Mission Statement

The Department of Mathematics, Physics, and Statistics (http://www.apu.edu/clas/mathphysics) at Azusa Pacific University:

1. Offers undergraduate programs in mathematics, applied mathematics, physics, and statistics, as well as a single subject waiver for a teaching credential in mathematics;
2. Provides General Education (http://catalog.apu.edu/undergraduate/academic-programs/general-education-program) mathematics and science courses consistent with the outcomes of a liberal arts education;
3. Prepares students for graduate study or success in their chosen careers; and

Math and Physics Fellowships

Each year, the Department of Mathematics, Physics, and Statistics awards two four-year fellowships (http://catalog.apu.edu/undergraduate/financial-information/types/institutional-aid/participatory-other-awards/math-and-physics-fellowship) to incoming freshmen. For more information, contact the department at (626) 815-6470 or mathphysics@apu.edu.

Majors

- Applied Mathematics (B.S.) (http://catalog.apu.edu/undergraduate/liberal-arts-sciences/mathematics-physics/applied-mathematics)
- Mathematics (B.S.) (http://catalog.apu.edu/undergraduate/liberal-arts-sciences/mathematics-physics/mathematics-major)
- Physics (B.S.) (http://catalog.apu.edu/undergraduate/liberal-arts-sciences/mathematics-physics/physics-major)

Minors

- Mathematics (http://catalog.apu.edu/undergraduate/liberal-arts-sciences/mathematics-physics/mathematics-minor)
- Physics (http://catalog.apu.edu/undergraduate/liberal-arts-sciences/mathematics-physics/physics-minor)

Mathematics Placement

APU uses the ALEKS PPL (http://www.apu.edu/lec/placement/math/about-aleks) system to determine the best initial math placement for most students who need to take a math course (whether to satisfy the General Education Quantitative Literacy requirement or a major or minor requirement). Students who need to use ALEKS (http://www.apu.edu/lec/placement/math/using-aleks) are encouraged to take an initial diagnostic assessment (http://www.apu.edu/lec/placement/math/start-aleks) at home and then to work in their personalized Prep and Learning Module (http://www.apu.edu/lec/placement/math/prep-learning-module) to review. They will then be able to retake the assessment up to four times in order to achieve their best possible score.

Math Course Prerequisites

Prerequisites for common math courses are as follows:

<table>
<thead>
<tr>
<th>Course(s)</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 90: Foundations of Mathematical Reasoning</td>
<td>ALEKS 15-29</td>
</tr>
<tr>
<td>MATH 95: Intermediate Algebra</td>
<td>ALEKS 30-44 or MATH 90</td>
</tr>
<tr>
<td>MATH 99: Self-Paced Mathematics Lab</td>
<td>ALEKS 0-29</td>
</tr>
<tr>
<td>MATH 115: Mathematics in Society</td>
<td>ALEKS 30-100 or MATH 90</td>
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<tr>
<td>MATH 130: Introduction to Statistics</td>
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<tr>
<td>MATH 110: College Algebra</td>
<td>ALEKS 45-100 or MATH 95</td>
</tr>
<tr>
<td>UNRS 299: Statistics and Data Management for Nursing and Health Care</td>
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</tbody>
</table>
Math Test Score Equivalents

The table below shows how various test scores translate into APU math placement and/or course credit:

<table>
<thead>
<tr>
<th>Scores</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• SAT Math (640 or higher on NEW version)</td>
<td>Treated as if you have passed MATH 110 College Algebra at the level of B- or higher</td>
</tr>
<tr>
<td>• SAT Math (620 or higher on OLD version)</td>
<td></td>
</tr>
<tr>
<td>• ACT Math (27 or higher)</td>
<td></td>
</tr>
<tr>
<td>• High School Calculus (at least one semester with a grade of B or higher)</td>
<td></td>
</tr>
<tr>
<td>• High School Precalculus (at least one semester with a grade of A- or higher)</td>
<td></td>
</tr>
<tr>
<td>• CLEP College Algebra, Precalculus, or Calculus (50)</td>
<td>Treated as if you have passed MATH 110 College Algebra at the level of B- or higher; credit granted</td>
</tr>
<tr>
<td>• IB Mathematics (5, 6, or 7)</td>
<td></td>
</tr>
<tr>
<td>• AP Calculus AB or BC (3, 4, or 5)</td>
<td></td>
</tr>
<tr>
<td>• AP Statistics (3, 4, or 5)</td>
<td>Credit granted for MATH 130 Introduction to Statistics</td>
</tr>
<tr>
<td>• ALEKS (65-100)</td>
<td>Treated as if you have passed MATH 110 College Algebra at the level of a B- or higher</td>
</tr>
<tr>
<td>• ALEKS (60-64)</td>
<td>Treated as if you have passed MATH 110 College Algebra at the level of C or higher (fails to meet the grade minimum of B- required as a prerequisite for CHEM 151 or to apply to any of the majors in the School of Business and Management other than the B.A. in Business Management)</td>
</tr>
</tbody>
</table>

MATH 90, Foundations of Mathematical Reasoning, 3 Units

This course prepares students for MATH 95 Intermediate Algebra, MATH 115 Mathematics in Society, or MATH 130 Introduction to Statistics. Topics include proportional reasoning; financial decision making; chance, risk, and probability; and algebraic modeling. Students practice reading, analyzing, and writing about quantitative texts; using spreadsheets to make efficient calculations; and solving algebraic equations to make predictions and decisions. This course does not meet the General Education Quantitative Literacy requirement and does not count toward total units needed for graduation.

Prerequisite: An appropriate score on the APU mathematics placement assessment.

MATH 95, Intermediate Algebra, 3 Units

This course prepares students for the General Education Quantitative Literacy courses. Topics include linear graphs, mathematical models, systems of equations in two and three variables, multiplying and factoring polynomial functions, rational and radical expressions and functions, complex numbers, quadratic equations, and mathematical modeling with quadratic functions. This course does not meet the General Education Quantitative Literacy requirement and does not count toward total units needed for graduation.

Prerequisite: MATH 90 or an appropriate score on the APU mathematics placement assessment

MATH 99, Self-paced Mathematics Lab, 1 Unit

This course is an alternative to MATH 90 for students who prefer an individualized developmental math experience. An adaptive online learning system enables students to skip topics they have already mastered and work at their own pace on the topics they need to learn, with support from a faculty member. The goal is to help students test out of MATH 90 in order to accelerate their path toward a General Education Quantitative Literacy course. This course does not meet the General Education Quantitative Literacy requirement and does not count toward total units needed for graduation.

Prerequisite: ALEKS math placement score of 0-29 (or no ALEKS score).

MATH 100, Mathematics Seminar I, 1 Unit

An exploration of the historical interactions between Christian faith and the development of science and mathematics. The course begins with several short guest lectures introducing the questions that animate various fields of mathematical inquiry. Readings and seminar discussions then focus on three questions: “When, how, and why did people find mathematics in nature?”, “Why is there so much mathematics in nature?”, and “Can everything be explained by mathematics?” The course concludes with student presentations on the role of faith in the life and work of certain famous mathematicians and scientists.
MATH 110, College Algebra, 3 Units
A study of basic college algebra, including various elementary functions (linear, polynomial, rational, radical, exponential, and logarithmic), their properties and graphs, and equations and systems of equations. Emphasis is placed on using algebraic concepts to model and analyze real-world phenomena. Meets the General Education Requirement: Quantitative Literacy (Math).
Prerequisite: MATH 95 or an appropriate score on the APU mathematics placement assessment

MATH 115, Mathematics in Society, 3 Units
This course helps students to make sense of quantitative information commonly encountered in everyday life in society. Students use mathematical methods and spreadsheets to analyze data from real newspaper articles in order to deepen their understanding of societal issues and personal financial management. Mathematical topics include estimation, unit conversions, percentages, indices, weighted averages, statistical summaries, linear and exponential models, and probabilities. These tools are used to analyze issues such as carbon footprints, crime rates, currency conversions, taxes, minimum wages, inflation, grade point averages, salary distributions, electricity bills, climate change predictions, interest and depreciation, gambling, insurance, screening for diseases, and DNA evidence. Meets the General Education Requirement: Quantitative Literacy (Math).
Prerequisite: MATH 90 or an appropriate score on the APU mathematics placement assessment

MATH 120, Contemporary Mathematics, 3 Units
An overview of various mathematical topics and their connections to modern society. Topics differ from those covered in the typical school mathematics sequence and may include voting theory, graphs and networks, modular arithmetic, symmetry, statistics and probability, infinity and cardinality, fractals and chaos, and others. Emphasis is placed on conceptual understanding, solid reasoning, and clear communication, rather than on algebraic manipulation. Meets the General Education Requirement: Quantitative Literacy (Math).
Prerequisite: MATH 95 or an appropriate score on the APU mathematics placement assessment

MATH 130, Introduction to Statistics, 3 Units
This course is an introduction to the basic concepts and practices of statistics, including frequency distributions; graphs; central tendency; variation; probability; binomial, normal, t, and chi-square distributions; confidence intervals; hypothesis testing; correlation; regression; and ANOVA. Meets the General Education Requirement: Quantitative Literacy (Math).
Prerequisite: MATH 90 or an appropriate score on the APU mathematics placement assessment.

MATH 149, Fundamentals of Precalculus, 1 Unit
This course is a condensed alternative to MATH 150 designed for biology, biochemistry, and chemistry majors. Topics include circle trigonometry and sinusoidal functions, right-triangle trigonometry, and trigonometric equations and identities, as well as a brief review of exponential and logarithmic equations.
Prerequisite: MATH 110 or an appropriate score on the APU mathematics placement assessment. Only students with a declared major or interest in biology, biochemistry, or chemistry are permitted to register for this class.

MATH 150, Precalculus, 3 Units
This course prepares students for the calculus sequence. Topics include number systems, analytic geometry, elementary function theory (including logarithmic and trigonometric functions), and basic proof techniques.
Prerequisite: MATH 110 or an appropriate score on the APU mathematics placement assessment

MATH 151, Applied Calculus I, 3 Units
An introduction to the calculus of a single variable with a focus on applications. Topics include elementary functions (linear, exponential, logarithmic, power, and periodic), differentiation, and optimization.
Prerequisite: MATH 110 or an appropriate score on the APU mathematics placement assessment

MATH 152, Applied Calculus II, 3 Units
A continuation of MATH 151 combining further study of calculus with an introduction to probability and statistics. Problem solving in the biological sciences is emphasized. Topics include integration, substitution, separable differential equation solutions and equilibria, discrete-time dynamical systems, probability, and the descriptive statistics of discrete and continuous random variables.
Prerequisite: MATH 151

MATH 161, Calculus I, 5 Units
An introduction to the calculus of a single variable. Topics include limits, continuity, differentiation, integration, and the Fundamental Theorem of Calculus, with application to rates of change, the shape of a graph, optimization, areas, and volumes.
Prerequisite: MATH 150 or an appropriate score on the APU mathematics placement assessment

MATH 162, Calculus II, 4 Units
A continuation of MATH 161. Topics include the calculus of exponential, trigonometric, and hyperbolic functions and their inverses, integration methods, arc length and surface area, parametric and polar curves, sequences, and series.
Prerequisite: MATH 161 with a C- or better
MATH 165, Calculus I, 3 Units
Students in this course learn the theory and applications of the derivative, a mathematical tool used to calculate instantaneous rates of change. Topics include limits, continuity, interpretation and computation of derivatives, shapes of graphs, optimization, related rates, and parametric equations.
Prerequisite: MATH 150 or an appropriate score on the APU mathematics placement assessment or MATH 149 (May be taken concurrently)

MATH 166, Calculus II, 3 Units
Students in this course learn the theory and applications of the integral, a mathematical tool used to calculate the net change in a quantity over time. Topics include the definite integral, antiderivatives, the Fundamental Theorem of Calculus, integration techniques and applications, area and volume, arc length and surface area, and polar coordinates. The course concludes with a brief introduction to differential equations.
Prerequisite: C- or better in MATH 165

MATH 167, Sequences and Series, 1 Unit
This course introduces the powerful method of representing a function as a "polynomial of infinite degree." Topics include sequences and series, tests for convergence, power series, intervals of convergence, Taylor series, and applications.
Prerequisite: MATH 166 (May be taken concurrently)

MATH 199, Calculus Fundamentals for Statistics, 1 Unit
An introduction to fundamental topics in calculus required for understanding statistical theory and methods. Topics in this course include the interpretation of derivatives and integrals, rules for single-variable differentiation and integration, applications to optimization, moments and areas, and basic multivariable differentiation and integration.
Prerequisite: Acceptance in M.S. in Applied Statistics and Analytics program.

MATH 200, Mathematics Seminar II, 1 Unit
An exploration of the value and purpose of mathematical work. Students engage with Christian perspectives on the value of work and culture in general, then assess a variety of viewpoints regarding the value of mathematical work in particular. These readings and conversations prepare students to develop and articulate an understanding of how mathematics could contribute to their personal vocation, calling, or life purpose.
Prerequisite: MATH 100

MATH 201, Mathematics Concepts for Elementary Teachers, 3 Units
The course provides the foundations of modern mathematics needed by the elementary school teacher. It is not a methods course, but a prerequisite to the Multiple-Subject Teaching Credential Program. This course does not count toward a mathematics major or minor.
Prerequisite: MATH 110 or equivalent

MATH 250, Data Analysis, 3 Units
This course features hands-on experience using statistical tools to answer real-world questions. Students design and implement a short survey and analyze their results. Emphasis is on analysis of actual survey data using statistical software. Statistical topics include numerical/graphical summaries, measures of association, and statistical techniques to include chi-square tests, t-tests, ANOVA, and regression. Focus is on interpretation, not calculation.
Prerequisite: MATH 130 or MATH 361

MATH 263, Multivariable Calculus, 4 Units
An introduction to the calculus of several variables. Topics include vectors, lines, and planes in three dimensions, vector-valued functions, partial and directional derivatives, Lagrange multipliers, multiple integration in rectangular, polar, cylindrical, and spherical coordinate systems, vector fields, line integrals, Green's Theorem, curl and divergence, surface integrals, Stokes' Theorem, and the Divergence Theorem.
Prerequisite: MATH 162

MATH 268, Multivariable Calculus, 3 Units
Students in this course learn about the calculus of functions of several variables. Topics include surfaces and contour diagrams, vectors, partial and directional derivatives, optimization and Lagrange multipliers, and multiple integration in rectangular, polar, cylindrical, and spherical coordinate systems.
Prerequisite: C- or better in MATH 166

MATH 269, Vector Calculus, 2 Units
Students in this course learn about the calculus of vector fields, leading to several higher-dimensional versions of the Fundamental Theorem of Calculus. Topics include parametrized curves; vector fields and flow; line integrals, gradients, and path-independence; Green's Theorem; divergence, flux integrals, and the Divergence Theorem; curl and Stokes' Theorem; and parametrized surfaces and change of coordinates.
Prerequisite: C- or better in MATH 268

MATH 270, Ordinary Differential Equations, 4 Units
An introduction to ordinary differential equations and their applications. Topics include first and second order equations, Laplace transform, systems of differential equations, phase plane analysis, numerical methods, and Sturm-Liouville boundary value problems.
Prerequisite: MATH 263 or Instructor's consent
MATH 280, Discrete Mathematics and Proof, 3 Units
This course is a rigorous introduction to discrete mathematics with an emphasis on problem solving and proof writing, preparing students to construct valid mathematical arguments in upper-division courses. Topics include mathematical logic and set theory; direct and indirect proof; proofs with conjunctions, disjunctions, and quantifiers; relations; equivalence relations and partitions; functions and invertibility; and mathematical induction. Lecture, 3 hours; Discussion, 1 hour.
Prerequisite: MATH 165

MATH 290, Linear Algebra, 3 Units
An introduction to matrix algebra, vector spaces, and linear transformations. Topics include systems of linear equations, subspaces, linear independence, bases and dimension, abstract vector spaces, orthogonality, least-squares methods, inner product spaces, determinants, eigenvalues, and diagonalization.
Prerequisite: MATH 268 or MATH 280

MATH 295, Applied Linear Algebra, 3 Units
An introduction to the analysis of numerical algorithms in linear algebra computations, including solution of linear systems, QR decomposition, singular value decomposition, and computation of eigenvalues and eigenvectors.
Prerequisite: MATH 162

MATH 299, Linear Algebra Fundamentals for Statistics, 1 Unit
An introduction to fundamental topics in linear algebra required for statistical courses such as linear and generalized linear models. Topics also include introduction to vectors and matrices, basic matrix operations, methods to solve linear systems, LU/QR decomposition, singular value decomposition, and computation of eigenvalues and eigenvectors.
Prerequisite: Acceptance in M.S. in Applied Statistics and Analytics program.

MATH 301, Mathematics for Secondary Teachers, 3 Units
A survey of the foundations of mathematics essential to the secondary school teacher. This course integrates secondary mathematics concepts with problem-solving strategies and technology. Students expand on their understanding of core math concepts, evaluate lesson plans used in secondary school mathematics, discuss and reflect on effective mathematics pedagogy, analyze readings in the field, engage in collegial interactions with the instructor and fellow students, and develop a repertoire of classroom-tested lessons that can be used in a high school classroom.

MATH 340, Geometry, 3 Units
This course is a study of Euclidean and hyperbolic geometries and their transformations and models. Students learn to write proofs within an axiomatic system and to form conjectures using interactive geometry software.
Prerequisite: MATH 166

MATH 350, Statistical Models, 3 Units
A study of investigative statistics emphasizing the process of data collection and data analysis relevant for science, social science, and mathematics students. The course incorporates case studies from current events and interdisciplinary research, taking a problem-based approach to learn how to determine which statistical techniques are appropriate. Topics include nonparametric tests, designing an experiment, multiple regression models, and Bayesian data analysis. Ethics in data analysis and reporting will be considered from a Christian perspective. Additionally, the course includes learning to program using a statistical software package.
Prerequisite: MATH 250

MATH 361, Probability and Statistics I, 3 Units
An introduction to probability and the theory and application of statistics. Topics include probability spaces, counting methods, discrete and continuous distributions, moments, conditional distributions, correlation, the Central Limit Theorem, estimation, and hypothesis testing.
Prerequisite: MATH 162

MATH 362, Probability and Statistics II, 3 Units
A continuation of MATH 361. This course develops additional applications of statistics, including estimation, hypothesis testing, and single and multiple linear regression. Nonparametric and Bayesian methods are introduced.
Prerequisite: MATH 361

MATH 370, Partial Differential Equations, 3 Units
An introduction to Fourier analysis and analytical techniques for solving partial differential equations, with application to physical phenomena.
Prerequisite: MATH 263 and MATH 270

MATH 375, Dynamical Systems, 3 Units
An introduction to phase plane analysis of first order differential equations and to bifurcations in continuous and discrete systems, with application to various branches of science.
Prerequisite: MATH 270
MATH 390, Number Theory, 3 Units
A study of elementary number theory, with an overview of the history of mathematics. Number theory topics include primes, divisibility, factorization, Diophantine problems, residue systems, theorems of Fermat and Euler, and continued fractions.
Prerequisite: MATH 280

MATH 400, Abstract Algebra, 3 Units
An introduction to groups and rings. Group theory topics include subgroups, cyclic groups, permutation groups, cosets and normal subgroups, factor groups, and homomorphisms. Ring theory topics include subrings and ideals, integral domains and fields, factor rings, and homomorphisms.
Prerequisite: MATH 280 with a C- or better

MATH 430, Mathematical Methods for Physics and Engineering, 3 Units
Students learn mathematical methods and their applications to physics problems. Topics include series, complex numbers, linear algebra, generalized vector spaces, vector calculus, special functions, Fourier series, and boundary value problems. The course may be applied towards upper-division physics or mathematics major requirements.
Prerequisite: MATH 263 and MATH 270

MATH 450, Real Analysis, 3 Units
This course is an advanced study of the real number system. Topics include completeness, convergence of sequences and series, topology of the real line, continuity, the Intermediate Value Theorem, differentiation, and the Mean Value Theorem.
Prerequisite: MATH 167 and a C- or better in MATH 280

MATH 455, Numerical Analysis, 3 Units
Numerical and approximation methods are covered, including solutions of functions in single and multi-variables, interpolation, numerical differentiation and integration, and numerical methods for differential equations. Applications are programmed using an appropriate language.
Prerequisite: MATH 167, MATH 295, and CS 220

MATH 460, Topology, 3 Units
An introduction to topological spaces and their applications. Topics include bases, interior closure, subspace, product, and quotient topologies, continuity and homeomorphisms, metric spaces, connectedness, and compactness, with application to genetics, geography, robotics, and error-correcting codes. Additional topics chosen from homotopy theory, knot theory, and compact surfaces.
Prerequisite: MATH 450

MATH 470, Complex Analysis, 3 Units
This course is an introduction to the calculus of functions of one complex variable. Topics include elementary functions, limits, differentiability, series, contour integrals, Cauchy's theorem, conformal mapping, and selected applications.
Prerequisite: MATH 167 and MATH 268

MATH 480, Writing 3: Mathematical Reading, Writing, and Presentation, 3 Units
In this seminar, students critically analyze journal articles in the field, receive writing instruction, write research and argumentative papers, and prepare effective mathematical presentations. Meets the General Education Requirement: Writing 3: Writing in the Disciplines.
Prerequisite: Junior or Senior Standing

MATH 495, Advanced Topics in Mathematics, 1-3 Units
This course engages students in focused study of an advanced topic which is not covered in the regular curriculum. The topic varies from semester to semester based on student interest. Possible topics include differential geometry, combinatorics, mathematical modeling, advanced linear algebra, game theory, cryptography, etc. This course may be taken more than once as the topic changes.
Prerequisite: Prerequisite(s) will vary depending upon the topic.

MATH 496, Senior Seminar, 3 Units
This senior seminar course prepares students to understand and express a Christian perspective on issues critical to the mathematics profession. Biblical, theological, and philosophical themes relating to the development and application of mathematics provide a base, while historical biographies and examples supply a context in which students generate a distinctively Christian response to contemporary problems facing a post-modern world. Meets the General Education Requirement: Integrative and Applied Learning.
Prerequisite: Senior standing, completion of Writing 3 (HIST 300 or POLI 300).

MATH 497, Readings, 1-4 Units
This is a program of study concentrating on assigned readings, discussions, and writing arranged between and designed by a student of upper-division standing and a full-time professor. An independent study fee is assessed for each enrollment in this class.
MATH 498, Directed Research, 1-4 Units
This course provides instruction in research design and technique, and gives students experience in the research process. The 1-unit expectation encompasses no fewer than 30 hours of work with accompanying reading, log, writing, and seminar presentation within the department or in a university research symposium. No more than 1 unit may be used to fulfill preparatory readings requirement. An independent study fee is assessed for each enrollment in this class.

Prerequisite: Junior or Senior Standing

MATH 499, Thesis/Project, 1-4 Units
This is a senior-level "capstone" type of independent study/research experience, involving the student in a unique project with a sophisticated level of research, synthesis, analysis, and communication. The 1-unit expectation encompasses no fewer than 30 hours of work with accompanying readings, log, instructor discussions, and writing of summary analysis and conclusions. The thesis or project may result in formal thesis, published article, or electronic media. No more than 1 unit may be used to fulfill preparatory readings requirement. An independent study fee is assessed for each enrollment in this class.

Prerequisite: Upper-division writing intensive course or instructor consent; and junior or senior standing

PHYC 100, Conceptual Physics, 2 Units
This course covers the topics of mechanics, heat, sound, light, electricity and magnetism, an introduction to relativity, and quantum mechanics. Physics concepts and thinking skills are emphasized instead of mathematics. Does not meet the General Education requirement.

PHYC 112, Physics for Difference Makers, 4 Units
This course examines fundamental concepts of physics with illustrations of how these concepts have led to technologies that have drastically changed the world and impacted modern life. The course also examines the nature of science, scientific methods, and how science informs decision-making on questions important to society. This course does not carry credit toward a science major or minor. Meets the General Education Requirement: Natural Science, Civic Knowledge and Engagement.

Special Fee Applies

PHYC 115, Physical Science for Teachers, 3 Units
This course focuses on three fundamental concepts of physics: conservation of energy, Newton's laws, and waves. Students will engage in practices of science such as performing experiments, collecting and analyzing data, developing models, and writing and evaluating explanations. Students will also examine the nature of science and learning. Course content is aligned with content, practices, and cross-cutting concepts of the Next Generation Science Standards. This course is intended for Liberal Studies majors and does not meet the APU General Education requirement in Natural Science.

PHYC 125, Earth Science Concepts and Applications, 3 Units
This course surveys Earth both inside and out. Topics investigated include Earth's solid surface and interior, the oceans, and Earth's atmosphere and weather patterns. Emphasis is placed on dynamic processes, including human activity that affects the nature of Earth's surface. Students also explore Earth's place in the solar system, the Sun, the stars, and exotic bodies beyond the solar system. Does not meet the APU General Education requirement in Nature.

PHYC 130, Earth Science, 4 Units
Lecture, 3 hours; Lab, 3 hours: Students survey the physical characteristics of the Earth and the forces acting upon it. The course includes consideration of the Earth's place in space, the nature of its crust and interior, the processes that affect its structure, and humanity's role in the processes. Meets the General Education Requirement: Natural Science.

Special Fee Applies

PHYC 140, Introduction to Astronomy, 4 Units
Lecture, 3 hours; Lab, 3 hours: This course introduces the history of astronomy, the solar system, the stellar systems, galactic systems, and cosmology. A lab is included. Meets the General Education Requirement: Natural Science.

Special Fee Applies

PHYC 151, Physics for Life Sciences I, 4 Units
Lecture, 3 hours; Lab, 3 hours: This noncalculus physics course develops the topics of translational and rotational mechanics and provides an introduction to thermodynamics. Meets the General Education Requirement: Natural Science.

Special Fee Applies

Prerequisite: MATH 110 or an equivalent score on the APU mathematics placement assessment. High school geometry and trigonometry are highly recommended.

PHYC 152, Physics for Life Sciences II, 4 Units
Lecture, 3 hours; Lab, 3 hours: This noncalculus physics course develops the topics of waves, sound, light, electricity and magnetism, quantum theory, and structure of matter.

Special Fee Applies

Prerequisite: PHYC 151
PHYC 161, Physics for Science and Engineering I, 5 Units
Students in this course are introduced to various areas of physics using basic differential and integral calculus. Topics include kinematics, Newton’s laws, conservation of energy, conservation of momentum, and rotation. Lecture, 4 hours; lab, 3 hours. Meets the General Education Requirement: Natural Science.
Special Fee Applies
Corequisite: MATH 165 or equivalent calculus background; high school physics or university-level conceptual physics strongly recommended.

PHYC 162, Physics for Science and Engineering II, 5 Units
Students in this course are introduced to various areas of physics using basic differential and integral calculus. Topics include oscillations, electricity, and magnetism. Lecture, 4 hours; lab, 3 hours.
Special Fee Applies
Prerequisite: PHYC 161 and MATH 166 (may be taken concurrently)

PHYC 263, Physics for Science and Engineering III, 5 Units
Lecture, 4 hours; Lab, 3 hours: Students are introduced to various aspects of physics using basic differential and integral calculus. Topics covered include thermodynamics, special relativity, vibrations and waves, optics, and nuclear and modern physics.
Special Fee Applies
Prerequisite: PHYC 162

PHYC 300, Physics Research Seminar, 1 Unit
This course surveys the major fields of modern physics research in a seminar format, with special attention to how physicists identify research questions and plan for research. The course culminates in a research proposal for the student’s thesis. Meets the General Education Requirement: Integrative and Applied Learning.
Prerequisite: PHYC 263

PHYC 361, Electricity and Magnetism, 3 Units
Students study the fundamental concepts of electricity and magnetism, electrostatic fields in a vacuum and dielectric materials, solutions of Laplace’s and Poisson’s equations, and electromagnetic waves.
Prerequisite: PHYC 162 and MATH 263

PHYC 370, Waves and Optics, 3 Units
Students study mechanical and electromagnetic waves and explore topics such as geometric optics, wave propagation, interference, diffraction, polarization, coherence, holography, and topics from nonlinear optics.
Prerequisite: PHYC 263, MATH 270 and MATH 263 (may be taken concurrently)

PHYC 380, Classical Mechanics, 4 Units
Students in this course apply mathematical methods commonly used in physics modeling and analysis to the study of particles experiencing linear and quadratic drag, momentum, energy, driven oscillations, central force motion, rigid-body rotation, and Lagrangian dynamics. The mathematical methods used include infinite series, complex numbers, linear algebra, curvilinear coordinates, vector calculus, Fourier analysis, partial differential equations, variational calculus, and numerical methods.
Prerequisite: PHYC 161, MATH 263, and MATH 270

PHYC 401, Thermodynamics, 3 Units
Students learn the theoretical basis of classical thermodynamics and statistical mechanics including the zeroth, first, second, and third laws. These laws are applied to equilibrium systems such as ideal gases, heat engines, chemical reactions, and phase transitions.
Prerequisite: PHYC 263 and MATH 263 (may be taken concurrently)

PHYC 430, Mathematical Methods for Physics and Engineering, 3 Units
Students learn mathematical methods and their applications to physics problems. Topics include series, complex numbers, linear algebra, generalized vector spaces, vector calculus, special functions, Fourier series, and boundary value problems. The course may be applied towards upper-division physics or mathematics major requirements.
Prerequisite: MATH 263 and MATH 270

PHYC 431, Computational Methods for Physics, 3 Units
Students in this course develop numerical modeling skills to solve representative problems in mechanics, quantum mechanics, thermal physics, and electromagnetism. The problems solved include multibody dynamics under gravity, Laplace equation, wave equation, Ising model, time-independent Schrodinger equation, and molecular dynamics.
Prerequisite: CS 220, MATH 263, MATH 270

PHYC 440, Quantum Mechanics, 3 Units
Students are introduced to the time-dependent and time-independent Schrodinger equations. The Schrodinger equation is solved for examples including potential wells and barriers, harmonic oscillators, and hydrogen atoms. These examples illustrate the concepts of quantization of energy and angular momentum, tunneling, wave properties of particles, and the uncertainty principle.
Prerequisite: MATH 270 and PHYC 370, or instructor consent
PHYC 470, Writing 3: Advanced Laboratory, 3 Units
This course prepares students for writing scientific journal articles and presenting scientific results to a technical audience. This course also acquaints students with advanced laboratory and analysis techniques. Activities include instruction and practice in scientific writing and presenting scientific information orally. *Meets the General Education Requirement: Writing 3: Writing in the Disciplines.*
Special Fee Applies
Prerequisite: PHYC 263, Writing 2, and junior or senior standing, or Instructor's consent

PHYC 497, Readings, 1-4 Units
This is a program of study concentrating on assigned readings, discussions, and writing arranged between and designed by a student of upper-division standing and a full-time professor. An independent study fee is assessed for each enrollment in this class.

PHYC 498, Directed Research, 1-4 Units
This course provides instruction in research design and technique, and gives students experience in the research process. The 1-unit expectation encompasses no fewer than 30 hours of work with accompanying reading, log, writing, and seminar presentation within the department or in a university research symposium. No more than 1 unit may be used to fulfill preparatory readings requirement. An independent study fee is assessed for each enrollment in this class.
Prerequisite: Junior or Senior Standing

PHYC 499, Physics Thesis, 1-4 Units
The student engages in an original research project in collaboration with a faculty member. Projects may be experimental, theoretical, or computational in nature. Projects will expand upon learning from previous courses in the major and apply that learning to make a novel contribution to the field. Successful completion of the course will result in completion of a journal-style article and/or professional-level poster presentation. *Meets the General Education Requirement: Integrative and Applied Learning.*
Prerequisite: PHYC 300

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