Professor: Gregory Elliott, James Evans (on leave 2018-2019); Andrew Rex; Amy Spivey (on leave spring 2019); Rand Worland, *Chair*

Associate Professor: David Latimer (on leave fall 2018); 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, 412, 494
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 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 105, 107, and 109 will not satisfy these requirements.)

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 grade of C- is required in Physics 122 to continue on to Physics 221, and a 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 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.

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 10.

Seminars in Scholarly Inquiry. *See Seminars in Scholarly Inquiry in the Core Curriculum section of this Bulletin for course descriptions (page 10).*

SSI1/SSI2 108 Empowering Technologies: Energy in the 21st Century
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 24).

HON 212 Origins of the Modern World View
Satisfies the Natural Scientific Approaches core requirement.

STS 314 Cosmological Thought
Satisfies the Connections core requirement.

STS 345 Physics in the Modern World: Copenhagen to Manhattan
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.

109 Astronomy A survey of descriptive and physical astronomy, which are given roughly equal stress. 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 Approaches core requirement.*

111/112 General College Physics This two-semester sequence of courses is designed for any interested student regardless of his or her major. The fundamental branches of physics are covered, including mechanics, heat, sound, optics, electricity, magnetism, and nuclear physics. Although it is assumed that the student brings only a background of high school algebra, trigonometry, and geometry, additional mathematical concepts are developed within the course. A weekly laboratory is required. *Credit for PHYS 111 will not be granted to students who have completed PHYS 121; credit for PHYS 112 will not be granted to students who have completed PHYS 122. Prerequisite: PHYS 111 or 121 is a prerequisite for PHYS 112. Each course satisfies the Natural Scientific Approaches core requirement.*

121 General University Physics Fundamental principles of mechanics (including rotational motion and oscillations) and gravity are treated. A weekly laboratory is required. *Credit for PHYS 121 will not be granted to students who have completed PHYS 111. Prerequisite: MATH 180 (may be taken concurrently). Satisfies Natural Scientific Approaches core requirements. Offered fall term only.*

122 General University Physics Fundamental principles of heat, electricity, and magnetism are treated. A weekly laboratory is required. *Credit for PHYS 122 will not be granted to students who have completed PHYS 112. Prerequisite: PHYS 121 and MATH 181 (may be taken concurrently). Satisfies the Natural Scientific Approaches core requirement. Offered spring term only.*

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. *Recommended: one semester of college-level music theory, formal music training, or permission of instructor. Satisfies the Natural Scientific Approaches 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 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 Approaches core requirement. Offered fall term only.*

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 Approaches core requirement. Offered spring term only.*

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. 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 timetelling, 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. Satisfies the Natural Scientific Approaches 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 concurrent), or permission of instructor. Offered fall term only.*

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 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 301 (may be taken concurrently). Offered fall term only.*

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

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. *Crosslisted with BIOL 363. Prerequisites: Math 180 and either Physics 111 or 121 are required, as is either Biology 212 or a previous 300-level course in biology or physics, or permission of instructor.*

390 Directed Research Variable credit: 0.25 .50 or 1.0 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. Offered each semester, including summer.*

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, and MATH 301, or permission of instructor. Offered fall term only.*

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 term only.*

491/492 Senior Thesis Credit, variable 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.

493/494 Special Topics in Theoretical 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, 351, or permission of instructor. Offered occasionally.*