Physics

The physics curriculum at California Lutheran University addresses the question of how and why things work, from the forces which govern subatomic particles to the large-scale phenomena which shape our universe as a whole. The fundamental nature of physics accounts for its relevance not only in engineering and technology but also in the life and earth sciences. The various introductory courses offered by the Physics Department are thus tailored to meet the different needs of physics majors, students in other sciences and liberal arts students, in particular future teachers. The physics faculty members use a blend of interactive lectures, illustrative demonstrations and hands-on laboratory exercises to enhance students' comprehension of the material.

Cal Lutheran offers both the bachelor of science and bachelor of arts in physics, as well as a physics minor. The B.S. program is well suited for students interested in graduate studies in physics or engineering or in careers in industry. The B.A. is a more liberal physics degree, where students can explore the relationship of physics with another field of interest. The minor strengthens the training of students majoring in other fields by providing high-level technological knowledge and enhanced problem-solving skills.

Beginning physics students gain a strong background in classical physics, modern physics and applied mathematics. Upper division courses focus on both theoretical topics and experimental techniques. These small upper division classes, together with close supervision by the faculty, provide a uniquely personalized learning experience for the students. Students develop employer-valued work-ready skills in areas such as electronics, optics and Matlab programming.

Physics students are encouraged to become actively involved in undergraduate research. In collaboration with Physics Department faculty, Cal Lutheran students develop next generation detectors and perform data analysis for experiments conducted at the CERN laboratory, use data obtained from telescopes throughout the world to improve models of massive stars and develop and assess models of superconducting compounds using the department's high-performance computing resources. Physics majors also participate in summer undergraduate research programs at other universities and national laboratories as well as internships with local industries.

Cal Lutheran Physics graduates have a strong record in obtaining employment after graduation and, for those who opt to continue studies in graduate school, are accepted into strong physics and engineering programs at universities throughout the nation.

Bachelor of Science in Physics

36 credits minimum (27 credits upper division); 20 supporting = 56 total credits.

PHYS 211/211L	Mechanics and Thermodynamics-Calculus and Mechanics and Thermodynamics-Lab (recommended)	5
or PHYS 201/201L	General Physics I	
PHYS 212/212L	Electricity, Magnetism, and Optics - and Electricity, Magnetism Optics Lab	5
PHYS 300	Pre-Capstone Seminar	2
PHYS 303	Modern Physics	4
PHYS 309/309L	Applied Electronics and Applied Electronics Lab	4
or PHYS 340	Advanced Experimental Physics	
PHYS 310	Physical Modeling With Matlab	2
Upper-division PHYS electives		20
PHYS 475	Capstone Senior Thesis	1
PHYS 492	Internship	1-4
or PHYS 494	Capstone Research Project	
or PHYS 496	Directed Research	
or UNIV 496	Directed Research	
Total Hours		**44-47**

Only physics courses numbered 200 and above can count toward the physics credit requirements.

Required Supporting Courses

MATH 251	Calculus I	4
MATH 252	Calculus II	4
MATH 261	Calculus III	4
MATH 265	Differential Equations	4
CSC 110	Concepts of Programming	4

or CSC 210	Introduction to Computer Programming	
Total Hours		**20**

Recommended

CHEM 151/151L	General Chemistry and General Chemistry Lab	5
CHEM 152/152L	General Chemistry II and General Chemistry II Lab	5
MATH 343	Linear Algebra	4
MATH 420	Real Analysis	4
MATH 450	Complex Variables	4
Total Hours		**22**

Bachelor of Arts in Physics

40 credits minimum (28 credits physics [20 upper division] and 12 credits concentration); 16 supporting = 56 total credits.

PHYS 211/211L	Mechanics and Thermodynamics-Calculus and Mechanics and Thermodynamics-Lab (recommended)	5
or PHYS 201/201L	General Physics I	
PHYS 212/212L	Electricity, Magnetism, and Optics - and Electricity, Magnetism Optics Lab (recommended)	5
or PHYS 202/202L	General Physics II	
PHYS 303/303L	Modern Physics and Modern Physics Lab	4
At least two physics courses numbered 410 and above		8
At least one upper division physics course with a lab component beyond 303		4
PHYS 400	Senior Research Seminar	4
12 Credit Concentration (at least 8 credits of upper division) *		12
Total Hours		**42**

*The concentration is a minimum of 12 credits in a single field outside of math or physics. It is expected that the presentation for the capstone will incorporate both physics and the field of concentration. Only physics courses numbered 200 and above can count toward the physics credit requirements.

Required Supporting Courses

MATH 251	Calculus I	4
MATH 252	Calculus II	4
MATH 261	Calculus III	4
MATH 265	Differential Equations	4
Total Hours		**16**

Recommended

CSC 210	Introduction to Computer Programming	4
MATH 343	Linear Algebra	4
MATH 420	Real Analysis	4
MATH 450	Complex Variables	4
Total Hours		**16**

Minor in Physics

18 credits minimum, 10 credits upper division

PHYS 211/211L	Mechanics and Thermodynamics-Calculus and Mechanics and Thermodynamics-Lab (recommended)	5
or PHYS 201/201L	General Physics I	
PHYS 212/212L	Electricity, Magnetism, and Optics - and Electricity, Magnetism Optics Lab (recommended)	5
or PHYS 202/202L	General Physics II	
10 Upper Division Physics Credits		10
Total Hours		**20**

Teaching Credential

Candidates for a California Secondary Teaching Credential should contact the School of Education Office for a complete list of course requirements for a Single Subject Waiver in Science.

Courses

Lower Division

PHYS 100. Introduction to Astronomy. (3).
An introduction to the solar and stellar objects in our visible universe.

PHYS 100L. Introduction to Astronomy Lab. (1).
Includes identification of constellations and planets, use of telescopes, analysis of astronomical data and field trips. Laboratory, 2 hours/week. Prerequisite or corequisite: PHYS 100.

PHYS 110. Physical Science for Liberal Art Majors. (4).
An introduction to physical science that includes a basic understanding of forces, conservation laws, energy transfer, and other selected physic topices, as well as topics in basic chemistry focused on matter and its interactions. Students participate in the scientific method, making predictions and observations to build models of everyday physical phenomena. Class format is equivalent to 3 hours lecture + 2 hours lab per week.

PHYS 110L. Physical Science Liberal Arts Majors Lab. (0).

PHYS 120. Musical Acoustics. (4).
Explores musical sound from a physics perspective. Basic physical principles underlying the production, transmission and perception of musical sound. Vibrations, waves, elementary acoustics with applications to a wide range of musical topics. Spectral analysis of waveforms. Studio format class equivalent to 3 hours lecture + 2 hours lab per week.

PHYS 201. General Physics I. (4).
This algebra-based introductory course covers the mathematical description of motion; Newton's Laws; linear and circular motion; rotational motion; elasticity and oscillatory motion. Topics from thermodynamics include heat transfer, ideal gas laws and entropy. Prerequisite: MATH 151 or equivalent. (fall).

PHYS 201L. General Physics I Lab. (0).
This algebra-based introductory course covers the mathematical description of motion; Newton's Laws; linear and circular motion; rotational motion; elasticity and oscillatory motion. Topics from thermodynamics include heat transfer, ideal gas laws and entropy. This course is comprised of both lecture and laboratory components. In this laboratory practical applications of the theory are demonstrated through experimentation and analysis. Prerequisite: MATH 151 or equivalent (fall).

PHYS 202. General Physics II. (4).
This algebra-based introductory course covers fluids, waves and sound, electrostatics, DC currents, magnetism, and geometric and physical optics. This course is comprised of both lecture and laboratory components. Prerequisite: PHYS 201 or PHYS 211 Corequisite: PHYS-202L.

PHYS 202L. General Physics Lab II. (0).
This algebra-based introductory course covers fluids, waves and sound, electrostatics, DC currents, magnetism, and geometric and physical optics. This course is comprised of both lecture and laboratory components. In this laboratory practical applications of the theory are demonstrated through experimentation and analysis. Prerequisite: PHYS 201 or PHYS 211 Corequisite: PHYS-202.

PHYS 209. Energy and Society. (4).
This introductory course is a discussion and empirical examination of the science of energy, its production, distribution, and consumption. Energy efficiency of automobiles and buildings. Energy production using fossil fuels, alternative energy, and renewable sources. Issues of economics, distribution and development. Students enrolled in the class MUST concurrently enroll in the corresponding laboratory course, PHYS 209L. Prerequisite: MATH 110 or equivalent.

PHYS 209L. Energy and Society Lab. (0).

PHYS 211. Mechanics and Thermodynamics-Calculus. (5).
This calculus-based introductory course covers the mathematical description of motion, Newton's Laws, linear and circular motion, oscillatory motion and waves. Topics from thermodynamics include heat transfer, ideal gas laws, cyclic processes and entropy. Lecture, 4 hours/week; Laboratory, 2 hours/week. Prerequisite or corequisite: MATH 251. (fall).

PHYS 211L. Mechanics and Thermodynamics-Lab. (0).

PHYS 211S. Supplmental Inst: PHYS 211. (0).
This is the Supplemental Instruction Blackboard Platform attached to PHYS 211. As a student enrolled in this section, you are automatically enrolled in the attached Supplemental Instruction Blackboard Platform. Supplemental Instruction (SI) is an academic support program designed to improve student success in challenging foundation courses. SI is a well-researched program that has been shown to improve students' letter grades by a half to a full grade, with consistent participation. With the SI model, a SI Leader (a student who has successfully completed the course with a B+ or better in the past, and who has an overall GPA of 3.0 or higher) is embedded into the course, attending all course meetings. The SI Leader then facilitates the scheduling and running of group SI study sessions throughout the week. There will typically be three one hour SI Sessions or two 90 minute SI Sessions per week. The SI Blackboard Platform is hosted by your SI Leader, who will utilize it to take confidential attendance at SI Sessions, to make general announcements to the class members, and to share helpful resources and study materials for SI Sessions. Participation in the SI study sessions is completely optional and always free, and you may come to as many or as few sessions as you would like over the semester. Your course professor does not receive any information about attendance, so you can be certain that your participation will be kept confidential.

PHYS 212. Electricity, Magnetism, and Optics -. (5).
This calculus-based introductory course covers electrostatics, DC and AC electric currents, magnetism, Maxwell's equations and geometric and physical optics. Lecture, 4 hours/week; Laboratory, 2 hours/week. Prerequisites: PHYS 211 (recommended) or PHYS 201; prerequisite or corequisite: MATH 252. (spring).

PHYS 212L. Electricity, Magnetism & Optics Lab. (0).

PHYS 212S. Supplemental Inst: PHYS 212S. (0).
This is the Supplemental Instruction Blackboard Platform attached to PHYS 212. As a student enrolled in this section, you are automatically enrolled in the attached Supplemental Instruction Blackboard Platform. Supplemental Instruction (SI) is an academic support program designed to improve student success in challenging foundation courses. SI is a well-researched program that has been shown to improve students' letter grades by a half to a full grade, with consistent participation. With the SI model, a SI Leader (a student who has successfully completed the course with a B+ or better in the past, and who has an overall GPA of 3.0 or higher) is embedded into the course, attending all course meetings. The SI Leader then facilitates the scheduling and running of group SI study sessions throughout the week. There will typically be three one hour SI Sessions or two 90 minute SI Sessions per week. The SI Blackboard Platform is hosted by your SI Leader, who will utilize it to take confidential attendance at SI Sessions, to make general announcements to the class members, and to share helpful resources and study materials for SI Sessions. Participation in the SI study sessions is completely optional and always free, and you may come to as many or as few sessions as you would like over the semester. Your course professor does not receive any information about attendance, so you can be certain that your participation will be kept confidential.

PHYS 282. Selected Topics. (1-4).

PHYS 282C. ST:. (1-4).
Select Topic approved to fill core requirement.

PHYS 282L. Selected Topics Lab. (0).

Upper Division

PHYS 300. Pre-Capstone Seminar. (2).
This seminar course provides sophomore and junior level students an introduction to career pathways with the physics major, including gaining experience pre-graduation, and career and post-graduate options. Students will develop communication skills needed by professionals in physics, engineering, and related fields to be successful in the diverse technical workplace. Students will be introduced to the various options to complete the capstone senior thesis. Minimum Sophomore Standing. Prerequisites: PHYS-202 or PHYS-212.

PHYS 303. Modern Physics. (4).
We will move beyond limitations of classical physics and introduce the foundations for the Theory of Relativity and quantum mechanics. This is the physics of the very fast, and the very small. The first part of the course is dedicated to the study of special relativity, including time dilation, space contraction, simultaneity, Lorentz transformations, relativistic energy and momentum, internal energy, the relativistic doppler effect, among other foundational topics. The second part of the course is directed to the study of the foundations of quantum mechanics. Some of the topics include blackbody radiation, the photoelectric effect, DeBroglie wavelength, Heisenberg's uncertainty principle, one dimensional Schrödinger equation solutions in free space and 1D potentials, and quantum tunneling. In the last third of the semester topics such as atomic spectra, the quantum description of angular momentum radioactive emissions, and topics in nuclear physics will be studied. Prerequisites: MATH-252 and PHYS-202 or PHYS-212.

PHYS 303L. Modern Physics Lab. (0).

PHYS 309. Applied Electronics. (4).
Includes the study of DC and AC circuit analysis, network theorems, digital logic and logic network design, analog circuit design and digital computer interface. Lecture, 3 hours/week; Laboratory, 3 hours/week. Prerequisites: MATH 151; PHYS 202 or PHYS 212 or high school physics. (spring, odd years).

PHYS 309L. Applied Electronics Lab. (0).

PHYS 310. Physical Modeling With Matlab. (2).
Computational solving of physics problems using the Matlab platform. Methods used include Euler and Runge-Kutta time-stepping algorithms, discretization and numerical solution of partial differential equations, computational linear algebra including solution of eigenvalue equations, and Monte Carlo simulations. Applications include few-body Newtonian mechanics, relativistic dynamics, time-dependent classical and quantum wave phenomena, normal modes, stationary states and random processes. Prerequisites: MATH-252 and PHYS-202 or PHYS-212 Prerequisite or Corequisite: PHYS-303.

PHYS 340. Advanced Experimental Physics. (4).
This course focuses on performing experimentally-based investigations in physics. Students develop skills programming data acquisition interfaces, using advanced equipment and performing data analysis. Important research skills covered include literature searches, experiment design and theory, laboratory techniques, and communication of research through oral presentations and written material. Topics investigated are drawn from multiple areas such as quantum physics, electricity and magnetism, optics and astronomy. Lecture 3 hours/week; laboratory 3 hours/week. PrerequisitesPhys 212 and MATH 252.

PHYS 370. Digital Electronics. (3).
Includes logic, number systems, buses, memory and register design and in-depth architecture. Lecture, 2 hours/week; Laboratory, 3 hours/week. Prerequisite: MATH 151.

PHYS 400. Senior Research Seminar. (4).
Independent study and research, interdisciplinary topic of current interest selected by the participants. Ongoing independent research results are presented for group discussions. Submittal of a research paper is required. Prerequisite: senior standing.

PHYS 410. Classical Mechanics. (4).
Includes the study of single-particle dynamics, reference systems, oscillations, Lagrangian and Hamiltonian mechanics. Prerequisites: MATH 261, MATH 265; PHYS 212.

PHYS 415. Statistical Physics and Thermodynamics. (4).
Development of the microscopic basis for fundamental thermodynamic principles and thermal properties cells, heat engines and classical and quantum distribution functions. Pre-requisites: MATH 261, MATH 265; PHYS 212.

PHYS 420. Electrodynamics. (4).
Solution techniques of Maxwell's equations are developed for static and time dependent electric and magnetic fields. Specific topics include: The electrical potential and Laplace's equation, boundary value problems, multipole expansions, electric and magnetic fields in matter, electrodynamics, and the propagation of electromagnetic fields through media. Also includes introduction to special relativity and relativistic electrodynamics. Prerequisites: MATH 261,MATH 265 and PHYS 212. Recommended: PHYS 440.

PHYS 425. Geometric and Physical Optics. (4).
We will study the fundamental properties of light, explore optical phenomena theoretically and in laboratory setting. We will start the study of light with the Fermat principle. Matrix element ray optical methods will allow students to resolve the geometry of optical systems through computer simulations. This followed by light's wave phenomena including designs for optical interferometers. Gaussian laser beams will be introduced. Fourier optical methods will be examined and applied to diffraction phenomena, and ultimately applied to phase retrieval in diffraction imaging. The quantum mechanical nature of light will be introduced, followed by laser systems and semiconductor light detection devices. In the laboratory students will build, and study, applied systems such as laser interferometers, Fabry-Perot spectrometers, external cavity laser designs, Fourier optical setups, laser ring gyroscopes, laser tweezer optical traps and quantum optics opto-electronics systems. Prerequisites: MATH-261, MATH-265, and PHYS-212.

PHYS 430. Quantum Physics. (4).
An introduction to quantum theory, beginning with the Schrödinger equation and the statistical interpretation of the wave function. One-dimensional applications, include the harmonic oscillator, square-well potentials and tunneling. Three dimensional applications include, the theory of angular momentum, spin, the hydrogen atom, identical particles, time-independent perturbation theory and the Pauli exclusion principle. Other approximate solution techniques with applications to atoms, molecules, and solids are presented. Prerequisites: MATH 261, MATH 265 PHYS 212. Recommended: PHYS 440.

PHYS 440. Mathematical Methods of Physics. (4).
Mathematics with a focus to meet the needs of students with a major or minor in physics or engineering disciplines. Topics include: complex variables, linear algebra, coordinate transformations, vector analysis, Fourier series and transforms; Laplace transforms, the Dirac delta function, Green functions, calculus of variations and solution techniques for partial differential equations with specific applications to Laplace's equation. Prerequisites: MATH 261 and PHYS 212. Recommended: MATH 265.

PHYS 475. Capstone Senior Thesis. (1).
In this course, students develop professional-level written and oral communication skills necessary for workplace standards. They will present the results of one of the following required experiences: research in Physics or a closely-aligned field performed through PHYS-496 or UNIV-496, an Internship through PHYS-492, or a Capstone project in PHYS-494. Each student will submit a professional written report, as well as an oral presentation by the end of the semester. Senior Standing Only. Prerequisite: PHYS-300 Corequisites: PHYS-492, PHYS-494, PHYS-496 or UNIV-496.

PHYS 482. Selected Topics. (1-4).

PHYS 482L. Sel Topics: Lab. (1-4).

PHYS 490. Independent Study. (1-4).

PHYS 492. Internship. (2-4).

PHYS 494. Capstone Research Project. (1).
Independent study and research, interdisciplinary topic of current interest selected by the participants. Ongoing independent research results are presented for group discussions during weekly class meetings. Senior Standing Only. Prerequisite: PHYS-300.

PHYS 496. Directed Research. (1-3).

PHYS 497. Departmental Honors. (4).
This course allows academically motivated students the opportunity to explore a research topic of their choosing at a level of depth beyond the one-semester Capstone course. Students will complete two semesters of Physics 497 to satisfy the requirements of the Physics department Honors program. Upon completion of the two semesters, the student will present in a public forum, such as the CLU Festival of Scholars, or equivalent.