PHYSICS

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The program in physics is designed to prepare students for a variety of career paths including (but not limited to) physics and engineering graduate study, teaching, and direct entry into industry. Physics students gain practical experience through hands-on projects in classes, as well as a senior capstone research project or professional internship. Facilities are available for student research in nonlinear optics, condensed-matter physics, and nuclear physics. The majority of our graduates goes to graduate school in physics and related fields or take engineering-related positions in technical industries.

The Physics program consists of a core set of courses plus additional courses organized by emphasis. Students choose the emphasis that best matches their personal goals.

Currently, the emphases we offer are:

- Traditional Physics, meant for students interested in pursuing careers in applied physics and engineering, or graduate study in physics, engineering, or professional fields, or teaching
- Environmental Science, meant for students interested in pursuing careers or graduate study in areas that combine technical knowledge with environmental issues, such as environmental engineering or alternative energy.

Upon successful completion of a major in physics, students will be able to:

- Demonstrate conceptual understanding of fundamental physics principles
- Communicate physics reasoning in oral and in written form
- Solve physics problems using qualitative and quantitative reasoning including sophisticated mathematical techniques
- Conduct independent research or work successfully in a technical position.

Physics: Requirements for the Major

Physics Core (required for all majors):

PHY 232-242	General Physics I-II	8 credits
OR		
PHY 202-204	Introductory Physics I-II	8 credits
PHY 322	Modern Physics with Health Applications	4 credits
PHY 332	Waves and Optics	4 credits
PHY 470	Advanced Analysis in Physics	2 credits
PHY 491-493	Physics Capstone	4 credits
MATH 226-228	Calculus I-III	12 credits
CHEM 220-230	General Chemistry I-II	8 credits
OR		
CS 150-250	Introduction to Computer Programming	8 credits
OR		
CHEM 220	General Chemistry I	4 credits
AND		
CS 150	Introduction to Computer Programming	4 credits

TOTAL: 42 Credits

Traditional Physics Emphasis:

PHY 410	Classical Mechanics: Dynamics	4 credits
PHY 420	Quantum Mechanics	4 credits
PHY 460	Electric and Magnetic Fields	4 credits
PHY 300-400-level electives		8 credits

TOTAL: 20 Credits
TOTAL including Physics Core: 62 Credits

Environmental Science Emphasis:

PHY 410	Classical Mechanics: Dynamics	4 credits
OR		
PHY 420	Quantum Mechanics	4 credits
OR		
PHY 460	Electric and Magnetic Fields	4 credits
PHY 384	Thermodynamics and Statistical Mechanics	4 credits
PHY 300-400-level elective		4 credits
ENV 200	Intro to Environmental Science	4 credits
ENV 330	Ecosystems and Ecological Design	4 credits
ENV 300-400-level elective		4 credits
OR		
PHY 325	Modern Topics in Physics: Environmental Physics	4 credits

TOTAL: 24 credits
TOTAL including Physics Core: 66 Credits

Health Professions Emphasis:

PHY 410	Classical Mechanics: Dynamics	4 credits
OR		
PHY 420	Quantum Mechanics	4 credits
OR		
PHY 460	Electric and Magnetic Fields	4 credits
PHY 300-400-level electives		8 credits
Approved 300-400 electives from BIO, CHEM, or EXIP		8 credits

TOTAL: 20 Credits
TOTAL, including Physics Core: 62 Credits

Engineering Physics Emphasis:

PHY 410	Classical Mechanics: Dynamics	4 credits
OR		
PHY 420	Quantum Mechanics	
OR		
PHY 460	Electric and Magnetic Fields	
Engineering credits transferred from an approved program*		24 credits

TOTAL: 28 credits
Required from Physics Core: 36**
TOTAL: 64 Credits

* A minimum of 24 semester credits in engineering courses in an approved engineering program at another institution will be transferred back to Pacific University and counted towards the completion of the physics degree. Approved coursework taken at the engineering institution along with an approved public presentation will satisfy the requirements for the Senior Capstone. Of the courses used to satisfy the major, at least 28 CR must be at the 300 or 400 level, or equivalent, with at least 4 of these credits at the 400-level, or equivalent.

** PHY 470, Advanced Analysis in Physics; and PHY 491 & 993, Capstone are omitted.

All physics majors are strongly encouraged to take MATH 311 (Differential Equations) and CS 150 (Introduction to Computer Science). Students also are encouraged to take other courses in Math and CS depending on their interests.

Students who are planning a career teaching physical science at the high school level may, with prior department approval, substitute either HUM 339 (History of Science) or PHIL 310 (Philosophy of Science) for four of the required upper-division elective credits. Students planning a teaching career also have the opportunity to gain valuable teaching experience by serving as teaching assistants for lower division courses.

Because there are so many possible career paths for physics majors, we would like to offer some recommendations for upper -division electives (of which 8 credits are required for the major). Below are suggestions for electives that provide pathways for students to follow toward some common career goals. However, each student has unique interests; please discuss yours with a member of the department to develop a personalized selection of courses

Graduate School in Physical Science:

- Relativity I & II
- Thermodynamics and Statistical Mechanics
- Modern Topics in Physics
- Electronics

Optics/Optometry:

- Modern Topics in Physics
- Electronics

Engineering/Applied Science/Health Science Careers:

- Electronics
- Engineering Mechanics: Statics I & II
- Thermodynamics and Statistical Mechanics

Teaching Physical Science in High School:

- Relativity I & II
- Thermodynamics and Statistical Mechanics
- History of Science
- Philosophy of Science

Applied Physics: Requirements for the Minor

Students interested in an Applied Physics minor should consult with a faculty member in the Department of Physics. The minor in Applied Physics is designed for students interested in employment in the hi-tech industry or in engineering. It can be used toward completion of the Applied Science major.

MATH 226-227	Calculus I-II	8 credits
PHY 232-242	General Physics I-II	8 credits
OR		
PHY 202 -204	Introductory Physics I-II	8 credits
PHY 322	Modern Physics with Health Applications	4 credits
OR		
PHY 332	Waves and Optics	4 credits
PHY 364	Electronics	4 credits
4 credits of the following (if not counted above):		4 credits
PHY 322	Modern Physics with Health Applications	
PHY 332	Waves and Optics	
PHY 377-378	Engineering Mechanics: Statics I & II	
PHY 384	Thermodynamics and Statistical Mechanics	
PHY 325	Selected Topics in Physics	
One of the following:		4 credits
PHY 380	Classical Mechanics: Dynamics	
PHY 420	Quantum Mechanics	
PHY 460	Electric & Magnetic Fields	

TOTAL: 32 credits

Physics: Requirements for the Minor

Students interested in a Physics minor should consult with a faculty member in the Department of Physics. The minor in Physics is designed to give students a deeper appreciation of physics than can be attained in a one-year sequence. The minor in Physics can enhance studies in other disciplines such as (but not limited to) chemistry, mathematics, computer science and Philosophy.

PHY 232-242	General (Workshop) Physics I-II	8 credits
OR		
PHY 202-204	Introductory Physics I-II	8 credits
MATH 226-227	Calculus I-II	8 credits
PHY 322	Modern Physics with Health Applications	4 credits
OR		
PHY 332	Waves and Optics	4 credits
Eight additional upper-division credits in physics		8 credits

TOTAL: 28

COURSES

PHY-110 Physics of Everyday Phenomena
Designed to develop an understanding of the phenomena of our everyday life via the laws of physics. The emphasis is not on problem solving but on encouraging students to understand and appreciate their environment from a new perspective. Includes topics in mechanics and other physics subfields such as thermal physics, electrical phenomena. 4 credits.

PHY-155 Special Topics
See department for course description.

PHY-160 Energy & the Environment
In order to live, humans require energy, and methods of energy production significantly affect the environment in which humans live. This course examines fundamental thermodynamic concepts such as energy and power and then explores the comparative environmental costs and benefits, including potential long term consequences, of producing energy from various sources such as fossil fuels, nuclear reactors, wood burning, solar panels, wind turbines, etc. Methods of estimation and risk assessment are emphasized so that meaningful comparisons between energy sources and their environmental consequences can be made. Also listed as ENV 160. 4 credits.

PHY-195 Independent Study
See department for details. Independent study contract required.

PHY-202 Introductory Physics I
The first semester of an algebra-based sequence in physics. Topics include Newtonian mechanics, work, momentum, and energy. The lab component includes computer based experiments in mechanics. Prerequisite: MATH 125 with a minimum grade of C-. Corequisite: PHY 202L. 4 credits.

PHY-202L Introductory Physics I Laboratory
Laboratory to accompany Introductory Physics I. Corequisite: PHY 202. 0 credits.

PHY-204 Introductory Physics II
The second semester of an algebra-based sequence in physics. Topics include heat and thermodynamics; electricity and magnetism; sound and light waves. The laboratory component includes computer based experiments in heat and thermodynamics; electric circuits. Prerequisite: PHY 202 or PHY 232 with a minimum grade of C-. Corequisite: PHY 204L. 4 credits.

PHY-204L Introductory Physics II Lab
Laboratory to accompany Introductory Physics II. Corequisite: PHY 204. 0 credits.

PHY-232 Gen Physics I-Workshop Phys I
An introductory course in physics (calculus-based) for science and pre-engineering students. First term includes Newtonian mechanics. This course is an inquiry-based, laboratory-oriented course. Corequisite: MATH 226. 4 credits.

PHY-242 General Physics II-Workshop Physics II
A continuation of PHY 232 including electricity and magnetism, thermodynamics, and nuclear physics. Prerequisite: MATH 226 or MATH 227 with a minimum grade of C-; and PHY 202 or PHY 232 with a minimum grade of C-. 4 credits.

PHY-275 Internship
See department for details. Internship contract required.

PHY-311 Relativity I
The first of a two-course introduction to Einstein's theory of relativity. This course emphasizes special relativity. Topics may include the principle of relativity, space-time effects of the Lorentz transformations, and Minkowski diagrams. Prerequisite: PHY 202 or 232 with a minimum grade of C-; and MATH 226 with a minimum grade of C-. Offered alternate years. 2 credits.

PHY-312 Relativity II
The second of a two-course introduction to Einstein's theory of relativity. This course extends the development of special relativity in PHY 311 and introduces general relativity. Topics may include relativistic energy and momentum, the equivalence principle, the geometry of space-time, and gravity. Prerequisite: PHY 311 with a minimum grade of C-. Offered alternate years. 2 credits.

PHY-322 Modern Physics With Health Applications
A project-orientated course taught in a workshop environment that covers important topics in modern physics with applications to human health. Topics include the Bohr theory of the atom, wave/particle duality, atomic and nuclear physics, and an introduction to Schrodinger's equation. Projects may include nuclear medicine, radiation therapy, neutron activation analysis, and magnetic resonance imaging. Prerequisite: PHY 204 or 242 with a minimum grade of C-. Corequisite: MATH 227. Offered alternate years. 4 credits.

PHY-325 Selected Topics in Physics
Study of a particular field in physics selected by the instructor and approved by the Physics Department. May or may not include a lab. Previous topics have included Environmental Physics, Particle Physics, Data Acquisition, Optics, Solid State Physics, and Non-Linear Dynamics. Prerequisite: PHY 242 with a minimum grade of C-; additional prerequisites may apply depending on the topic. Some topics may require the instructor's consent. Refer to the online course

schedule to verify if instructor consent is required for the offered topic. May be repeated for credit when topic varies. Prerequisite: PHY-242. May be repeated for credit. 2-4 credits.

PHY-332 Waves and Optics
A course on the mathematical description of waves with application to optics. Topics will include wave addition, an introduction to Fourier analysis, laws of geometric optics, image formation, optical systems, interference and diffraction, polarization, lasers, and an introduction to transform optics including holography. The laboratory component will include selected experiments in wave motion, geometric optics, and physical optics. Prerequisite: PHY 204 or PHY 242 with a minimum grade of C-. Corequisite: MATH 227. Offered alternate years. 4 credits.

PHY-355 Special Topics
See department for course description.

PHY-364 Electronics
The basic principles underlying circuit analysis and the operation of analog and digital electronic devices, including: diodes; transistors; op-amps; logic gates; multivibrators; counters; registers; memories; and A/D and D/A converters. Prerequisite: MATH 125 with a minimum grade of C-; and PHY 204 or 242 with a minimum grade of C-. Offered alternate years. 4 credits.

PHY-377 Engineering Mechanics: Statics I
The first of a two-course introduction to the principles of static mechanics. Special emphasis is given to problem solving techniques in physics and engineering. Topics may include: force analysis, equilibrium in two dimensions, trusses and frames, internal forces, and centroids. Prerequisite: PHY 232 or PHY 202; and MATH 226 each with a minimum grade of C-. Offered alternate years. 2 credits.

PHY-378 Engineering Mechanics: Statics II
The second of a two-course introduction to the principles of static mechanics. Special emphasis is given to problem solving techniques in physics and engineering. Topics may include: equilibrium in three dimensions, distributed forces in cables, centroids of composite bodies, fluid statics, and frictional phenomena. Prerequisite: PHY 377 with a minimum grade of C-. Offered alternate years. 2 credits.

PHY-384 Thermodynamics and Statistical Mechanics
Presentation, discussion, and application of the laws of thermodynamics and statistical mechanics including gas behavior, equations of states, phase transformations, kinetic theory, probability distributions, ensembles, and the partition function. Prerequisites: MATH 227 with a minimum grade of C-; PHY 204 or PHY 242 with a minimum grade of C-; and one upper division PHY course with a minimum grade of C-. Offered alternate years. 4 credits.

PHY-395 Independent Study
See department for details. Independent study contract required.

PHY-410 Classical Mechanics: Dynamics
Presentation and discussion of the kinematics and dynamics of single particles and systems of particles, both in inertial and non-inertial frames of reference. In addition to the standard analytical techniques, approximation techniques and a computer algebra system will be used for problem solving. Several mechanical systems will be studied experimentally and computationally. Prerequisite: PHY 204 or 242 with a minimum grade of C-. Corequisite: MATH 228 with a minimum grade of C-. Offered alternate years. 4 credits.

PHY-420 Quantum Mechanics
An introduction to quantum mechanics and its application to: free particles, barriers, the simple harmonic oscillator, the hydrogen atom, angular momentum, spin, and identical particle systems. A computer algebra system will be utilized for problem solving and visualization. Prerequisite: PHY 322 or PHY 332 with a minimum grade of C-; and MATH 228 or MATH 311 with a minimum grade of C-. Offered alternate years. 4 credits.

PHY-460 Electric & Magnetic Fields
Development of the nature and mathematical description of electric and magnetic fields in free space and material media, including: Maxwell's equations, electrostatics, magnetostatics, dielectrics, and solutions of Laplace's and Poisson's equations. Prerequisite: PHY 322 or PHY 332 with a minimum grade of C-; and MATH 228 with a minimum grade of C-. Offered alternate years. 4 credits.

PHY-470 Advanced Analysis in Physics
This course provides students with experience in analyzing and describing complex physical systems from current topics in physics. Emphasis is on the synthesis of concepts learned throughout the undergraduate physics curriculum in order to approach advanced problems. Prerequisite: Senior standing (90 or more completed credits) and declared Physics major. 2 credits.

PHY-475 Internship
See department for details. Internship contract required.

PHY-491 Physics Capstone I
The first semester of a year-long research experience. Students will work with individual faculty research advisors. At the end of Physics 491 students will give oral presentations on their research progress and submit a draft research paper. Prerequisite: Senior standing (90 or more completed credits) and declared Physics major. 2 credits.

PHY-493 Senior Capstone II
The second semester of a year-long research experience. Students will work with individual faculty research advisors. At the end of Physics 493 students will give final oral presentations on their research and submit a final research paper. Prerequisite: PHY 491 with a minimum grade of C-. 2 credits.

PHY-495 Physics Research
Student-conducted individual research project. Instructor's consent required. May be repeated for credit.