Department of Computer Science, Engineering, Mathematics, Physics, and Statistics

Mission Statement

The Department of Computer Science, Engineering, Mathematics, Physics, and Statistics (http://www.apu.edu/clas/mathphysics/) at Azusa Pacific University is a community of students and scholars dedicated to seeking truth. We foster academic and research excellence and equip undergraduate and graduate students with practical skills in data analysis, quantitative and computational thinking, and problem solving. We prepare students to use their technical skills to do good, serve others, and glorify God.

Math, Physics, and Statistics Fellowships

Each year, the Department of Computer Science, Engineering, Mathematics, Physics, and Statistics awards fellowships (https://www.apu.edu/clas/mathphysics/opportunities/fellowships/) to a select number of incoming and returning students. For more information, contact the department at (626) 815-6470 or mathphysics@apu.edu.

Department Resources

The department operates two computer science laboratories on the Azusa campus: the advanced technologies/multimedia laboratory and the computer science main laboratory. Lab technicians are available during lab hours for tutoring, free of charge to all students enrolled in computer science courses. There is also a new engineering lab.

Although the university provides extensive computer lab facilities for student use, each student in the computer science and engineering majors is required to purchase a personal computer, as students with their own computers have a definite advantage in using and applying engineering and computer science instruction.

Programs

Majors

- Applied Mathematics (BS) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/applied-mathematics-bs/)
- Computer Information Systems (BS) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/computer-information-systems-bs/)
- Computer Science (BS) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/computer-science-bs/)
- Engineering (BS) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/engineering-bs/)
- Mathematics (BA) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/mathematics-ba/)
- Mathematics (BA) with Integrated Single Subject (Math) Teaching Credential (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/mathematics-ba/mathematics-ba-with-integrated-bachelors-credential/)
- Mathematics (BS) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/mathematics-bs/)
- Physics (BS) (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/physics-bs/)

Minors

- Computer Information Systems (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/computer-information-systems-minor/)
- Computer Science (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/computer-science-minor/)
- Data Science (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/data-science-minor/)

- Mathematics (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/mathematics-minor/)
- Physics (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/physics-minor/)
- Statistics (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/statistics-minor/)

Master's

- Master of Science in Applied Statistics and Data Science (http://catalog.apu.edu/academics/college-arts-humanities-theology-sciences/school-humanities-sciences/math-physics-statistics/applied-statistics-and-analytics-ms/)

Math Placement

Mathematics Placement

APU uses the ALEKS PPL (https://www.apu.edu/academic-success/services/testing/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 (https://www.apu.edu/academic-success/testing/math/#using-aleks) are encouraged to take an initial diagnostic assessment (https://www.apu.edu/academic-success/testing/math/#start-aleks) at home and then to work in their personalized Prep and Learning Module (https://www.apu.edu/academic-success/testing/math/prep-learning-module/) to review. They will then be able to take the assessment again (up to four times total) in order to achieve their best possible score.

Math Course Prerequisites

Prerequisites for common math courses are as follows:

Course(s)	Prerequisite(s)
MATH 90: Foundations of Mathematical Reasoning	ALEKS 15-29
MATH 95: Intermediate Algebra	ALEKS 30-44 or MATH 90
MATH 99: Self-Paced Mathematics Lab	ALEKS 0-29
MATH 115: Mathematics in Society MATH 130: Introduction to Statistics	ALEKS 30-100 or MATH 90
MATH 110: College Algebra UNRS 299: Statistics and Data Management for Nursing and Health Care	ALEKS 45-100 or MATH 95
MATH 149: Fundamentals of Precalculus MATH 150: Precalculus	ALEKS 60-100 or MATH 110
MATH 151: Applied Calculus I	ALEKS 65-100 or B- or better in MATH 110
MATH 165: Calculus I	ALEKS 75-100 or MATH 149 (which may be taken concurrently) or MATH 150

Math Test Score Equivalents

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

Scores	Results
• SAT Math (640 or higher on NEW version) • SAT Math (620 or higher on OLD version) • ACT Math (27 or higher) • High School Calculus (at least one semester with a grade of B or higher) • High School Precalculus (at least one semester with a grade of A- or higher)	Treated as if you have passed MATH 110 College Algebra at the level of B- or higher
• CLEP College Algebra, Precalculus, or Calculus (50) • IB Mathematics (5, 6, or 7) • AP Calculus AB or BC (3, 4, or 5)	Treated as if you have passed MATH 110 College Algebra at the level of B- or higher; credit granted
• AP Precalculus (3, 4, or 5)	Credit granted for MATH 150 Precalculus
• AP Statistics (3, 4, or 5)	Credit granted for MATH 130 Introduction to Statistics

• ALEKS (65-100)	Treated as if you have passed MATH 110 College Algebra at the level of a B- or higher
• ALEKS (60-64)	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 BA in Business Management)

Courses

CS 100, Introduction to Programming, 3 Units

Students in this course are introduced to basic programming concepts using a suitable and modern programming language, with a strong emphasis on problem solving through programming fundamentals such as variables, expressions, data types, branching, loops, functions, lists, dictionaries, and file input/output. Although the course may use an object-oriented language, object-oriented principles are not covered, as the course is intended to provide non-computer-science majors the tools needed to be successful in carrying out common programming tasks in their fields, such as basic scripting, data analysis, and automation. In-class exercises and several programming projects are included.
Corequisite: MATH 110

CS 120, Introduction to Computer Science I, 4 Units

This course introduces students to object-oriented programming, with an emphasis on problem solving, design and analysis of algorithms, and programming principles. Course material also covers principles of object-oriented and structured programming, problem analysis, and documentation. Attendance at a weekly computer lab is required. Students complete a number of programming projects, and learn how to effectively communicate technical matters orally. *Meets the APU Core: Oral Comm (ENGR 120+ENGR 240+ENGR 480), Oral Communication (CS 120+CS 290+CS 480) general education requirement.*

CS 125, Introduction to Computer Science II, 4 Units

This course is a continuation of object-oriented programming and other topics from ENGR 120/CS 120, and provides an introduction to arrays, inheritance, file I/O, and GUIs. Problem analysis, program design, development and implementation, and related topics are covered. Lab is required. Students complete a number of programming projects. Lecture, 3 hours; lab, 3 hours.
Prerequisite: CS 120/ENGR 120

CS 150, Operating Systems, 3 Units

This course provides an introduction to the basic functions of modern operating systems, including multitasking, process synchronization, deadlocks, memory management, virtual memory, file systems, protection, and security. The course also includes a comparative analysis of several popular operating systems.
Prerequisite: CS 120/ENGR 120

CS 160, Discrete Structures, 3 Units

Students in this course explore the mathematical elements of computer science, including propositional logic, predicate logic, sets, functions and relations, combinatorics, mathematical induction, recursion, algorithms, matrices, graphs, trees, and Boolean logic. Attention is given to the direct applications to computer science.
Prerequisite: MATH 110 or MATH 130

CS 205, Microcomputer Software Tools, 3 Units

This PC-based course covers the basics of MS Windows and the use of applications software as problem-solving tools. In-depth coverage of popular word processing, database, and spreadsheet packages is included.

CS 230, Systems Programming and Operating Systems, 3 Units

This course provides an in-depth study of systems programming using the C language and Linux operating system. Applications include programming projects in threads, signals, memory, and critical sections. It also provides an introduction to the basic functions of modern operating systems. These include multitasking, process synchronization, deadlocks, memory management, virtual memory, file systems, protection, and security.
Prerequisite: CS 125/ENGR 125

CS 240, Assembly Language Programming, 3 Units

This programming class includes the architecture and organization of microcomputer systems, fundamentals of assemblers, assembly language programming, and advanced topics on the Intel 80X86 family of microprocessors. Students write several programs which are assembled and run on Intel 80X86-based microcomputers. Students become proficient at keyboard, screen, and disk I/O as well as character manipulation and screen graphics.
Prerequisite: CS 125/ENGR 125

CS 242, Digital Logic Systems, 4 Units

This course covers Boolean algebra, Karnaugh maps, logic gates, combinational circuit design, sequential circuits analysis and design, Register, and counter and memory system analysis and design, as well as laboratory experiments with TTL logic gates, flip-flops, and counters. Students also learn how to effectively communicate technical matters orally. *Meets the APU Core: Oral Comm (ENGR 120+ENGR 240+ENGR 480) general education requirement.*

Prerequisite: CS 125/ENGR 125

CS 260, Algorithms and Data Structures, 3 Units

This course provides a study of algorithms and their related data structures, including linear lists, linked lists, trees, graphs, sorting techniques, and dynamic storage allocation. Applications are implemented using an appropriate computer language.

Prerequisite: CS 125/ENGR 125

CS 290, Database Management Systems, 3 Units

This course covers database concepts; relational and nonrelational database systems; database environment, theory, and applications; and design, development, and implementation of database systems. Students develop a practical database project utilizing a popular database development system, and generate user interfaces and reports. Students also learn how to make persuasive technical arguments concerning common database tradeoffs that must be considered when choosing a database in a real-world project, and are instructed on how to effectively communicate technical matters orally. *Meets the APU Core: Oral Communication (CS 120+CS 290+CS 480) general education requirement.*

Prerequisite: CS 125/ENGR 125

CS 315, Computer Networks and Distributed Systems, 3 Units

This course covers principles and techniques in computer networks and distributed systems. Computer networking topics include the OSI reference model, the function and protocols in each protocol layer, and network security. Distributed systems topics include client-server systems, peer-to-peer systems, interprocess communication, replication and consistency, and fault tolerance.

Prerequisite: CS 230 and CS 260

CS 342, STEM Writing and Communication, 3 Units

In this course, students practice communicating about STEM in oral presentations and in writing. Students examine writing styles and forms of argument for a variety of audiences, and writing assignment genres include journal articles, technical reports, and popular articles. Students also explore potential career paths and write cover letters and resumes.

Prerequisite: HON 101 or WRIT 110; ENGR 215, ENGR 281, MATH 166, or PHYC 145

CS 360, Computer Architecture and Organization, 3 Units

This course covers the architecture and organization of computer systems, including hardware/software design considerations, implementation, interrelationships, and performance. Fundamentals of assemblers and assembly language programming using the MIPS instruction set are included, as is the use of combinational and sequential logic in the components of CPUs, buses, and interfaces. Details include input/output, memory hierarchies, pipelining, ALU operations, and CPU control. Processors include CISC and RISC, as well as multiprocessor systems. Students also take part in several programming and modeling projects that model key computer architecture components.

Prerequisite: CS 260/ENGR 260 or ENGR 240

CS 363, Web Programming, 3 Units

This course is a study of website development, emphasizing web-based programming using open-source software including Apache Server, PHP, Linux, XHTML, CSS, JavaScript and DHTML, MySQL, and others. The concepts, principles, procedures, methods, tools, and techniques used in the development and management of internet websites are covered, including the design, construction, implementation, testing, and maintenance of complex websites using cutting-edge tools. Sites are developed on the Linux platform. Each student makes assigned presentations, develops small internet projects, serves on a development team, and implements part of one major term project.

Prerequisite: CS 125/ENGR 125

CS 432, Machine Learning, 3 Units

This course covers introductory machine learning topics, including supervised and unsupervised learning, linear and logistic regression, neural networks, support vector machines, recommender systems, and more. Coursework includes instruction and programming assignments in algorithmic implementations and high-level library usage. Students also apply machine learning techniques to a unique research project.

Prerequisite: CS 260/ENGR 260

CS 440, Mobile App Development, 3 Units

This course serves as an introduction to mobile app development, with students building several cross-platform apps using cutting-edge technologies that target the Android and iOS operating systems. Topics include authentication, component creation and layout, state management, HTTP/API requests, push notifications, navigation, datastore (or database) connection, and server-side programming using cloud-based server/serverless infrastructure.

Prerequisite: CS 125

CS 452, Internet of Things, 3 Units

This course covers the fundamental aspects of the Internet of Things (IoT), including devices, protocols, security, and product development. Through hands-on labs and projects, students develop the ability to build IoT devices and systems, and a final project showcases their ability to plan, design, and execute their own IoT devices and systems. Students become proficient in embedded programming, cross-compilation, web servers and clients, basic digital electronics, communications protocols, and special programming techniques.
Prerequisite: ENGR 125/CS 125, and CS 230 or ENGR 240.

CS 455, Numerical Analysis, 3 Units

This course covers numerical and approximation methods, 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: CS 120

CS 470, Software Engineering, 3 Units

This course covers the concepts, principles, techniques, methods, procedures, and documents of software engineering. Emphasis is on systematic approaches to software engineering and the software life cycle. Each student participates in a major team project.
Prerequisite: CS 260, CS 290, and CS 363 (may be taken concurrently) or CS 440 (may be taken concurrently)

CS 480, Senior Capstone Project, 3 Units

The primary goal for students in this course is to implement a major team-based software product based on their own software documentation and planning from the previous semester. As a secondary goal, students study and practice software engineering concepts, principles, and methodologies relevant to the implementation phase of software engineering. Students also learn how to prepare and present a technical demo aimed at "selling" their product. *Meets the APU Core: Oral Communication (CS 120+CS 290+CS 480) general education requirement.*
Prerequisite: CS 470

CS 484, Cyber Security, 3 Units

In this course, students systematically study the fundamental principles of computer system security, including authentication, access control, capability, security policies, sandbox, software vulnerabilities, and web security, with most of these principles studied within the scope of concrete systems such as Linux and Windows. The course emphasizes "learning by doing," requiring students to conduct a series of lab exercises through which students enhance their understanding of the principles and learn to apply them to solve real-world problems.
Prerequisite: CS 230, CS 260/ENGR 260

CS 491, Computer Science Internship, 1-3 Units

This course gives students practical experience in computer science and computer information systems as they complete a computer science internship in a nonacademic facility, preferably off campus but under the joint supervision of a computer science faculty member and an outside mentor. A total of 3 units is required to satisfy the General Education Integrative and Applied Learning requirement.
Prerequisite: Sophomore standing in computer science major and department approval.

CS 495, Topics in Computer Science, 3 Units

This course presents timely and new topics in computer science, with different material covered each time the course is offered. Most topics require prerequisites, which vary according to the topic. The course may be repeated for credit.
Prerequisite: Department consent (note course description).

CS 496, Ethics in Computing and Engineering, 3 Units

This course equips students with the skills to write in several genres that are relevant to Computing and Engineering, such as resumes, cover letters, professional memos, and research proposals. Students complete reading assignments on the topics of writing and ethics as applied to Computing and Engineering, then weekly writing assignments based upon the reading. The course culminates in a portfolio of the writing completed throughout the semester.

CS 497, Readings, 1-4 Units

This course consists of assigned readings, discussions, and writing arranged between and designed by student and professor. An independent study fee is assessed for each enrollment in this course.
Prerequisite: Junior or senior standing and department permission.

CS 498, Directed Research, 1-4 Units

Students in this course learn about research design and technique and gain 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 course.
Prerequisite: Junior or senior standing and department permission.

CS 499, Thesis/Project, 1-4 Units

In this senior-level "capstone" type of independent study/research experience, students participate 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 project may result in a formal thesis, published article, electronic media, annotated recital, or artistic creation of a material form. No more than 1 unit may be used to fulfill preparatory readings requirement. An independent study fee is assessed for each enrollment in this course.
Prerequisite: Junior or senior standing and department permission.

CS 532, Machine Learning, 3 Units

This course covers machine learning topics including supervised and unsupervised learning, linear and logistic regression, neural networks, support vector machines, recommender systems, and more. Coursework includes instruction and programming assignments in algorithmic implementations and high-level library usage. Students also apply machine learning techniques to a unique research project.
Prerequisite: Instructor permission required

ENGR 101, Introduction to Engineering, 3 Units

Students in this course engage in hands-on exploration of the engineering design process. Course material incorporates computer-aided design (CAD) software and other relevant design and simulation programs. Students engage in projects and collaborative activities, learning to identify problems, brainstorm innovative solutions, and develop tangible prototypes.

ENGR 120, Introduction to Computer Science I, 4 Units

This course introduces students to object-oriented programming, with an emphasis on problem solving, design and analysis of algorithms, and programming principles. Course material also covers principles of object-oriented and structured programming, problem analysis, and documentation. Attendance at a weekly computer lab is required. Students complete a number of programming projects, and learn how to effectively communicate technical matters orally. *Meets the APU Core: Oral Comm (ENGR 120+ENGR 240+ENGR 480), Oral Communication (CS 120+CS 290+CS 480) general education requirement.*
Prerequisite: MATH 110 (may be taken concurrently) or proven competence in college algebra.

ENGR 125, Introduction to Computer Science II, 4 Units

This course is a continuation of object-oriented programming and other topics from ENGR 120/CS 120, and provides an introduction to arrays, inheritance, file I/O, and GUIs. Problem analysis, program design, development and implementation, and related topics are covered. Lab is required. Students complete a number of programming projects. Lecture, 3 hours; lab, 3 hours.
Prerequisite: ENGR 120/CS 120

ENGR 160, Discrete Structures, 3 Units

Students in this course explore the mathematical elements of computer science, including propositional logic, predicate logic, sets, functions and relations, combinatorics, mathematical induction, recursion, algorithms, matrices, graphs, trees, and Boolean logic. Attention is given to the direct applications to computer science.
Prerequisite: MATH 150

ENGR 215, Electrical Circuits and Systems, 4 Units

This course covers resistive circuits with dependent and independent sources, node and loop analyses, reactive elements and circuits, steady-state solution for RLC circuits with sinusoidal inputs, resistive and reactive power, three-phase systems, motors, generators, time domain analysis of circuits, transient responses, Laplace transforms, Fourier series, and SPICE analysis. Laboratory exercises include steady-state and transient circuit design and measurements.
Prerequisite: MATH 166

ENGR 230, Computation and Modeling, 3 Units

This course is an introduction to computational modeling for applied math, engineering, physics, and other STEM majors. Students explore tools and strategies that are broadly applicable for use in computational models to understand complex problems, and learn how to apply these tools in their subsequent coursework and career. Examples and projects are drawn from a variety of fields. Topics covered include use of spreadsheet and programming solutions, discretization, boundary conditions, strategies for finding minima, model validation and verification, Monte Carlo analysis, dimensional analysis, and strategies for troubleshooting and identifying modeling errors.
Prerequisite: MATH 166 (may be taken concurrently) and CS 120

ENGR 240, Digital Logic Systems, 4 Units

This course covers Boolean algebra, Karnaugh maps, logic gates, combinational circuit design, sequential circuits analysis and design, Register, and counter and memory system analysis and design, as well as laboratory experiments with TTL logic gates, flip-flops, and counters. Students also learn how to effectively communicate technical matters orally. *Meets the APU Core: Oral Comm (ENGR 120+ENGR 240+ENGR 480) general education requirement.*
Prerequisite: CS 120/ENGR 120

ENGR 245, Electronics, 4 Units

This course covers amplifier basics; multistage, feedback, and operational amplifiers; wave-shaping and waveform generation; digital electronics; bipolar and CMOS logic; and switching circuits. Laboratory exercises include significant design experience.
Prerequisite: ENGR 215

ENGR 260, Algorithms and Data Structures, 3 Units

This course provides a study of algorithms and their related data structures, including linear lists, linked lists, trees, graphs, sorting techniques, and dynamic storage allocation. Applications are implemented using an appropriate computer language.
Prerequisite: ENGR 125/CS 125

ENGR 271, Advanced Math for Engineers, 4 Units

This course is an introduction to topics in advanced mathematics necessary in most engineering fields. Beginning with key concepts in vector calculus and matrix algebra, the course also covers orthogonal functions, Fourier series, boundary-value problems in several coordinate systems, and the integral transform method. Additional topics may include partial differential equations and complex analysis.
Prerequisite: MATH 310

ENGR 281, Statics, 3 Units

Statics is the branch of physical science that deals with the rest state of bodies under the action of forces. It also includes resultants of force systems and equilibrium on rigid bodies using vector algebra, friction, centroids and centers of gravity, and moments of inertia of areas and masses.
Prerequisite: PHYC 165

ENGR 282, Dynamics, 3 Units

Dynamics is the branch of mechanics that deals with the motion of bodies under the action of forces. Dynamics has two distinct parts: kinematics, the study of motion without reference to the forces that cause motion; and kinetics, which relates the action of forces on bodies to the resulting motions of bodies.
Prerequisite: PHYC 165; ENGR 281; or instructor consent

ENGR 300, Engineering Research Seminar, 1 Unit

This course surveys the major fields of modern engineering and physics research in a seminar format, with special attention to how researchers identify research questions and plan for research. The course culminates in a research proposal for the student's thesis or research project.
Prerequisite: ENGR 215, ENGR 281, PHYC 166, or PHYC 168

ENGR 325, Control Systems, 3 Units

This course introduces systems and their modeling and control, exploring open- and closed-loop control, feedback, transfer functions, signal flow graphs, stability, and root locus methods. Frequency response methods and Nyquist and Bode diagrams are used for system representation. PID compensators, state-space representation, and digital implementation of control systems are also studied.
Prerequisite: ENGR 215 and MATH 310

ENGR 335, Embedded Systems, 4 Units

Embedded systems are found in most computing systems outside of traditional desktop/laptop/server computers, such as in cars, household appliances, handheld electronics, video game consoles, and wearable technologies. This course provides an introduction to programming embedded systems, covering fundamental topics such as timing diagrams, basic coding operations and datatypes (e.g., binary, hexadecimal, bitwise/shift operators, etc.), state machines (synchronous and concurrent), I/O, and peripheral connections. Laboratory experience includes microprocessor-based design projects with real hardware and electronic components.
Prerequisite: ENGR 240 and CS 125/ENGR 125

ENGR 340, Digital Signal Processing, 3 Units

Students in this course learn about discrete-time and sampled-data signals and systems, and their representations using z-transforms, as well as digital filters, FIR and IIR filters, stability, and round-off errors. They design different types of digital filters such as Butterworth, Chebychev, and others. The basics of discrete Fourier transforms and the fast Fourier transform (FFT) algorithm are introduced.
Prerequisite: CS 120 and MATH 165

ENGR 342, STEM Writing and Communication, 3 Units

In this course, students practice communicating about STEM in oral presentations and in writing. Students examine writing styles and forms of argument for a variety of audiences, and writing assignment genres include journal articles, technical reports, and popular articles. Students also explore potential career paths and write cover letters and resumes.
Prerequisite: HON 101 or WRIT 110; ENGR 215, ENGR 281, MATH 166, or PHYC 145

ENGR 350, Computer Networks, 3 Units

This course introduces the basics of computer networks, including the seven-layer ISO model for networks, with layers 2, 3, and 4 studied in detail. Medium access control protocols and TCP/IP are presented, as well as wireless LAN standards. An introduction to emerging wireless networks is also included.
Prerequisite: ENGR 215, MATH 361

ENGR 355, Communications Systems, 3 Units

This course provides an introduction to the principles of communication systems, including signal representation in time and frequency domains, Fourier series and transforms, analog amplitude, frequency and phase modulation systems, noise effects, applications to radio transmission, digital modulation (ASK, FSK, and PSK [binary and M-ary variants]), noise effects and error probabilities, error detection and correction, block and convolutional codes, and elements of information theory, modulation, and coding applications in wireless, satellite, and optical transmission systems.
Prerequisite: CS 120 and MATH 165

ENGR 360, Computer Architecture and Organization, 3 Units

This course covers the architecture and organization of computer systems, including hardware/software design considerations, implementation, interrelationships, and performance. Fundamentals of assemblers and assembly language programming using the MIPS instruction set are included, as is the use of combinational and sequential logic in the components of CPUs, buses, and interfaces. Details include input/output, memory hierarchies, pipelining, ALU operations, and CPU control. Processors include CISC and RISC, as well as multiprocessor systems. Students also take part in several programming and modeling projects that model key computer architecture components.
Prerequisite: CS 260/ENGR 260 or ENGR 240

ENGR 370, Cyber Physical Systems Security [Proposed], 3 Units

In this course, students systematically study the fundamental principles of computer system security, including authentication, access control, capability, security policies, sandbox, software vulnerabilities, and web security, with most of these principles studied within the scope of concrete systems such as Linux and Windows. The course emphasizes "learning by doing," requiring students to conduct a series of lab exercises through which students enhance their understanding of the principles and learn to apply them to solve real-world problems.
Prerequisite: CS 260/ENGR 260

ENGR 384, Mechanics of Materials, 3 Units

This course covers plane stress and strain, principal stresses and strains, Mohr's Circle, properties of materials, stress-strain diagrams, generalized Hooke's Law for isotopic materials, design loads, working stresses, factors of safety, statically indeterminate axially loaded members, torsional shearing stresses and displacements, combined axial and torsional loads, flexural and transverse shear stresses, shear and moment diagrams, and beams of two materials.
Prerequisite: PHYC 165; ENGR 281

ENGR 452, Internet of Things, 3 Units

This course covers the fundamental aspects of the Internet of Things (IoT), including devices, protocols, security, and product development. Through hands-on labs and projects, students develop the ability to build IoT devices and systems, and a final project showcases their ability to plan, design, and execute their own IoT devices and systems. Students become proficient in embedded programming, cross-compilation, web servers and clients, basic digital electronics, communications protocols, and special programming techniques.
Prerequisite: ENGR 125/CS 125, and CS 230 or ENGR 240.

ENGR 470, Senior Design Project I, 3 Units

In this first part of a two-semester engineering design project experience, students are encouraged to engage in group-based projects and industrial sponsorship, and must complete a fully documented design solution by the end of the course. Use of oral and written professional communication skills is emphasized.
Prerequisite: Senior standing in the engineering program

ENGR 480, Senior Design Project II, 3 Units

This course involves the implementation of the design developed in ENGR 470, including prototyping and testing. Students are also instructed on how to prepare and present a technical demo aimed at "selling" their product. *Meets the APU Core: Oral Comm (ENGR 120+ENGR 240+ENGR 480) general education requirement.*
Prerequisite: ENGR 470

ENGR 489, Engineering Internship Preparation, 1 Unit

This course offers a comprehensive overview of the internship search process. Students develop strong resumes and cover letters, practice effective interview techniques, learn how to network with industry professionals, and gain insights into workplace expectations. Course material empowers students to confidently pursue and excel in engineering internships.
Prerequisite: Sophomore standing

ENGR 491, Engineering Internship, 1-3 Units

Students in this course gain practical experience in engineering as they complete a semester-long engineering project under the joint supervision of an engineering faculty member and an outside mentor. Through actual and practical working experience in an internship, students synthesize the statement of the problem and the solutions they face in the working environment, based on the application of learning from multiple courses from various fields. These include, but are not limited to, courses in engineering (mechanics, electronics, digital logic), computing (programming, database), writing (writing 1 and 2), oral communications, ethics, etc. A total of 3 units is required to satisfy the General Education: Integrative and Applied Learning requirement.
Prerequisite: Sophomore standing in the engineering major, and department consent.

ENGR 495, Topics in Engineering, 1-3 Units

This course presents timely and new topics in engineering. Different material is covered each time the course is offered. The course may be repeated for credit. Most topics require prerequisites, which vary according to the topic.
Prerequisite: Department consent

MATH 89, Mathematics Lab, 1 Unit

The Mathematics Lab provides additional support for students enrolled in MATH 90 Foundations of Mathematical Reasoning or MATH 95 Intermediate Algebra. Students receive weekly tutorials on assignments in MATH 90 or MATH 95 and complete brief tasks that prepare them for those assignments. A mathematics coach works with students to further their progress in mathematics and prepare them for success in MATH 90 or MATH 95.
Prerequisite: Concurrent enrollment in MATH 90 or MATH 95 and any ALEKS score

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: ALEKS score of 15-29 or concurrent enrollment in MATH 89

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 110, College Algebra, 3 Units

This course offers 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 on using algebraic concepts to model and analyze real-world phenomena. *Meets the APU Core: Quantitative Reasoning general education requirement.*
Prerequisite: MATH 95 or an appropriate score on the APU mathematics placement assessment.

MATH 115, Mathematics in Society, 3 Units

This course helps students 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 APU Core: Quantitative Reasoning general education requirement.*
Prerequisite: MATH 90 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 APU Core: Quantitative Reasoning general education requirement.*
Prerequisite: MATH 90 or an appropriate score on the APU mathematics placement assessment.

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 165, Calculus I, 4 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

MATH 166, Calculus II, 4 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, polar coordinates, sequences, series, tests for convergence, power series, intervals of convergence, and Taylor series. 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 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 230, Computation and Modeling, 3 Units

This course is an introduction to computational modeling for applied math, engineering, physics, and other STEM majors. Students explore tools and strategies that are broadly applicable for use in computational models to understand complex problems, and learn how to apply these tools in their subsequent coursework and career. Examples and projects are drawn from a variety of fields. Topics covered include use of spreadsheet and programming solutions, discretization, boundary conditions, strategies for finding minima, model validation and verification, Monte Carlo analysis, dimensional analysis, and strategies for troubleshooting and identifying modeling errors.
Prerequisite: MATH 166 (may be taken concurrently) and CS 120

MATH 250, Introduction to Data Science, 3 Units

This course features hands-on experience using statistical tools to answer real-world questions, with emphasis on analysis of actual data using statistical software. Students learn to explore, visualize, and analyze data in a reproducible and shareable manner to understand natural phenomena, investigate patterns, and uncover insight. Students gain experience in data wrangling, exploratory data analysis, statistical inference, uncertainty quantification, linear modeling, data visualization, and effective communication of results.
Prerequisite: MATH 130, MATH 361, or CS 120

MATH 260, Introduction to Number Theory and Proofs, 3 Units

This course is a study of elementary number theory, with an introduction to proofs. An emphasis on problem solving and proof writing prepares students to construct valid mathematical arguments in upper-division courses. Topics include primes, divisibility, factorization, Diophantine problems, residue systems, theorems of Fermat and Euler, and continued fractions. Proof techniques include mathematical logic; direct and indirect proofs; proofs with conjunctions, disjunctions, and quantifiers; relations; and mathematical induction.
Prerequisite: MATH 165

MATH 268, Multivariable Calculus, 4 Units

Students in this course explore the calculus of functions of several variables, including scalar functions and vector fields. Topics include surfaces and contour diagrams; partial and directional derivatives; optimization and Lagrange multipliers; multiple integration in rectangular, polar, cylindrical, and spherical coordinate systems; parameterized curves and surfaces; line integrals; gradients, divergence, and curl; and Green's and Stokes' theorems.
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 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

This course is 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 260 or MATH 166 (both recommended)

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 310, Ordinary Differential Equations, 4 Units

This course is 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, and introduction to numerical methods.
Prerequisite: MATH 268, or B- or better in MATH 166

MATH 311, Teaching and Learning in STEM, 2 Units

Students in this course learn about the fundamentals of effective STEM teaching, including common challenges for STEM learners, active engagement strategies, assessment techniques, supporting diverse learners, designing assignments, and planning courses and lessons.
Prerequisite: BIOL 151, CHEM 151, CS 120, MATH 165, PHYC 155, PHYC 165, or equivalent

MATH 312, STEM Education Research Seminar, 1 Unit

Students identify challenges for effective STEM education that they observe during their experiences as STEM students and in STEM teaching support roles. Using readings drawn from the STEM education research literature, students identify and evaluate solutions to these challenges.
Prerequisite: BIOL 151, CHEM 151, CS 120, MATH 165, PHYC 155, PHYC 165, or instructor permission

MATH 313, STEM Teaching Practicum, 1 Unit

This course is intended for students serving in teaching support roles for STEM courses, including Learning Assistants, Teaching Assistants, and tutors. Students observe and reflect on effective STEM teaching practices and assist learners in engaging with and understanding course content.
Prerequisite: BIOL 151, CHEM 151, CS 120, MATH 165, PHYC 155, PHYC 165, or instructor permission

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 342, STEM Writing and Communication, 3 Units

In this course, students practice communicating about STEM in oral presentations and in writing. Students examine writing styles and forms of argument for a variety of audiences, and writing assignment genres include journal articles, technical reports, and popular articles. Students also explore potential career paths and write cover letters and resumes.
Prerequisite: HON 101 or WRIT 110; ENGR 215, ENGR 281, MATH 166, or PHYC 145

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, Introduction to Modeling with Probability, 3 Units

This course is an introduction to probability models used in statistics and data analysis. Topics include basic axioms of probability, random variables, probability distributions, expected values, and probability distribution theory.
Prerequisite: MATH 166

MATH 362, Mathematical Statistics, 3 Units

This course is an introduction to descriptive and inferential statistics used in data analysis. Topics include random sampling, parameter estimation, hypothesis testing and goodness of fit, summarizing data, and comparing samples.
Prerequisite: MATH 361 or STAT 501

MATH 370, Partial Differential Equations, 3 Units

This course is an introduction to Fourier analysis and analytical techniques for solving partial differential equations, with application to physical phenomena.
Prerequisite: MATH 310

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 310

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 396, Topics in Mathematics and Christian Thought, 2 Units

Students in this seminar course examine the philosophy of mathematics in light of history and Christian faith, exploring the historical development of mathematics concepts and reflecting on the interplay between mathematics, theology, and Christian practice.
Prerequisite: Junior or senior standing

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 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 451, Data Visualization, 3 Units

This course introduces students to the field of data visualization. Students learn basic visualization design and evaluation principles, and how to acquire, parse, and analyze data sets using various data visualization software tools. Data types covered include multivariate, temporal, text-based, geospatial, and network/graph-based.
Prerequisite: MATH 130 or MATH 361

MATH 455, Numerical Analysis, 3 Units

This course covers numerical and approximation methods, 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: CS 120

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, Mathematical Reading, Writing, and Presentation, 3 Units

In this seminar course, students critically analyze journal articles in the field, receive writing instruction, write research and argumentative papers, and prepare effective mathematical presentations.
Prerequisite: Junior or senior standing

MATH 492, Ethics in Data Analytics, 2 Units

The availability and use of data has led to tremendous opportunities. Businesses mine data to gain a competitive advantage, and healthcare organizations use it to help improve medical decision making. The use of data, however, has led to potential abuses. This course explores ethical issues in big data analytics, including issues surrounding collection, use, and reporting of data, and considers them from a Christian worldview.

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, cryptology, etc. This course may be taken more than once as the topic changes.
Prerequisite: Prerequisite(s) will vary depending upon the topic.

MATH 496, Mathematics Senior Seminar, 3 Units

In this culminating mathematics seminar, students wrestle with an outward-focused question - "How can I apply what I have learned in order to make a difference in the world?" - as well as an inward-focused question - "How can I develop the strength of character that will sustain me in living a life of mission?" Through research and reflection, students develop personal vision for how they will deploy their mathematical skills to do God's work in the world. At the same time, students engage with readings, seminar discussions, and spiritual practices that support the long-term growth of character and virtue.

Prerequisite: MATH 250, MATH 480 (waived for Honors College students), and senior standing.

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

PRMA 90, Foundations of Mathematical Reasoning, 3 Units

This course prepares students for Intermediate Algebra, Mathematics in Society, or Introduction to Statistics. Topics include proportional reasoning; experimental design; graphical, tabular, and numerical presentations of data; chance, risk, and probability; and algebraic modeling. Students practice displaying, summarizing, and analyzing data; computing and interpreting probabilities; 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.

PRMA 110, College Algebra, 3 Units

This course offers 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 on using algebraic concepts to model and analyze real-world phenomena. *Meets the APU Core: Quantitative Reasoning general education requirement.*

Prerequisite: MATH 95 or an appropriate score on the APU mathematics placement assessment.

PRMA 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 APU Core: Quantitative Reasoning general education requirement.*

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

PHYC 112, Science and Technology for Everyday Applications, 4 Units

This course is a nonmathematical introduction to everyday science and technologies that have drastically changed the world and impacted modern life. Despite their apparent complexity, these technologies can be understood from basic physical principles. Students in this course also examine topics of current interest such as climate change, environmental stewardship, and scientific methods. This course does not carry credit toward a science major or minor. *Meets the APU Core: Natural Science general education requirement.*

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 145, Physics Laboratory I, 1 Unit

This lab course is a companion to PHYC 155 or PHYC 165. Students in this lab course are introduced to scientific thinking skills including designing experiments, analyzing data, comparing measurements, and testing theoretical models. Experimenters answer research questions using data they obtain. Experimental topics are drawn from mechanics. Completion of this course and PHYC 155 or PHYC 165 *meets the General Education Natural Sciences requirement.*

Corequisite: PHYC 155 or PHYC 165

PHYC 146, Physics Laboratory II, 1 Unit

This lab course is a companion to PHYC 156, PHYC 166, and PHYC 168. Students in this course are introduced to scientific thinking skills including designing experiments, analyzing data, comparing measurements, and testing theoretical models. Experimenters answer research questions using data they obtain. Experimental topics are drawn from electricity, magnetism, thermodynamics, and waves.

Prerequisite: PHYC 145; concurrent enrollment in PHYC 156, PHYC 166, or PHYC 168 is recommended.

PHYC 147, Physics Laboratory III, 1 Unit

In this lab course, students develop scientific thinking skills by comprehensively developing an experiment on introductory physics topics, including proposing a research question, designing experiments, analyzing data, comparing measurements, and testing theoretical models. Experimenters answer research questions using data they obtain.

Special Fee Applies

Prerequisite: PHYC 146

PHYC 155, Physics for Life Sciences I, 3 Units

Students in this noncalculus physics course study translational and rotational mechanics and begin to explore thermodynamics. *Meets the APU Core: Natural Science (PHYC 155 + PHYC 145) general education requirement.*

Prerequisite: MATH 110 or equivalent score on APU mathematics placement assessment; high school geometry and trigonometry highly recommended.

PHYC 156, Physics for Life Sciences II, 3 Units

Students in this noncalculus physics course explore the topics of waves, sound, light, electricity and magnetism, quantum theory, and structure of matter.

Prerequisite: PHYC 155

PHYC 165, Physics for Science and Engineering: Mechanics, 4 Units

Students in this course explore various areas of physics using basic differential and integral calculus. Topics include kinematics, Newton's laws, conservation of energy, conservation of momentum, and rotation. *Meets the APU Core: Natural Science (PHYC 165 + PHYC 145) general education requirement.*

Corequisite: MATH 165 or equivalent calculus background; high school physics or university-level conceptual physics strongly recommended.

PHYC 166, Physics for Science and Engineering: Electricity and Magnetism, 4 Units

Students are introduced to the various areas of physics using basic differential and integral calculus. Topics include electricity, circuits, magnetism, and modern physics.

Prerequisite: PHYC 165 and MATH 166 (may be taken concurrently)

PHYC 167, Physics for Science and Engineering: Relativity, 1 Unit

Students are introduced to the various areas of physics using basic differential and integral calculus. This course focuses on Einstein's theory of special relativity, including frames of reference, spacetime diagrams, Lorentz transformations, and mass-energy equivalence.

Prerequisite: MATH 110, MATH 150, or MATH 165

PHYC 168, Physics for Science and Engineering: Waves and Thermodynamics, 4 Units

Students explore the various areas of physics using basic differential and integral calculus. Topics include simple harmonic motion, traveling and standing waves, superposition of waves, geometric optics, energy transfers, properties of pure substances, the first and second laws of thermodynamics, control volume, irreversibility, gas power cycles, and refrigeration.

Prerequisite: PHYC 155 or PHYC 165

PHYC 230, Computation and Modeling, 3 Units

This course is an introduction to computational modeling for applied math, engineering, physics, and other STEM majors. Students explore tools and strategies that are broadly applicable for use in computational models to understand complex problems, and learn how to apply these tools in their subsequent coursework and career. Examples and projects are drawn from a variety of fields. Topics covered include use of spreadsheet and programming solutions, discretization, boundary conditions, strategies for finding minima, model validation and verification, Monte Carlo analysis, dimensional analysis, and strategies for troubleshooting and identifying modeling errors.
Prerequisite: MATH 166 (may be taken concurrently) and CS 120

PHYC 300, Physics Research Seminar, 1 Unit

This course surveys the major fields of modern engineering and physics research in a seminar format, with special attention to how researchers identify research questions and plan for research. The course culminates in a research proposal for the student's thesis or research project.
Prerequisite: ENGR 215, ENGR 281, PHYC 166, or PHYC 168

PHYC 311, Teaching and Learning in STEM, 2 Units

Students in this course learn about the fundamentals of effective STEM teaching, including common challenges for STEM learners, active engagement strategies, assessment techniques, supporting diverse learners, designing assignments, and planning courses and lessons.
Prerequisite: BIOL 151, CHEM 151, CS 120, MATH 165, PHYC 155, PHYC 165, or equivalent

PHYC 312, STEM Education Research Seminar, 1 Unit

Students identify challenges for effective STEM education that they observe during their experiences as STEM students and in STEM teaching support roles. Using readings drawn from the STEM education research literature, students identify and evaluate solutions to these challenges.
Prerequisite: BIOL 151, CHEM 151, CS 120, MATH 165, PHYC 155, PHYC 165, or instructor permission

PHYC 313, STEM Teaching Practicum, 1 Unit

This course is intended for students serving in teaching support roles for STEM courses, including Learning Assistants, Teaching Assistants, and tutors. Students observe and reflect on effective STEM teaching practices and assist learners in engaging with and understanding course content.
Prerequisite: BIOL 151, CHEM 151, CS 120, MATH 165, PHYC 155, PHYC 165, or instructor permission

PHYC 342, STEM Writing and Communication, 3 Units

In this course, students practice communicating about STEM in oral presentations and in writing. Students examine writing styles and forms of argument for a variety of audiences, and writing assignment genres include journal articles, technical reports, and popular articles. Students also explore potential career paths and write cover letters and resumes.
Prerequisite: HON 101 or WRIT 110; ENGR 215, ENGR 281, MATH 166, or PHYC 145

PHYC 361, Electricity and Magnetism, 3 Units

Students in this course study the fundamental concepts of electricity and magnetism, electrostatic fields in a vacuum and dielectric materials, solutions of the Laplace and Poisson equations, and electromagnetic waves.
Prerequisite: PHYC 166, MATH 268, and MATH 269

PHYC 370, Waves and Optics, 3 Units

Students in this course study mechanical and electromagnetic waves and explore topics such as geometric optics, wave propagation, interference, diffraction, polarization, coherence, and holography, as well as topics from nonlinear optics.
Prerequisite: PHYC 168, MATH 268, and MATH 310 (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 165, MATH 167, MATH 268, and MATH 310

PHYC 401, Thermodynamics, 3 Units

Students in this course 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 168 and MATH 268 (may be taken concurrently)

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 310 and PHYC 370, or instructor consent

PHYC 470, Advanced Laboratory, 2 Units

This course acquaints students with additional laboratory and analysis techniques and scientific writing. Students participate in a number of experiments that develop themes from various courses that do not have a laboratory component, such as optics, quantum mechanics, and classical mechanics.
Special Fee Applies
Prerequisite: PHYC 147 and junior or senior standing

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

Students engage in original research projects in collaboration with a faculty member. Projects may be experimental, theoretical, or computational in nature, and projects 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 results in completion of a journal-style article and/or professional-level poster presentation.
Prerequisite: PHYC 300

PRPY 112, Science and Technology for Everyday Applications, 4 Units

This course is a nonmathematical introduction to everyday science and technologies that have drastically changed the world and impacted modern life. Despite their apparent complexity, these technologies can be understood from basic physical principles. Students in this course also examine topics of current interest such as climate change, environmental stewardship, and scientific methods. This course does not carry credit toward a science major or minor. *Meets the APU Core: Natural Science general education requirement.*
Special Fee Applies

PRPY 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.

STAT 501, Introduction to Modeling with Probability, 3 Units

This course is an introduction to probability models used in statistics and data analysis. Topics include basic axioms of probability, random variables, probability distributions, expected values, and probability distribution theory.
Prerequisite: Calculus (multivariable preferred) and linear algebra.

STAT 502, Mathematical Statistics, 3 Units

This course offers an introduction to descriptive and inferential statistics used in data analysis. Topics include random sampling, parameter estimation, hypothesis testing and goodness of fit, summarizing data, and comparing samples.
Prerequisite: STAT 501

STAT 511, Applied Regression Analysis, 3 Units

This course is an introduction to simple and multiple linear regression models. Topics include parameter estimation, diagnostics, model selection, prediction, and models with categorical predictors.
Prerequisite: STAT 501;
Corequisite: STAT 502

STAT 512, Analysis of Variance and Design of Experiments, 3 Units

This course offers an introduction to designing and analyzing data using experiments. Basic experimental designs are covered, including block, factorial, and fractional factorial. Analysis of Variance (ANOVA) models and their assumptions, estimation, and interpretation are introduced. Statistical software is used for all analysis.
Prerequisite: STAT 501;
Corequisites: STAT 502, STAT 511

STAT 521, Statistical Computing and Programming, 3 Units

Students in this course gain basic familiarity with SAS and R programming for data management and analysis. The course takes place in a computer lab, enabling students to implement the lecture material as it is presented. Assignments require using SAS and R to perform data management techniques, generate descriptive statistics and graphical representations of data, and apply statistical methods available in software.
Prerequisite: MATH 361 or equivalent

STAT 541, Epidemiology Research Methods, 3 Units

The purpose of this course is to equip students with the basic concepts and principles of epidemiology, a discipline that identifies the determinants of disease in human populations and assesses the magnitude of public health problems and the success of interventions designed to control them. Students learn about various epidemiologic study designs and their strengths and limitations, the basic mathematical tools needed in epidemiology, the collection of epidemiologic data, and the criteria of causality. Also, the course addresses the biases that may invalidate epidemiologic studies, and considers ethical concerns in epidemiology from a Christian faith perspective.

STAT 542, Applied Logistic Regression and Survival Analysis, 3 Units

This course offers an introduction to methods for analyzing binary outcome and time-to-event data, with the primary focus on how to analyze such data using methods available in standard statistical software packages. Topics include logistic regression estimation, interpretation, and assessment. For time-to-event data, summary statistics for censored data, nonparametric methods (specifically Kaplan-Meier), and semiparametric regression methods centered on the Cox model are introduced.

Prerequisite: STAT 511 and STAT 521 or equivalent

STAT 543, Advanced Modeling for Data Science, 3 Units

This course introduces advanced modeling approaches in data science, focused on classical and modern approaches to analyzing continuous and discrete longitudinal data. Topics include exploratory analysis of correlated data, data visualization, generalized linear models, random effects models, Generalized Estimating Equations (GEE), analysis of discrete longitudinal data, and statistical analysis with missing data. Emphasis is on estimation using statistical software and model interpretation.

Prerequisite: STAT 511 and STAT 521 or equivalent

STAT 551, Data Visualization, 3 Units

This course introduces students to the field of data visualization. Students learn basic visualization design and evaluation principles, and also how to acquire, parse, and analyze data sets using various data visualization software tools. Data types included in the course include multivariate, temporal, text-based, geospatial, and network/graph-based.

Prerequisite: B- or better in MATH 361, or admission to graduate school.

STAT 552, Time Series Analysis and Forecasting, 3 Units

In this course, students develop a working knowledge of time series analysis and forecasting methods, with a focus on applications. Topics include descriptive analysis, probability models for time series, fitting and forecasting for time series models, bootstrapping, models for nonstationary series, and an introduction to spectral analysis.

Prerequisite: STAT 502 and STAT 521

STAT 553, Data Mining, 3 Units

Data mining focuses on algorithms and computational paradigms that allow computers to find patterns and regularities in data in order to perform prediction or find structure and relationships to help improve decision making. This course covers basic methodology, major software tools, and applications in data mining. Students learn conceptual underpinnings of methods in data mining while focusing more on usage of existing software packages than developing the algorithms. In particular, the course covers the methodology, motivation, assumptions, strengths, and weaknesses of the most widely applicable methods in the field.

Prerequisite: STAT 511 or STAT 521 or STAT 551 or PSYC 518

STAT 571, Applied Multivariate Analysis, 3 Units

This course introduces a variety of standard statistical methods used to analyze multivariate data, emphasizing the implementation and interpretations of the methods. Topics covered include matrix computation of summary statistics, graphical techniques, the geometry of sample data, the multivariate normal distribution, principal components analysis, factor analysis, classification and discrimination, and cluster analysis.

Prerequisite: STAT 511 and STAT 521

STAT 572, Applied Bayesian Analysis, 3 Units

This course provides a practical introduction to Bayesian data analysis. Students are exposed to a variety of Bayesian models, including the Bayesian linear model and Bayesian hierarchical modeling as a strategy for modeling complex processes and as a means of assimilating a variety of sources of data. Models are fit for various types of data using modern simulation techniques in statistical software. The focus of the course is modeling, assessing model appropriateness, and interpretation.

Prerequisite: STAT 511 and STAT 521

STAT 573, Applied Nonparametric Statistics, 3 Units

This course provides an overview of nonparametric statistics, helping students learn the difference between parametric and nonparametric statistics and when each is appropriate. This course includes the basic theory and computing tools to perform traditional rank-based nonparametric tests, and advanced topics include nonparametric density estimation, nonparametric regression, and the bootstrap.

Prerequisite: STAT 511 and STAT 521

STAT 574, Discrete Data Analysis, 3 Units

This course covers basic methods for analysis of discrete data, including methods for analyzing and describing discrete data in contingency tables, and statistical models for discrete outcomes that are binary, counts, nominal, and ordinal. Emphasis is on using statistical software to fit models to data, assessing the appropriateness, and interpreting the results in context.
Prerequisite: STAT 511 and STAT 521

STAT 575, Applied Survey Sampling, 3 Units

This course covers sampling design and analysis methods useful for research and management in many fields. Students learn about the basic methods of sampling and estimation and then explore selected designs and recent developments. Topics include simple random sampling with associated estimation and confidence interval methods, selecting sample sizes, estimating proportions, unequal probability sampling, ratio and regression estimation, stratified sampling, cluster, systematic sampling, multistage designs, and double sampling.
Prerequisite: STAT 502 and STAT 521

STAT 592, Ethics in Data Analytics, 2 Units

The availability and use of data has led to tremendous opportunities. Businesses mine data to gain a competitive advantage, and healthcare organizations use it to help improve medical decision making. The use of data, however, has led to potential abuses. This course explores ethical issues in big data analytics, including issues surrounding collection, use, and reporting of data, and considers them from a Christian worldview.

STAT 595, Special Topics in Applied Statistics, 3 Units

This course presents coverage of topics in applied statistics.
Prerequisite: Based upon the topic offered.

STAT 596, Practicum, 0-1 Units

In this course - the practicum course of the Master of Science in Applied Statistics and Analytics program - students collaborate with professionals in academic or industry organizations to develop professional experience.
Prerequisite: Instructor permission required

STAT 597, Statistical Consulting Practicum, 4 Units

Students in this course investigate the role of the statistician as consultant and collaborator. Topics include problem solving and communication skills (oral and written), structuring working engagements with nonstatisticians and collaborators, and skills specific to statistical consulting. Case studies or ongoing projects are used to provide hands-on consulting experience. Students identify, and produce their proposal for, their culminating project during this course.
Prerequisite: STAT 511 and STAT 521

STAT 598, Culminating Project, 4 Units

This is the capstone course of the Master of Science in Applied Statistics and Analytics program. It is open to second-year students in good standing. Students provide an oral presentation and a written report of the project.
Prerequisite: STAT 597

STAT 599, Independent Study, 1-3 Units