Professor: Gregory Elliott; David Latimer, *Chair*; Andrew Rex; Amy Spivey; Rand Worland

Associate Professor: Rachel Pepper, *William D. and Flora McCormick Chair in Biophysics*

Visiting Assistant Professor: Tsunefumi Tanaka

Instructor: Bernard Bates

About the Department

The department addresses the needs of physics majors, Dual Degree Engineering students, and other science majors. The department also supports the university's liberal arts emphasis by providing coursework for students majoring in all areas, in order to broaden their intellectual reach. Several courses for non-science majors focus on the historical development of scientific ideas and the connection of physics with other realms of human endeavor.

The mission of the Department of Physics is to educate undergraduate students in the fundamental ideas and methods of physics. The department strives to provide an environment of scientific inquiry and discovery on the part of both students and faculty. It offers a curriculum of classical and modern physics that prepares students for careers as scientists and citizens. Students who complete a Physics major will gain the following skills and proficiencies:

1. Problem-solving skill in a variety of disciplines, including classical mechanics, waves and optics, electromagnetism, quantum mechanics, and relativity;
2. Ability to apply higher-level mathematical reasoning in the process of problem-solving, using mathematical tools that include calculus of one and more than one variable, linear algebra, ordinary differential equations, and partial differential equations;
3. Proficiency in laboratory work, through a minimum of four semesters of lab-based courses;
4. Ability to express their work clearly in writing, including written reports on their laboratory work that contain discussion of results, quantitative reasoning, and error analysis; and
5. Use computers to solve problems related to the physical world that lack simple analytical solutions.

The Bachelor of Science degree is appropriate for students who are planning advanced studies in physics or are interested in careers in engineering, biophysics, astronomy, meteorology, oceanography, geophysics, mathematical physics, education, law, environmental physics, and the history and philosophy of science. The Bachelor of Arts degree for dual degree engineering students is appropriate for students who are interested in undergraduate studies in physics and who complete their studies at an engineering institution through the DDE program.

Independent research projects and senior thesis presentations are encouraged of all Physics majors. Students who complete distinguished projects will be eligible for graduation with Honors in Physics.

General Requirements for the Major or Minor

General university degree requirements stipulate that 1) at least four units of the major or three units of the minor be taken in residence at Puget Sound; 2) students earn a GPA of 2.0 in courses taken for the major or the minor; and 3) all courses taken for a major or minor must be taken for graded credit. Any exceptions to these stipulations are indicated in the major and minor degree requirements listed below.

Requirements for the Major

Before declaring a physics major, students should schedule an appointment with the department chairperson. This will usually be held no later than a student's fourth semester.

Bachelor of Science

1. PHYS 121, 122, 221, 222, 305, 351, 352, and 411, and one elective at the 200 level or higher and one elective at the 300 level or higher from: 209, 231, 299, 310, 322, 363, 412, 493;
2. MATH 180, 181, 280, 290, and 301.

Bachelor of Arts (Engineering, Dual Degree)

Degree is awarded upon completion of Baccalaureate in Engineering.

1. PHYS 121, 122, 221, 305, 351, and two additional upper-division (209 or higher) courses;
2. MATH 180, 181, 280, 290, and 301, or equivalent;
3. CHEM 110/120 or 115/230; and
4. CSCI 161, or equivalent.

Requirements for the Physics Minor

PHYS 121/122 (or 111/112); three additional units at least one of which must be at the 300 level or higher. (Ordinarily PHYS 109 will not satisfy this requirement.)

Notes:

For students pursuing the BS in Physics, there are two grade level requirements in the first two years of course work. The department chair may waive these requirements under appropriate circumstances. Students pursuing the BA in Physics for the Dual Degree Engineering program and other students interested in upper level physics courses are not subject to these requirements.

1. A minimum grade of C- is required in Physics 122 to continue on to Physics 221, and a minimum grade of C- in Physics 221 is required to continue on to Physics 222.
2. To pursue the major with 300 level courses and higher, a GPA of at least 2.0 is required for all 100 and 200 level physics courses required for the major, and a GPA of 2.0 is required for all 100 and 200 level math courses required for the major.

The Physics Department does not restrict the applicability of courses to major or minor requirements based on the age of the course.

Requirements for the Biophysics Minor

Completion of five units to include:

1. BIOL 111 (Unity of Life: Cells, Molecules, and Systems)
2. PHYS 111/112 or 121/122 (Introductory Physics Sequence)
3. BIO/PHYS 363 (Biophysics). *This course has a prerequisite of Math 180 or instructor permission.*
4. An additional elective course chosen from: BIOL 112, 212, 362, NRSC 201, PHYS 310, CSCI 16, EXSC 336, and CHEM 460.

In addition to the courses above, students must satisfy one of the following:

a) At least one of the courses used to satisfy the minor must be from outside the course requirements of the student's major.
or
b) Completion of an internship, research experience, or outreach experience in biophysics which must be approved in advance.

Students must meet with a biophysics advisor and submit an application for internship/research/outreach prior to the end of the second semester of their junior year.

Course Offerings

Unless otherwise specified, each course carries 1 unit of credit and is offered at least once each academic year. Please see "Frequency of Course Offerings" on page 18.

Seminars in Scholarly Inquiry. *See Seminars in Scholarly Inquiry in the Core Curriculum section of this Bulletin for course descriptions (page 18).*

SSI1/SSI2 108 Empowering Technologies: Energy in the 21st Century
SSI1 119 Water in the Western United States
SSI2 123 The Search for Extraterrestrial Intelligence

Other courses offered by Physics Department faculty *See Connections in the Core Curriculum section of this Bulletin for course descriptions (page 34).*

STS 314 Cosmological Thought
Satisfies the Connections core requirement.
STS 345 Science and War in the Modern World
Satisfies the Connections core requirement.
STS 348 Strange Realities: Physics in the Twentieth Century
Satisfies the Connections core requirement.
STS 361 Mars Exploration
Satisfies the Connections core requirement.

Physics (PHYS)

109 Astronomy A survey of descriptive and physical astronomy, which are given roughly equal emphasis. Descriptive astronomy involves time reckoning, calendars, and the motions of the sun, moon, and planets. Physical astronomy deals with the composition and origin of the planets and solar system, as well as the evolution of stars and galaxies. A weekly laboratory is required. *Satisfies the Natural Scientific core requirement.*

111 General College Physics This course is designed for any interested student regardless of major, although some majors require the calculus-based PHYS 121 course instead. Fundamental principles of mechanics, gravity, and oscillations are covered. Although it is assumed that the student brings only a background of high school algebra and geometry, additional mathematical concepts are developed within the course. A weekly laboratory is required. *Prerequisite: Credit will not be granted to students who have completed PHYS 121. Satisfies the Natural Scientific Approaches core requirement.*

112 General College Physics This course is designed for any interested student regardless of major, although some majors require the calculus-based PHYS 122 course instead. Fundamental principles of thermodynamics, sound, optics, electricity, magnetism, and nuclear physics are covered. Although it is assumed that the student brings only a background of high school algebra and geometry, additional mathematical concepts are developed within the course. A weekly laboratory is required. *Prerequisite: PHYS 111 or 121. Credit will not be granted to students who have completed PHYS 122. Satisfies the Natural Scientific Approaches core requirement.*

121 General University Physics This course is the first in a sequence of calculus-based introductory physics classes and is required for the physics major and some other science majors. Fundamental principles of mechanics, gravity, and oscillations are covered. A weekly laboratory is required. *Prerequisite: MATH 180 or its equivalent (may be taken concurrently). Credit will not be granted to students who have completed PHYS 111.Satisfies the Natural Scientific Approaches core requirement. Offered fall semester.*

122 General University Physics This course is the second in a sequence of calculus-based introductory physics classes and is required for the physics major and some other science majors. Fundamental principles of thermodynamics, electricity, and magnetism are covered. A weekly laboratory is required. *Prerequisite: PHYS 121 and MATH 181 (may be taken concurrently). Credit for PHYS 122 will not be granted to students who have completed PHYS 112. Satisfies the Natural Scientific Approaches core requirement. Offered spring semester.*

202 Research in Fusion Reactor Physics 0.25 units. This course explores the principles of nuclear fusion through the engineering of an inertial electrostatic confinement (IEC) nuclear reactor. Students gain both theoretical knowledge and practical skills on a diverse range of topics, including vacuum systems, high-voltage electrical systems, computer controls and sensing, radiation safety, and fabrication. The course is inquiry-based and student-centered. As such, students in this course are expected to design and carry out independent research and communicate their findings to the class and public. No prior knowledge is required for this course. *Prerequisite: Permission of the instructor. Pass/Fail Required.*

205 Physics of Music This course is intended primarily for students having some background in music. The scientific aspects of musical sound are treated including the basic physics of vibrating systems, wave phenomena, and acoustics and their applications to musical instruments and musical perception. A weekly laboratory is required. *Prerequisite: One semester of college-level music theory, formal music training, or permission of the instructor. Satisfies the Natural Scientific core requirement.*

209 Introduction to Astrophysics Astrophysics is the application of the laws and principles of physics to answer questions about the cosmos. This course develops the physics necessary to understand the origins, properties, and evolution of planets, stars and galaxies as well as investigating the application of physics to questions of cosmological significance. The semester is divided between studying the theoretical tools astrophysicists have developed and using those tools with several small hands-on archival data analysis tutorials. Each student will end the semester by completing an individual observational or theoretical research project. *Prerequisite: PHYS 121/122 and MATH 180/181 or permission of the instructor. Offered every other year.*

221 Modern Physics I The physics of waves is studied with emphasis on the nature of light, including propagation, interference, diffraction, and polarization. The constant speed of light leads to a careful study of the theory of special relativity. A weekly laboratory is required. Prerequisite: PHYS 122 and MATH 280 (may be taken concurrently). Satisfies the Natural Scientific core requirement. Offered fall semester.

222 Modern Physics II A continuation of PHYS 221, this course is an introduction to quantum mechanics with applications to atomic and solid state systems. A weekly laboratory is required. *Prerequisite: PHYS 221. Satisfies the Natural Scientific core requirement. Offered spring semester.*

231 Circuits and Electronics This course is intended to teach the fundamental behavior of electronic components and their applications in various circuits. A balance of lecture and laboratory experience demonstrates the practical method of investigation of electronic devices. Original design of electronic circuits is emphasized. Topics include AC

and DC circuit analysis, amplifiers, active and passive filters, operational amplifiers, and digital electronics. *Prerequisite: PHYS 112 or 122. Offered every other year.*

299 The History and Practice of Ancient Astronomy This course treats the ancient astronomical tradition from its beginnings around 700 BC down to its culmination in the astronomical Renaissance of the sixteenth century. Attention is devoted not only to the emergence of astronomy as a science, but also to the place of astronomy in ancient life, including its use in time-telling, and its affiliations with literature and philosophy. The treatment of ancient technical astronomy is thorough enough to permit the student to apply ancient techniques in practical problems, e.g., in the design of sundials and the prediction of planet positions. Concrete models and scale drawings are used to deepen understanding and to simplify analysis, but some geometry is required. *Prerequisite: One course satisfying the Humanistic Approaches core requirement. Satisfies the Natural Scientific core requirement.*

305 Analytical Mechanics This introduction to mechanics begins with the formulation of Newton, based on the concept of forces and ends with the formulations of Lagrange and Hamilton, based on energy. The undamped, damped, forced, and coupled oscillators are studied in detail. *Prerequisite: PHYS 122 and MATH 301 (may be taken concurrently), or permission of the instructor. Offered fall semester.*

310 Statistical Mechanics and Thermodynamics Newtonian mechanics and methods of probability are combined and used to gain new insights regarding the behavior of systems containing large numbers of particles. The concept of entropy is given new meaning and beauty. Certain properties of metals and gases are derived from first principles. The analysis of spectra leads to the initial development of the quantum theory and the statistics obeyed by fundamental particles. This course assumes a knowledge of calculus. *Prerequisite: PHYS 305 and MATH 280 or permission of the instructor. Offered every other year.*

322 Experimental Physics An introduction to experimental physics, involving independent work on several physical systems. *Prerequisite: PHYS 221 or permission of the instructor. Offered every other year.*

351 Electromagnetic Theory Theory of electrostatic and magnetostatic fields is discussed, with emphasis on the theory of potential, harmonic functions, and boundary value problems. *Prerequisite: PHYS 122, MATH 280, and MATH 301 (may be taken concurrently). Offered fall semester.*

352 Electromagnetic Theory This is a continuation of PHYS 351, emphasizing radiation, the propagation of electromagnetic waves, and the theory of special relativity. *Prerequisite: PHYS 351. Offered spring semester.*

363 Biophysics This course explores the principles of physics applied to living systems. Topics include diffusion, hydrodynamics and the low Reynolds-number world, importance of entropy and free energy, entropic forces, molecular machines, membranes, and nerve impulses. Written and oral scientific communication is emphasized. This course is appropriate for junior or senior undergraduates in the sciences, particularly physics and biology. No specialized knowledge of biology or physics is expected, but a facility with algebraic manipulations and a working knowledge of calculus is needed. *Cross-listed as BIOL/PHYS 363. Prerequisite: Math 180 and Physics 111 or 121; and either BIOL 212 or a 300-level course in Biology or Physics; or permission of the instructor.*

390 Directed Research Variable credit up to 1.00 unit. This course provides a theoretical or experimental physics research experience for juniors or seniors under the direction of a faculty mentor in the Department of Physics. The research will result in a written summary of the research results. *Prerequisite: Completion of Directed Research Contract with permission of research mentor, to be approved by department chair and Registrar before student registers. May be repeated for credit up to 1.00 unit. Offered every semester.*

411 Quantum Mechanics I This course is an introduction to the quantum theory of matter. The emphasis is on exactly soluble systems including the infinite square well, harmonic oscillator, and hydrogen atom. The theory of angular momentum is also discussed. *Prerequisite: PHYS 305, PHYS 351, MATH 290, and MATH 301, or permission of the* instructor. *Offered fall semester.*

412 Quantum Mechanics II This is a continuation of Physics 411. The emphasis is on achieving perturbative solutions to real physical systems. Topics may include time-independent and dependent perturbation theory, the WKB method, a discussion of the interaction between light and matter, and scattering. *Prerequisite: PHYS 411, or permission of instructor. Offered spring semester.*

491 Senior Thesis Variable credit up to 1.00 unit. Research may be undertaken under the supervision of a faculty member on a topic agreed upon and described in a proposal to the supervising instructor. *May be repeated for credit up to 1.00 unit. Cannot be audited.*

492 Senior Thesis Variable credit up to 1.00 unit. Research may be undertaken under the supervision of a faculty member on a topic agreed upon and described in a proposal to the supervising instructor. *May be repeated for credit up to 1.00 unit. Cannot be audited.*

493 Advanced Special Topics in Physics Advanced topics in mechanics, optics, quantum mechanics, or other fields are studied. This course is offered in response to student interest in particular advanced topics. *Prerequisite: PHYS 305 and 351 or permission of the instructor. May be repeated for credit. Offered occasionally.*

495/496 Independent Study Variable credit up to 1.00 unit. Independent study is available to those students who wish to continue their learning in an area after completing the regularly offered courses in that area. *May be repeated for credit up to 4.00 units. Cannot be audited. Cannot be taken Credit/No Credit.*

498 Internship Seminar This scheduled weekly interdisciplinary seminar provides the context to reflect on concrete experiences at an off-campus internship site and to link these experiences to academic study relating to the political, psychological, social, economic and intellectual forces that shape our views on work and its meaning. The aim is to integrate study in the liberal arts with issues and themes surrounding the pursuit of a creative, productive, and satisfying professional life. Students receive 1.0 unit of academic credit for the academic work that augments their concurrent internship fieldwork. This course is not applicable to the Upper-Division Graduation Requirement. Only 1.0 unit may be assigned to an individual internship and no more than 2.0 units of internship credit, or internship credit in combination with co-operative education credit, may be applied to an und *May be repeated for credit. Cannot be audited. Cannot be taken Credit/No Credit.*