized, using advanced computer analysis and data acquisition techniques. Prerequisite: PHYS 142 and 142L. Normally offered in spring semesters.

PHYS 246. Data Reduction and Error Analysis.
Cr. 1. The study and application of various techniques employed in the reduction and analysis of laboratory data to include probability distributions, regressions, tests of goodness of fit, data smoothing and the methods for determining the errors of measured and fitted parameters. Extensive use of the computer is expected. Prerequisite: MATH 253.

PHYS 250. Mechanics.
Cr. 3. The classical mechanics of particles, systems of particles and rigid bodies, utilizing analytical techniques of vectors and differential and integral calculus. Among the topics included are Newton's laws of motion in one and three dimensions, conservation laws, harmonic oscillation, central force motion, scattering and an introduction to rigid body motion. Prerequisites: PHYS 142 and MATH 253 (may be taken concurrently).

PHYS 252. Materials Science.
2.5+1.5, Cr. 3. (Also offered as ME 252.) A study of structure-property-processing relationships of engineering materials related to their selection in design and manufacturing processes. Based on an understanding of atomic and crystal structure, the methods of controlling structure and mechanical properties of materials are studied with an emphasis on strengthening mechanisms. Processes studied include solidification, phase transformation, and mechanical working of metals. A field trip to an industrial facility is arranged. Prerequisite: MATH 132 or 152.

PHYS 281. Electricity and Electronics.
2.5+1.5, Cr. 3. (Also offered as ECE 281.) A study of the fundamental methods of electric circuit analysis with emphasis on computer-aided analysis. AC and DC circuits, operational amplifiers. Laboratory exercises emphasize measurement techniques and reinforce lecture material. Prerequisite: PHYS 142 and 142L.

PHYS 322. Embedded Microcontrollers.
2.5+1.5, Cr. 3. (Also offered as ECE 322). The application of microcontrollers in embedded system design, emphasizing the interaction of hardware and software design. Use of assembly language programming to interface external hardware to a microcontroller. Prerequisite: ECE 221 with a minimum grade of C.

PHYS 333. Mechanical Measurements Laboratory.
3+3, Cr. 4. (Also offered as ME 333.) A study of fundamental concepts and physical principles involved in the science of measurement. Experiments involve calibration and testing (both static and dynamic) of primary elements, signal amplifiers, transducers and readout devices.

Experimentation utilizes laboratory and industrial instruments. Extensive use is made of computer data acquisition and spreadsheets. Prerequisite: PHYS 142.

PHYS 342. Electronics.
3.5+1.5, Cr. 4. (Also offered as ECE 340.) An introduction to semiconductor theory and the design and analysis of electronic circuits. Topics include diodes, bipolar and field effect transistors, single-stage and multistage amplifiers, frequency response, and feedback. Computer simulation is included as an analysis and design tool. Laboratory experiments emphasize evaluation of circuit performance and measurement techniques. Prerequisite: ECE 263 or permission of the instructor.

PHYS 345. Experimental Physics IV.
0+3, Cr. 1. Experiments in radiation detection and analysis using modern modular electronics. Prerequisites: PHYS 243, 245, and 246 and MATH 253.

PHYS 360. Thermal Physics.
Cr. 3. A study of the basic principles of thermodynamics, kinetic theory and elementary statistical mechanics. Among the topics included are equations of state, laws of thermodynamics, reversibility, entropy, kinetic theory, transport phenomena and statistical description of systems of particles. Normally offered in the spring semester of odd numbered years. Prerequisite: PHYS 243.

PHYS 371. Electromagnetic Fields.
Cr. 3. A study of electric and magnetic fields, their sources and interactions in vacuum and in dielectric and magnetic media. Prerequisites: PHYS 250 and MATH 234 or 265 or 350.

PHYS 372. Electromagnetic Waves and Physical Optics.
Cr. 3. Proceeding from Maxwell's equations, students investigate the wave aspects of electromagnetic fields including propagation, reflection, refraction, polarization, interference and diffraction. Other topics include radiating systems and wave guides. Normally offered in the spring semester of odd numbered years. Prerequisite: PHYS 371.

PHYS 381. Advanced Mechanics.
Cr. 3. The application of advanced mathematical methods to physical problems. Topics may include Lagrange's method, small oscillation theory including coupled oscillators, generalized rotation, the theory of special relativity, numerical methods and perturbation theory. Normally offered in the fall semester of even numbered years. Prerequisites: PHYS 250 and MATH 234 or 265 or 350 (may be taken concurrently).

PHYS 390. Topics in Physics.
Cr. 1-4. A study of various topics of current interest in physics. Prerequisites are dependent upon the topic. Interested students are urged to contact the instructor or Chair of the Department for specific information.

PHYS 421. Quantum Mechanics I.
Cr. 3. The fundamental concepts and principles of quantum physics are developed in a mathematically rigorous way and applied to atomic, nuclear and solid state physics. Topics include the fundamental postulates of quantum mechanics, the Schroedinger equation, and selected topics such as the harmonic oscillator, orbital and spin angular momentum, the hydrogen atom, identical particles, elementary matrix mechanics, multi-electron atoms, and collision theory. Normally offered in the fall semester of odd numbered years. Prerequisites: PHYS 243 and MATH 234 or 265 (both of which may be taken concurrently with permission of the instructor).

PHYS 422. Quantum Mechanics II.
Cr. 3. A continuation of PHYS 421, with further development and application of quantum theory. Topics may include time independent and time dependent perturbation theory with applications, scattering theory, matrix mechanics, multi-electron and molecular systems, elementary Hartree-Fock theory, superconductivity, and elementary relativistic quantum mechanics. Normally offered in the spring semester of even numbered years. Prerequisite: PHYS 421 or the permission of the instructor.

PHYS 430. Nuclear Physics.
Cr. 3. Nuclear physics for students with physics or engineering backgrounds. Topics include nuclear models, nuclear reactions, alpha, beta, and gamma radioactivity, and fission physics. Prerequisite: PHYS 243. Normally offered in the spring semester of even numbered years.

PHYS 430L. Nuclear Physics Laboratory.
0+3, Cr. 1. An advanced laboratory to study nuclear reactions, nuclear structure, radioactivity. Experiments may use the 300 keV particle accelerator and a neutron howitzer. Prerequisites: PHYS 246 and 345; corequisite: PHYS 430. Normally offered in the spring semester of even numbered years.

PHYS 440. Condensed Matter Physics.
Cr. 3. A presentation of the basic concepts of the quantum theory of matter, with emphasis on physical models which provide a quantitative description of the solid state. Topics includes crystal structure, diffraction, the reciprocal lattice, chemical bonding in molecules and solids, lattice dynamics, phonons, thermal properties,

the free electron gas, electrons in a periodic lattice, band structure, semiconductors, magnetic and optical properties, and superconductivity. Normally offered in the spring semester of odd numbered years. Prerequisites: PHYS 243.

PHYS 445. Senior Research in Physics.
0+3, Cr. 1-2. Each student undertakes a physics research problem. A written report and an oral presentation at the Physics Colloquium are required. Student research problems must be approved by the Department. Prerequisite: consent of the Chair of the Department. Two credits are required for the physics major. May be taken as two credits in one semester or preferably as one credit in each of two consecutive semesters.

PHYS 481. Cooperative Education in Physics I.
Cr. 0.5-3. Experience in basic or applied physics with a cooperating employer. Midterm and final written reports required. Prerequisites: PHYS 245 and approval of the Chair of the Department. S/U grade.

PHYS 482-483. Cooperative Education in Physics II-III.
Cr. 0.5-3. Continuation of PHYS 481. Midterm and final written reports required. Prerequisites: PHYS 481 and approval of the Chair of the Department. S/U grade. May be repeated beyond 483 for additional credit.

PHYS 489. The Teaching of Natural Sciences.
Cr. 3. (See ED 489.) A study of the methods of teaching natural sciences in the secondary schools. This course may not be counted toward a major or a minor in Physics. Prerequisite: admission to Teacher Education.

PHYS 490. The Scientific Endeavor.
Cr. 3. An exploration of the scientific enterprise involving a study of foundational principles and assumptions of the scientific endeavor, its various methodologies, and its scope and limitations. This will include illustrations from historical case studies and "scientific revolutions". Students will also study the ethical and moral connections between their personal and professional science lives. Prerequisite: junior or senior standing. This course may not be used to fulfill the minimum requirements of a physics major.

PHYS 492. Research or Reading in Physics.
Cr. 0.5-3. Research or reading in physics, under the supervision of a faculty member. Prerequisite: consent of the Chair of the Department.

PHYS 497. Honors Work in Physics.
Cr. 3. See Honors Work, page 54.

PHYS 498. Honors Candidacy in Physics.
Cr. 3. See Honors Work, page 54.

PHYS 499. Physics Colloquium.
Cr. 0. All physics majors are expected to register for this course. S/U grade.