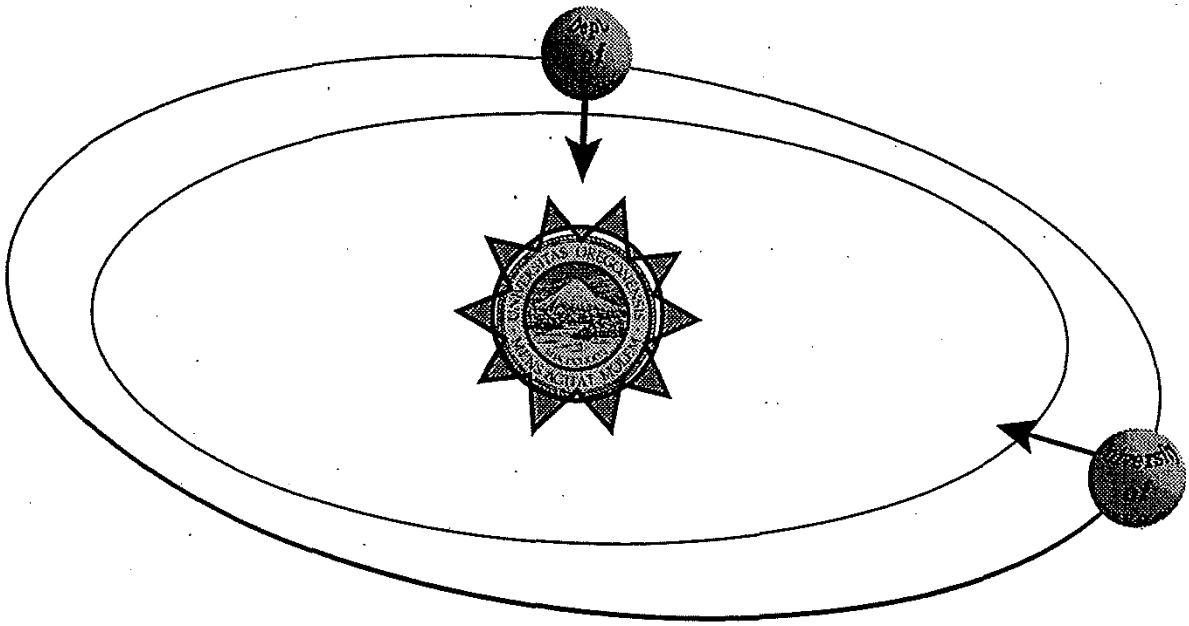
Undergraduate Program in Physics



University of Oregon

Department of Physics

University of Oregon
Undergraduate Program in Physics

Why study physics?

Physics is that branch of science which applies the laws of nature towards understanding the physical world in quantitative detail. Students who pursue a bachelor's degree in physics will learn how these laws can systematically be applied to understand diverse phenomena and solve seemingly complex problems. For example, in quantum physics courses students apply the principles of quantum mechanics to subjects as diverse as atoms in lasers and nuclei undergoing fusion in the sun. The analytical and problem solving skills acquired in the study of physics will serve students well regardless of what career path they choose after graduation.

Careers

Some students who earn a bachelor's degree in physics continue their studies towards a graduate degree in physics or a related field of natural science or engineering. Others opt to apply their analytical and problem-solving skills to a variety of jobs ranging from medical physics to semiconductor design to financial analysis. Students who have demonstrated their abilities with a good record in an undergraduate physics program are generally considered very favorably for admission to professional schools.

Course of Study

The Physics Department offers a special introductory sequence designed for physics majors. This sequence provides an excellent opportunity for incoming majors to begin their physics studies with ample individual attention. Class sizes are typically 15 to 25 students at upper-division levels in the physics major program, and courses taught by faculty who bring their research interests to the classroom.

Undergraduate Physics major Susan Kasper coats thin films with a silver nitrate solution

Sample Physics Major Program (for Graduate School Bound Students)

	Major Core Minimum of B.S.	Recommended Enhancements	Required Related Subjects	University Requirements
First Year	Foundations of Physics I (251, 252, 253)		Calculus and Chemistry	Composition
Second Year	Foundations of Physics II (351, 352, 353) Intermediate Lab (391, 392, 393)		Differential Equations and Several Variable Calculus	Group- satisfying courses from Arts & Letters and Social Sciences (16 credits each)
Third Year	Mechanics, Electricity & Magnetism (411, 412, 413) 6 cr. Hours upper-division labs	Electives in Physics from Electromagnetism, Optics, Math Methods, & Astrophysics	Electives in Mathematics from Complex Variables, Partial Diff. Equations, Linear Algebra	Multicultural Courses (2 courses required)
Fourth Year	Quantum Physics (414, 415, 417)	Physics Labs from Electronics, Optics Advanced Lab		

The course requirements and suggested electives for graduate school-bound students are shown in the chart above. Students who will seek employment in industry with a bachelor's degree in physics should consider the applied emphasis (see chart on the next page), an alternative to the graduate school-bound track. Students pursuing a career in the semiconductor or another technical industry might consider the Industrial Internship or Applied Master's Degree programs.
Students who wish to start physics their first year at the university should come prepared to study calculus.

Engineering Preparation

Students interested in engineering may complete preparatory course work at the University of Oregon before enrolling in a professional engineering program at Oregon State University or elsewhere. The physics and math courses needed for engineering preparation typically enroll 20 to 40 students. The Department of Physics coordinates a three-plus-two program that allows students to earn a bachelor's degree in physics or chemistry from the University of Oregon and one in engineering from Oregon State University.

Industrial Internship-Master's Degree Programs

Students who successfully complete the undergraduate program in physics can apply to one of two industrial internship programs leading to a Master's degree in physics. The Semiconductor Science program entails summer coursework in Semiconductor Processing and Characterization Techniques and the Device Processing and Characterization Lab. The Polymer Science program requires taking summer classes in Polymer Chemical Physics and the Polymer Synthesis and Characterization Lab. After summer coursework, both programs place students in 6- or 9-month long industry internships for which they are paid and graduate course credit is received. Finally, those wishing to complete requirements for a Master's degree must complete one additional, year-long, graduate course sequence.

Applied Master's Program

Students with an undergraduate degree in physics can apply to the Applied Masters Program in physics. The curriculum for this program is flexible and includes concentrations in semiconductor processing, optics, and photonics, computational physics and modeling, and entrepreneurship. Students normally enter the program in the fall of a given year and can expect to finish their coursework the following summer, to be followed by a paid industrial internship or alternative research practicum.

Facilities

The Physics Department is housed in the beautifully constructed Willamette Hall (see photo on front cover). Laboratory facilities for undergraduates include specialized introductory lab rooms as well as state-of-the-art advanced optics and electronics laboratories. All laboratories are equipped with microcomputers to aid students in data acquisition and analysis. The department also has a comprehensive program of physics demonstrations to be used in conjunction with introductory and advanced courses. The Physics Department reading room, a study area in Willamette Hall, is available to physics majors.

Faculty Research Interests

Current research areas include astronomy and astrophysics, atomic and molecular physics, biophysics, chemical physics, condensed matter theory, elementary particle physics, nuclear physics, physics education research, quantum optics, solid state physics, statistical mechanics, superfluid mechanics and areas of applied physics. Additional interdisciplinary research is carried out together with the institutes of Molecular Biology, Chemical Physics, Materials Science, Optics, and Theoretical Science. This vigorous research activity provides numerous opportunities for the participation of undergraduate students.

Special Awards

The Graduate School at the University of Oregon has two programs for undergraduates which are designed to encourage diversity at the graduate level. The *Women in the Physical Sciences* program allows qualified junior and senior women, who are interested in pursuing graduate studies, to apply for merit-based tuition waivers. A similar, university –wide program, *Target of Opportunity Laurel Awards Program,* is available to students of color.

Sample Physics Major Program (for Applied Emphasis Students)

	Major Core Minimum of BS	**Recommended Enhancements**	**Required Related Subjects**	**University Requirements**
First Year	Foundations of Physics I (251, 252, 253)		Calculus and Chemistry	Composition
Second Year	Foundations of Physics II (351, 352, 353) Intermediate Lab (391, 392, 393)		Differential Equations and Several Variable Calculus	Group-satisfying courses from Arts & Letters and Social Sciences (16 credits each)
Third Year	Electricity & Magnetism (412, 413) Applied Quantum Physics (354) Analog & Digital Electronics (432, 433)	Electives in Physics from Electromagnetism, Optics, Math Methods, & Astrophysics	Electives in Mathematics from Complex Variables, Partial Diff. Equations, Linear Algebra	Multicultural Course (2 courses required)
Fourth Year	Classical & Modern Optics (424, 425) Design of Experiments (481) 6 credits upper-division labs	Physics Laboratories from Physics Instrumentation, Modern Optics Lab, Advance Lab		

For more information

The following pages are taken from the Physics section from the 2013-14 University of Oregon Catalog: Information for Undergraduate and Graduate Students. They list all the requirements for the Bachelor of Science and Bachelor of Arts programs with Major or Minor in Physics. They also include a list of the Department of Physics Faculty and descriptions of all Physics and Astronomy courses offered by the Department.

For additional information contact Dr. Scott Fisher, Interim Director of Undergraduate Studies for the Department of Physics, 145 Willamette Hall, (541) 346-4799, rsf@uoregon.edu.

PHYSICS

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FACULTY

Dietrich Belitz, Professor (condensed matter theory). Dipl Phys., 1980, Dr.rer.nat., 1982, Technical University Munich. (1987)
Gregory Bothun, Professor (astronomy). BS, 1976, PhD 1984, Washington (Seattle). (1990)
James E. Brau, Phillip H. Knight Professor of Science (experimental elementary particle physics). BS, 1969, U.S. Air Force Academy; MS, 1970, PhD, 1978, Massachusetts Institute of Technology. (1988)
Spencer Chang, Assistant Professor (theoretical high-energy physics). BS 1999, Stanford; PhD, 2004, Harvard. (2010)
Eric Corwin, Assistant Professor (biophysics, soft condensed matter). BA, 2001, Harvard; PhD, 2007, Chicago. (2010)
Paul L. Csonka, Professor (elementary particle theory). PhD, 1963, John Hopkins. (1968)
Nilendra Deshpande, Professor (elementary particle theory). BSc, 1959, MSc, 1960, Madras; PhD, 1965, Pennsylvania. (1975)
Miriam Deutsch, Professor (optical physics). BSc, 1988, PhD, 1996, Hebrew. (2000)
Russell J. Donnelly, Professor (physics of fluids, superfluidity, astrophysics). BSc, 1951, MSc, 1952, McMaster, MS, 1953, PhD 1956, Yale. (1966)
R. Scott Fisher, Lecturer (astronomy). BS, 1993, PhD, 2001, Florida. (2012)
Raymond E. Frey, Professor (experimental elementary particle physics). BA, 1978, California, Irvine, MS, 1981, PhD, 1984, California, Riverside. (1989)
Stephen Gregory, Associate Professor (solid state physics). BSc, 1969, Manchester. MSc, 1970, Essex, PhD, 1975, Waterloo. (1982)

Roger Haydock, Professor (sold state theory). BA 1968, Princeton; MA, PhD, 1972, ScD, 1989, Cambridge. (1982)
James N. Imamura, Professor (astrophysics). BA, 1974, California, Irvine; MA, 1978, PhD, 1981, Indiana. (1985)
Timothy Jenkins, Senior Instructor (physics education). BA, 1975, Linfield College; PhD, 1992, Clarkson. (1992)
Stephen D. Kevan, Professor (solid state physics). BA, 1976, Wesleyan, PhD, 1980, California, Berkeley. (1985)
Graham Kribs, Associate Professor (elementary particle theory). BASc, 1993, Toronto; PhD, 1998, Michigan, Ann Arbor. (2004)
Dean W. Livelybrooks, Senior Instructor (geophysics). BS, 1977, Massachusetts Institute of Technology; MS, 1984, PhD, 1990, Oregon. (1996)
Stephanie Majewski, Assistant Professor (elementary particle physics). BS, 2002, Illinois, Urbana-Champaign; PhD, 2007, Stanford. (2012)
Brian W. Matthews, Professor (protein crystallography). BSc, 1959, BSc, 1960, PhD, 1964, Adelaide. (1969)
Benjamin McMorran, Assistant Professor (experimental condensed matter, optical physics). BS, 2000, Oregon State; MS, PhD, 2009, Arizona. (2011)
Stanley J. Micklavzina, Senior Instructor (physics education) BS, 1982, MS 1985, Oregon. (1985)
Jens Noeckel, Associate Professor (optical physics). Dipl. Phys., 1992, Hamburg; PhD, 1997, Yale. (2001)
Raghuveer Parthsarathy, Associate Professor (condensed matter physics, biophysics). BA, 1997, California, Berkeley; PhD, 2002, Chicago. (2006)
Michael G. Raymer, Phillip H. Knight Professor of Liberal Arts & Sciences (quantum optics and optical physics). BA, 1974, California, Santa Cruz; PhD, 1979, Colorado. (1988)
Stephen J. Remington, Professor (protein crystallography). BS, 1971, Oregon State, PhD, 1977, Oregon. (1985)
James M. Schombert, Professor (astronomy). BS, 1979, Maryland, MPhil, 1982, PhD, 1982, Yale. (1996)
Davison E. Soper, Professor (elementary particle physics). BA, 1965, Amherst; PhD, 1971, Stanford. (1977)
Daniel Steck, Associate Professor (atom optics and nonlinear dynamics). BS, 1995, Dayton; PhD, 2001, Texas, Austin. (2004)
David M. Strom, Professor (experimental elementary particle physics). BA, 1980, St. Olaf; PhD, 1986, Wisconsin, Madison. (1991)
Richard P. Taylor, Professor (solid state physics). BS, 1985, PhD, 1988, Nottingham. CAD, 1995, Manchester School of Art; MA, 2000, New South Wales. (1999)
John J. Toner, Professor (condensed matter theory). BS, 1977, Massachusetts Institute of Technology; MA, 1979, PhD, 1981, Harvard. (1995)
Eric Torrence, Professor (experimental elementary particle physics). BS, 1990, Washington (Seattle); PhD, 1997, Massachusetts Institute of Technology. (2000)
Steven J. van Enk, Professor (theoretical optical physics). MSc, 1988, Utrecht; PhD, 1992, Leiden. (2006)

Hailin Wang, Professor (quantum optics). BS, 1982, Science and Technology (China); MS, 1986, PhD, 1990, Michigan. (1995)

SPECIAL STAFF

Robert Schofield, Senior Research Associate (nuclear biophysics). BS, 1992, Brigham Young; PhD, 1990, Oregon. (1993)
Nikolai Sinev, Senior Research Associate (experimental high energy physics). BS, 1968, PhD, 1974, Moscow State. (1993)
Frank Vignola, Senior Research Associate (solar energy). BA, 1967, California, Berkeley; MS, 1969, PhD, 1975, Oregon. (1977)

EMERITI

Bernd Crasemann, Professor Emeritus. AB, 1948, California, Los Angeles; PhD, 1953, California, Berkeley. (1953)
Marvin D. Girardeau, Professor Emeritus. BS, 1952, Case Institute of Technology; MS, 1954, Illinois; PhD, 1958, Syracuse. (1963)
Rudolph C. Hwa, Professor Emertitus. BS, 1952, MS, 1953, PhD, 1957, Illinois, PhD, 1962, Brown. (1971)
Harlan Lefevre, Professor Emeritus. BA, 1951, Reed; PhD, 1961, Wisconsin. (1961)
Joel W. McClure, Jr., Professor Emeritus. BS, 1949, MS, 1951, Northwestern; PhD, 1954, Chicago. (1954)
David K. McDaniels, Professor Emeritus. BS, 1951, Washington State; MS 1958, PhD, 1960, Washington (Seattle). (1963)
John T. Moseley, Professor Emeritus. BS, 1964, MS 1966, PhD, 1969, Georgia Institute of Technology. (1979)
Jack C. Overley, Professor Emeritus. BS, 1954, Massachusetts Institute of Technology; PhD, 1960, California Institute of Technology. (1968)
Kwangjai Park, Professor Emeritus. BA, 1958, Harvard; PhD, 1965, California, Berkeley. (1966)
George W. Rayfield, Professor Emeritus. BS, 1958, Stanford; PhD, 1964, California, Berkeley. (1967)
David R. Sokoloff, Professor Emeritus. BA, 1966, City University of New York, Queens; PhD, 1972, Massachusetts Institute of Technology. (1978)
Robert L. Zimmerman, Professor Emeritus. BA, 1958, Oregon; PhD, 1963, Washington (Seattle). (1966)
The date in parentheses at the end of each entry is the first year on the University of Oregon faculty.

UNDERGRADUATE STUDIES

Physics, the most basic of the natural sciences, is concerned with the discovery and development of the laws that describe our physical universe. This endeavor serves, also, to directly benefit humankind: integrated circuits found in computers, mobile phones, and solar cells, lasers in DVD players and computer mice, and the Internet itself were developed from fundamental physics discoveries. As it involves the development of analytical, technical,

problem-solving, and science communication skills, a major in physics provides a good start for many career paths. In addition to major and minor programs, the Department of Physics offers a variety of courses for nonmajors and health science premajor students.

Preparation. Entering freshmen should have taken as much high school mathematics as possible in preparation for starting calculus in their freshman year. High school study of physics and chemistry is desirable.

Transfer Students. Because of the sequential nature of the physics curriculum, it is useful for students from two-year colleges to complete as much as possible of calculus, differential equations, several-variable calculus, chemistry, and calculus-based physics (part of an associate's degree) before transferring. Those who transfer after two years should prepare for upper-division course work by taking one year of differential and integral calculus (the equivalent of MATH 251, 252, 253), one year of general physics with laboratory (the equivalent of PHYS 251, 252, 253, 291), general chemistry (the equivalent of CH 221, 222 or CH 224H, 225H), and, if possible, one term of differential equations and two terms of multivariable calculus (the equivalent of MATH 256 and MATH 281, 282). Students who transfer after attending a four-year college or university for more than two years should have completed a second year of physics. Transfer students should also have completed as many as possible of the university requirements for the bachelor's degree (see Bachelor's Degree Requirements under **Registration and Academic Policies**).

Careers. Fifty percent of graduates with bachelor's degrees in physics find employment in the private sector working as applied physicists, software developers, managers, or technicians, typically alongside engineers and computer scientists. About 30 percent of students who earn an undergraduate degree continue their studies in a graduate degree program, leading to a career in teaching or research or both at a university, at a government laboratory, or in industry. In addition, a degree in physics is good preparation for a career in business. Students who have demonstrated their ability with a good record in an undergraduate physics program are generally considered very favorably for admission to medical and other professional schools.

Major Requirements

The major in physics leads to a bachelor of arts (BA) or a bachelor of science degree (BS). Complete requirements are listed under Bachelor's Degree Requirements in the **Registration and Academic Policies** section of this catalog. The bachelor of arts degree has a second-language requirement. Knowledge of a language other than English is recommended for students planning graduate study in physics.

The sequential nature of physics courses makes it imperative to start planning a major program in physics early. Interested students should consult the advising coordinator in the Department of Physics near the beginning of their studies.

The department offers three areas of emphasis for the physics major. The emphasis in traditional physics is designed for majors with a strong interest in studying physics in graduate school. The emphasis in applied physics is for majors who seek a less theoretical study of physics and a more applied focus in optics, electronics, and other project areas. A third emphasis is for majors preparing to teach physical sciences in middle or high school. All physics majors have the same curriculum for the first two years.

Common Curriculum

Complete the following courses or their equivalents:

General Chemistry (CH 221, 222) or Honors General Chemistry (224H, 225H)

Calculus I,II,III (MATH 251, 252, 253) or Honors Calculus I,II,III (MATH 261, 262, 263)

Foundations of Physics I (PHYS 251, 252, 253)

Introduction to Differential Equations (MATH 256)

Several-Variable Calculus I,II (MATH 281, 282)

Foundations of Physics II (PHYS 351, 352, 353)

Physics Experimentation Data Analysis Laboratory (PHYS 391)

Applied Physics Emphasis

Complete the following upper-division courses:

Introduction to Quantum Mechanics (PHYS 354)

Mechanics, Electricity, and Magnetism (PHYS 412, 413)

Design of Experiments (PHYS 481)

Applied Core. Classical Optics (PHYS 424) and Modern Optics (PHYS 425) or Analog Electronics (PHYS 431) and Digital Electronics (PHYS 432)

Laboratory Core. Any combination of the four course options listed above not used to satisfy the applied core and Research Project I,II,III (PHYS 491, 492, 493) topic modules to total 6 credits. Different topic modules of PHYS 491, 492, 493 (e.g., optics, instrumentation, fundamental) may be taken. Each laboratory core course is worth 2 credits in satisfying the 6-credit requirement

Physics Teaching Emphasis

Complete the following upper-division courses:

Topics in Astrophysics (ASTR 321)

Introduction to Quantum Mechanics (PHYS 354)

Biological Physics (PHYS 362)

Physics Demonstrations (PHYS 420)

Analog Electronics (PHYS 431) and Digital Electronics (PHYS 432)

Research Project I,II,III (PHYS 491, 492, 493) to total 8 credits

Two terms of Supervised Tutoring (PHYS 409) to total 6 credits

Physics Emphasis

Complete the following upper-division courses:

Mechanics, Electricity, and Magnetism (PHYS 411, 412, 413). Note that PHYS 411 and 412 are sometimes offered out of sequence

Quantum Physics (PHYS 414, 415) and Topics in Quantum Physics (PHYS 417)

Upper-Division Laboratory. Any combination of Analog Electronics (PHYS 431), Digital Electronics (PHYS 432), or Research Project I,II,III (PHYS 491, 492, 493) topic modules to total 6 credits. Different topic modules for PHYS 491, 492, 493 (e.g., optics, instrumentation, fundamental) may be taken. Each upper-division laboratory course is worth 2 credits in satisfying the 6-credit requirement

Physics Electives. Topics in Astrophysics (ASTR 321), Modern Science and Culture (PHYS 361), Biological Physics (PHYS 362), Electromagnetism (PHYS 422), Classical Optics (PHYS 424), Modern Optics (PHYS 425)

Undergraduate research is strongly encouraged. Approximately 50 percent of physics undergraduates engage in substantive research during their course of study—often starting with Research Project I,II,III (PHYS 491, 492, 493). Contact the advising coordinator for more information.

Required courses must be taken for letter grades, with the exception of Supervised Tutoring (PHYS 409), and a grade point average of 2.00 (mid-C) or better must be earned in these

courses. Courses beyond the minimum requirement may be taken pass/no pass (P/N). At least 20 of the upper-division credits must be completed in residence at the University of Oregon. Exceptions to these requirements must be approved by the physics advising coordinator.

Sample Programs

The following sample programs are designed for students who are preparing for employment in industry and choose the applied physics emphasis or who are preparing for graduate studies and choose the physics emphasis. The programs assume that students are prepared to take calculus in their freshman year. Consult the physics advising coordinator for assistance in planning a specific program adapted to a student's individual needs. In addition to general graduation requirements, students should plan to take the following courses:

Common Curriculum

Freshman Year	**35 credits**
General Chemistry (CH 221, 222)	8
Foundations of Physics I (PHYS 251, 252, 253)	12
Foundations of Physics Laboratory (PHYS 291), three terms	3
Calculus I,II,III (MATH 251, 252, 253)	12
Sophomore Year	**28 credits**
Introduction to Differential Equations (MATH 256)	4
Several-Variable Calculus I,II (MATH 281, 282)	8
Foundations of Physics II (PHYS 351, 352, 353)	12
Physics Experimentation Data Analysis Laboratory (PHYS 391)	4

Applied Physics Emphasis

Junior Year	**24 credits**
Introduction to Quantum Mechanics (PHYS 354)	4
Mechanics, Electricity, and Magnetism (PHYS 412, 413)	8
Electromagnetism (PHYS 422)	4
Analog Electronics (PHYS 431), Digital Electronics (PHYS 432)	8
Senior Year	**20 credits**
Classical Optics and Modern Optics (PHYS 424, 425)	8
Modern Optics Laboratory (PHYS 426)	4
Design of Experiments (PHYS 481)	4
Research Project I,II,III (PHYS 491, 492, 493)	4

Physics Teaching Emphasis

Junior Year	**26 credits**
Topics in Astrophysics (ASTR 321)	4
Introduction to Quantum Mechanics (PHYS 354)	4
Supervised Tutoring (PHYS 409)	6
Physics Demonstrations (PHYS 420)	4
Analog Electronics (PHYS 431), Digital Electronics (PHYS 432)	8
Senior Year	**8 credits**
Research Project I,II,III (PHYS 491, 492, 493)	8

Physics Emphasis

Junior Year	**24–28 credits**
Mechanics, Electricity, and Magnetism (PHYS 411, 412, 413)	12
Electromagnetism (PHYS 422)	4
Upper-division laboratory (e.g. PHYS 426, 431, 432, 491, 492, 493)	4–8
Mathematics or physics electives or both	4
Senior Year	**28–32 credits**
Quantum Physics (PHYS 414, 415)	8
Topics in Quantum Physics (PHYS 417)	4
Upper-division laboratory (e.g., PHYS 426, 431, 432, 491, 492, 493)	4–8
Physics or mathematics electives or both	12

Sample Programs for Transfer Students

These sample programs are for transfer students who have completed two years of college work including one year of calculus, one year of general physics with laboratories, one year of general chemistry, and as many as possible of the university requirements for the bachelor's degree. In addition to graduation requirements for the bachelor's degree, transfer students should plan to take the following courses, depending on their area of emphasis:

Applied Physics Emphasis

Junior Year	**32 credits**
Introduction to Differential Equations (MATH 256)	4
Several-Variable Calculus I,II (MATH 281, 282)	8

Foundations of Physics II (PHYS 351, 352, 353)	12
Introduction to Quantum Mechanics (PHYS 354)	4
Physics Experimentation Data Analysis Laboratory (PHYS 391)	4
Senior Year	**28–32 credits**
Mechanics, Electricity, and Magnetism (PHYS 412, 413)	8
Electromagnetism (PHYS 422)	4
Classical Optics (PHYS 424) and Modern Optics (PHYS 425)	8
Upper-division laboratory (e.g., PHYS 431, 432, 491, 492, 493)	4–8
Design of Experiments (PHYS 481)	4

Physics Teaching Emphasis

Junior Year	**30 credits**
Topics in Astrophysics (ASTR 321)	4
Introduction to Quantum Mechanics (PHYS 354)	4
Biological Physics (PHYS 362)	4
Supervised Tutoring (PHYS 409)	6
Physics Demonstrations (PHYS 420)	4
Analog Electronics (PHYS 431), Digital Electronics (PHYS 432)	8
Senior Year	**8 credits**
Research Project I,II,III (PHYS 491, 492, 494)	8

Physics Emphasis

Junior Year	**28 credits**
Introduction to Differential Equations (MATH 256)	4
Several-Variable Calculus I,II (MATH 281, 282)	8
Foundations of Physics II (PHYS 351, 352, 353)	12
Physics Experimentation Data Analysis Laboratory (PHYS 391)	4
Senior Year	**40–44 credits**
Mechanics, Electricity, and Magnetism (PHYS 411, 412, 413)	12
Quantum Physics (PHYS 414, 415)	8
Topics in Quantum Physics (PHYS 417)	4
Electromagnetism (PHYS 422)	4
Upper-division laboratory (e.g., PHYS 424, 425, 426, 431, 432, 491, 492, 493)	4–8
Mathematics or physics electives or both	8

Honors

To be recommended by the faculty for graduation with honors in physics, a student must complete at least 46 credits in upper-division physics courses, of which at least 40 credits must be taken for letter grades, and earn at least a 3.50 grade point average in these courses.

As an alternative, undergraduate research leading to the defense of a thesis accompanied by at least a 3.30 grade point average can lead to recommendation for graduation with honors. Contact the director of undergraduate studies for more information.

Minor Requirements

Students seeking a minor in physics must complete a minimum of 24 credits in physics, of which at least 15 must be upper division. These credits must include Foundations of Physics II (PHYS 351, 352, 353) or Mechanics, Electricity, and Magnetism (PHYS 411, 412, 413). Four credits in Physics Experimentation Data Analysis Laboratory (PHYS 391) or a 4-credit 400-level physics course completes the upper-division requirements. Course work must be completed with grades of C– or better or P. At least 12 of the upper-division credits must be completed in residence at the University of Oregon.

Prospective minors must take Foundations of Physics I (PHYS 251, 252, 253) or the equivalent. General Physics (PHYS 201, 202, 203) may be substituted with the physics undergraduate advisor's approval.

Engineering

Students interested in engineering may complete preparatory course work at the University of Oregon before enrolling in a professional engineering program at Oregon State University (OSU) or elsewhere. The Department of Physics coordinates a three-plus-two program that allows a student to earn a bachelor's degree in physics from Oregon and one in engineering from OSU. For more information, see Preparatory Programs in the **Academic Resources** section of this catalog.

Engineering students interested in semiconductor process engineering or polymer science may be interested in the nationally recognized industrial internship master's program sponsored by the UO Materials Science Institute. For more information, see Materials Science Institute in the **Research Institutes and Centers** section of this catalog.

Preparation for Kindergarten through Secondary School Teaching Careers

The College of Education offers a fifth-year program for middle-secondary teaching licensure in physics and integrated sciences and a program for elementary teaching. Students considering a

career pathway to teaching should consider following the physics teaching emphasis to prepare for the licensure programs. More information is available from the department's education advisor, Scott Fisher; see also the **College of Education** section of this catalog.

Graduate Studies

The Department of Physics offers graduate programs leading to the master of science degree in applied physics or to the master of arts (MA), master of science (MS), and doctor of philosophy (PhD) degrees in physics with a variety of opportunities for research. Current research areas include astronomy and astrophysics, biophysics, condensed matter physics, elementary particle physics, and optical physics.

The interdisciplinary Institute of Theoretical Science houses theoretical research in some of the above areas as well as in areas of overlap between chemistry and physics.

The Center for High Energy Physics conducts research in particle physics, much of it in laboratories outside Oregon.

The Materials Science Institute and the Oregon Center for Optics provide facilities, support, and research guidance for graduate students and postdoctoral fellows in the interdisciplinary application of concepts and techniques from both physics and chemistry to understanding physical systems.

Cooperative programs of study are possible in molecular biology through the Institute of Molecular Biology.

Pine Mountain Observatory

Pine Mountain Observatory, operated by the Department of Physics for research and advanced instruction in astronomy, is located thirty miles southeast of Bend, Oregon, off Highway 20 near Millican, at an altitude of 6,300 feet above sea level. The observatory has three telescopes—fifteen inches, twenty-four inches, and thirty-two inches in diameter—the largest governed by computer. All are Cassegrain reflectors. A wide-field CCD camera is available on the thirty-two-inch telescope. The site has an astronomers' residence building and a caretaker's house. Professional astronomical research is in progress at the observatory on every partially or totally clear night of the year, and the site is staffed year round.

Admission and Financial Aid

For admission to graduate study, a bachelor's degree in physics or a related area is required with a minimum undergraduate grade point average (GPA) of 3.00 (B) in advanced physics and mathematics courses. Submission of scores on the Graduate Record Examinations (GRE), including the physics test, is required. Students from non-English-speaking countries must demonstrate proficiency in English by submitting scores from the Test of English as a Foreign

Language (TOEFL). Information about the department and the Graduate Admission Application are available through the department's website.

Financial aid in the form of graduate teaching or research fellowships (GTFs) is available on a competitive basis to PhD students. GTFs require approximately sixteen hours of work a week and provide a stipend and tuition waiver. New students are typically eligible only for teaching fellowships.

The sequential nature of most physics courses makes it difficult to begin graduate study in terms other than fall. Furthermore, financial aid is usually available only to students who begin their studies in the fall.

To ensure equal consideration for fall term admission, the deadline for applications for financial aid is January 15. Late applications for admission may be considered until July 15.