SCHOOL OF ENGINEERING AND COMPUTER SCIENCE

https://engineering.pacific.edu/engineering
Phone: (209) 946-2151
Location: John T. Chambers Technology Center
Elizabeth Orwin, Dean

Degrees Offered

Bachelor of Science in Bioengineering
Bachelor of Science in Civil Engineering
Bachelor of Science in Computer Engineering
Bachelor of Science in Computer Science
Bachelor of Science in Data Science
Bachelor of Science in Electrical Engineering
Bachelor of Science in Engineering Management
Bachelor of Science in Engineering Physics
Bachelor of Science in Mechanical Engineering
Bachelor of Science in Product Design and Entrepreneurship
Bachelor of Science in Sustainability
Master of Science in Computer Science
Master of Science in Cybersecurity
Master of Science in Data Science
Master of Science in Engineering

Minors

Computer Engineering
Computer Science
Data Science
Engineering Management
Environmental Engineering
Project Management (for non-engineering majors)
Structural Engineering
Sustainability
Technology (for non-engineering majors)
Technological Innovation and Entrepreneurship

Certificates Offered

Certificate in Secure Software Systems
Certificate in Cyber defense and Offense

Mission

The mission of the School of Engineering and Computer Science is to deliver transformative learning experiences that prepare our graduates to meet society's greatest challenges.

Engineering

No single definition of engineering is adequate; however, engineering is well described as the application link between science and society. Engineers must have the ability to apply theoretical knowledge to practical situations. They are agents through whom science influences our society.

At the School of Engineering and Computer Science, engineers must develop dual competencies - technical and social. They must understand the principles of science as well as the nature of human needs and behavior and the impact of technology on society. The modern engineer deals with socially relevant matters that include pollution, energy resources, sustainability, health care and public transportation systems. Engineers are experts in manufacturing processes, communications systems, medical electronics, the space program and numerous other endeavors that provide citizens of the world with a safer, more enjoyable life.

The Engineering Program at University of the Pacific consists of three well-integrated parts:

a. Mathematics, natural sciences and a broad range of courses in the humanities and social sciences;
b. Engineering courses, which provide the specialized training for professional competence in engineering;
c. On-the-job experience in the Cooperative Education (Co-op) Program described below.

Through this threefold program, theory and practice are brought together; human problems and engineering come into sharp focus; and students find increased meaning in their studies.

By studying at a private university with a strong liberal arts heritage, Pacific engineering students interact with students whose objectives, attitudes and approaches to human problems are different from their own. They experience meaningful associations with students from a variety of social, political and cultural backgrounds.

Computer Science

The Computer Science Department provides an education in computer science which features current and emerging technologies and experiential learning. This program offers a strong background in the theory and practice of computer science. Students select a concentration based on their post-graduation plans. Selection of an area of concentration guides students in the selection of elective courses. Students trained in computer science are among the change agents responsible for forging new computing breakthroughs and new interactions with other disciplines.

The computer science program includes a general education component, a math and science component, a computer science core component and upper division electives. The electives may be chosen based on a selected area of concentration or may be determined by the student in consultation with their academic advisor.

Degrees in Engineering and Computer Science

The School of Engineering and Computer Science offers eight Bachelor of Science (BS) degree programs: Bioengineering, Civil Engineering, Computer Engineering, Computer Science, Electrical Engineering, Engineering Management, Engineering Physics, and Mechanical Engineering. The curricula are divided into lower-division and upper-division segments.

The lower-division engineering curriculum stresses fundamentals in science, mathematics and engineering. The first two years are similar for all engineering majors. The upper-division curricula combine courses for the degree major with work experience through the Co-op Program.

The Computer Science Department offers a BS degree in Computer Science. A minor program is also available. The curriculum for the Computer Science program includes a core of courses that give students a solid understanding of fundamental computing knowledge and skills. The major has a variety of concentrations that offer a course of study around a theme. The concentrations offer a flexible range of courses that promote a student's specific interests and post-graduate plans. They

also guide the selection of elective courses. The available concentrations are Networking and Computer Security, Graphics and Simulation, and Software Development. Students may also choose to select a custom set of electives in consultation with their academic advisor, for a degree without a specific concentration.

The School of Engineering and Computer Science offers two Master of Science (MS) programs: the MS in Data Science and the MS in Engineering. The Masters of Science in Engineering (MSE) degree has four concentration options in:

a. Civil Engineering
b. Computer Engineering, Electrical Engineering
c. Engineering Management
d. Mechanical Engineering

The MSE degree is designed to strengthen students' technical, analytical, and professional breadth and depth. Students are introduced to techniques and best practices of professional research and learn the foundations for assessing the merits of published technical findings.

Accelerated Blended Program

The accelerated Blended Program provides an excellent opportunity for students to begin their graduate work while completing their undergraduate degree requirements. Students can pursue the accelerated Blended Program which allows them to complete their bachelors and masters degree in as little as five years. This five year period includes some summer sessions, depending upon whether advanced placement units were earned prior to starting at Pacific.

Students begin by enrolling in an undergraduate program in the Pacific SOECS. Following acceptance into the Blended Program, students may begin taking graduate level courses at any time after they reach senior status which allows the bachelors and masters degrees to blend together. The two degrees are awarded on the same date.

Accreditation

The Bioengineering (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Bioengineering and Biomedical and Similarly Named Engineering Programs.

The Computer Engineering (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Electrical, Computer, Communications, Telecommunication(s), and Similarly Named Engineering Programs.

The Civil Engineering (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Civil and Similarly Named Engineering Programs.

The Computer Science (B.S.) program is accredited by the Computing Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Computer Science and Similarly Named Computing Programs.

The Electrical Engineering (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Electrical, Computer, Communications, Telecommunication(s), and Similarly Named Engineering Programs.

The Engineering Physics (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Engineering, General Engineering, Engineering Physics, Engineering Science, and Similarly Named Engineering Programs.

The Engineering Management (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Engineering Management and Similarly Named Engineering Programs.

The Mechanical Engineering (B.S.) program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Mechanical and Similarly Named Engineering Programs.

Student Organizations

All students are encouraged to actively participate in a professional society appropriate to their major.

National Honor Societies

Tau Beta Pi (Engineering Honor Society - all engineering majors)
Eta Kappa Nu (Honor Society for Electrical, Computer Engineering, Engineering Physics majors)

Student Affiliates of Professional Organizations

American Society of Civil Engineers (ASCE)
American Society of Mechanical Engineers (ASME)
Association for Computing Machinery (ACM)
Institute of Electrical and Electronic Engineers (IEEE)
National Society of Black Engineers (NSBE)
Society of Hispanic Professional Engineers (SHPE)
Society of Women Engineers (SWE)
Society of Automotive Engineers (SAE)
Associated Engineering Students (AES)
Associated Students of Engineering Management (ASEM)
Biomedical Engineering Society (BMES)
Theta Tau (Professional Engineering Fraternity)

Pacific MESA Center

The Pacific Mathematics, Engineering and Science Achievement (MESA) Center is the home of two programs: The MESA Schools Program (MSP) and the MESA Engineering Program (MEP).

Both MSP and MEP programs serve educationally disadvantaged students who have traditionally not considered entering into math or science based professions. MSP goals are to create an academic community that increases the number of students who graduate from high school and attend college, majoring in math-based fields. MSP provides hands-on math and science activities as well as academic enrichment to 1,900 students in the 6-12th grades. By providing a rigorous, all-sided learning environment that includes academic advising, peer group learning, career exploration, parent involvement, and other services, students' confidence, expectations, and successes have soared. Specific MEP goals are to increase matriculation, retention, and graduation rates of the students enrolled in the School of Engineering

and Computer Science. MEP seeks to fulfill the above goals through collaborations and partnerships with an Industrial Advisory Board, three student chapters of related professional organizations, the National Consortium for Minority Engineering Students Pursuing a Graduate Degree (GEM), the National Association for Minority Engineering Program Administrators (NAMEPA), and the National Action Council for Minorities in Engineering (NACME).

Pacific MESA Center activities and support features include: pre-college outreach, financial aid (scholarships), career fairs, awards banquets, hands-on math and science workshops, enhanced advising and counseling, tutoring, motivational seminars, Saturday and summer programs, and a student study center.

General Education Requirements for Engineering and Computer Science Programs

All engineering and computer science students must satisfy the requirements of the university's General Education program. Several of the General Education requirements are satisfied by engineering and computer science program requirements. Engineering and computer science students must satisfy the program requirements and do not need additional courses for these general education requirements.

a. Diversity & Inclusion requirement: Satisfied by ENGR 030.
b. World Perspectives & Ethics area of inquiry requirement: Satisfied by ENGR 030.
c. Quantitative Reasoning area of inquiry requirement: Satisfied by program mathematics requirements.
d. Scientific Inquiry area of inquiry requirement: Satisfied by program science requirements.

General Academic Policies

Engineering and Computer Science Prerequisite Requirement

All engineering and computer science course prerequisites must be passed with a C- or higher grade.

Courses Taken Pass/No Credit

A student may request to register for one (1) general education course per semester on a Pass/No Credit basis in either Category I or II of the general education program by filing the completed Pass/No Credit form in the Office of the Registrar before the deadline established by the Office of the Registrar (approximately the end of the second week of classes). This petition must include the approval of the professor teaching the course and the student's advisor. A maximum of 16 Pass/No Credit units may be applied to meet the GE degree requirements. All other classes, including Technical Writing, Independent Studies and the basic science or mathematics elective classes, must be taken for a letter grade.

Independent Studies and Undergraduate Research

Students who have an interest in a subject not offered as a regular course and who, by their overall performance at Pacific, have proven their ability to do independent work, may enroll in an independent study. The qualified student initiates discussions with his/her advisor and with a professor who is knowledgeable in the subject. If both parties are in agreement, the student must complete the Independent Study Form and submit it to the instructor before the end of the third week of classes. If the independent study is to be used to meet a general education requirement, it must also have the approval of the Department's General Education Coordinator. Students on academic probation are not permitted to enroll in independent study courses in any department of the University. The following School of Engineering and Computer Science policies apply:

a. The course(s) may not be substituted for a regularly scheduled course unless approved by the department.
b. If the course is to be used as an elective, approval by the student's advisor and the department chairperson is required.
c. All courses must be taken for a letter grade; the pass/no credit option is not allowed for independent study courses.
d. Only one independent study course may be taken per term.
e. Each course may be taken for one (1), two (2), three (3), or four (4) units. The unit value for the course is established between the student and the professor responsible for the course. The student's advisor is informed of this decision.
f. A maximum of eight (8) units of independent study and undergraduate research may be used to satisfy graduation requirements.

Course Substitutions

The substitution of course(s) from the printed major program is discouraged. When extenuating circumstances warrant consideration, the student meets with his/her advisor, and the final decision must have the approval of the department chair. Consideration is given to the source of the problem (school, student, etc.), severity of the hardship case, and what the department considers best for the individual.

If a course substitution is allowed, ABET guidelines must be followed.

Students who enter an engineering or computer science program with 28 or more units are exempt from ENGR 010.

Fundamental Skills Requirement

Students are required to satisfy all the University Fundamental Skills Requirements (i.e., Writing and Mathematics) prior to enrolling in any upper-division engineering or computer science courses.

Internal Transfer Requirements

Students at University of the Pacific wishing to transfer into the School of Engineering and Computer Science:

a. Must have satisfied all Pacific Fundamental Skills requirements
b. Must have completed Math 41 (or equivalent).
c. Must have a cumulative GPA of 2.5
d. International students must demonstrate English proficiency through either: TOEFL - 80/213/550 or IELTS 6.0.

Graduation Requirements (Engineering Degree Programs)

It is important that each student carefully monitor his or her academic program. Each student is expected to consult regularly with his or her faculty advisor. Meeting the graduation requirements is each student's responsibility. If a student deviates from the printed curriculum, careful academic scheduling is required and a plan must be developed that indicates all courses needed for graduation, and when the classes will be taken. After the plan of classes is completed, the schedule must be approved by the student's faculty advisor and the Director of Cooperative Education.

In order to graduate, students must meet the following requirements:

a. Successful completion of at least 120 units.
b. Successful completion of all courses required in the student's major.

c. Successful completion of a minimum of 32 Cooperative Education credits and the Professional Practice Seminar.
d. A GPA of at least 2.0 on all letter-graded work completed at Pacific.
e. A GPA of at least 2.0 for all engineering and computer science courses completed at Pacific.
f. Engineering Management students must have at least a 2.0 GPA in their business/management classes.
g. Submission of application for graduation to the Office of the Registrar. Refer to the Academic Regulations section of the catalog.

Graduation Requirements (Computer Science Degree Program)

a. Successful completion of at least 120 units.
b. Successful completion of all courses required in the student's major.
c. A GPA of at least 2.0 on all letter-graded work completed at Pacific.
d. A GPA of at least 2.0 for all engineering and computer science courses completed at Pacific.
e. Submission of application for graduation to the Office of the Registrar. Refer to the Academic Regulations section of the catalog.

Limitation on Obtaining Two Degrees

The SOECS, in conjunction with the Office of the Registrar, approves the student who receives a second bachelor of science degree subject to the following conditions:

a. The student must meet all requirements for each degree and must file a study plan, approved by his/her advisor, with the Office of the Registrar.
b. The pursuit of a double degree is not a valid reason for waiving any SOECS or University requirements.

Minor in Computer Science

Computing technology is an integral part of many fields of study. The Computer Science minor provides students with an introduction to application development. Students must take three core courses and three elective courses that are tailored to a specific interest. It is recommended that students begin the minor program early in their college career (21-24 units).

Minor in Computer Science Requirements

Students must complete a minimum of 21 units and 6 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in computer science.

Select one of the following:		
COMP 051	Introduction to Computer Science	
COMP 061	Introduction to Programming for Data Science	
COMP 053	Data Structures	4
One COMP course numbered 025 or higher		3-4
One COMP course numbered 047 or higher		3-4
Two upper division COMP courses		6-8

Minor in Data Science

Students must complete a minimum of 20 units and 5 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in data science.

Select one of the following:	
DATA 051	Foundations of Data Science
COMP 051	Introduction to Computer Science
COMP 061	Introduction to Programming for Data Science
Select one of the following:	
MATH 035	Elementary Statistical Inference
MATH 037	Introduction to Statistics and Probability
Select one of the following:	
DATA 053	Applications of Data Science
COMP 162	Data Analytics Programming
MATH 133	Statistical Learning Methods
Two one-unit courses labeled DATA 010 through DATA 019	
Two additional upper division electives chosen from PHIL 126, DATA 199 or one of the tracks in the DATA science major.	

Minor in Engineering Management

Industry and the engineering societies encourage engineering students to have management skills because the average engineering graduate is in some aspect of management within three to five years of graduation.

The minor in Engineering Management is for students majoring in engineering who desire an understanding of management concepts and basic engineering management skills.

Minor in Engineering Management Requirements

Students must complete a minimum of 20 units and 5 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in engineering management.

BUSI 031	Principles of Financial Accounting	4
EMGT 170	Project Decision Making	4
EMGT 174	Engineering Project Management	3
Select one of the following:		4
EMGT 176	Systems Engineering Management	
BUSI 104	Operations Management	
Select one of the following:		4
BUSI 033	Principles of Managerial Accounting	
BUSI 100	Management Information Systems	
BUSI 105	Financial Management	
BUSI 107	Marketing Management	

Note: 1) *At least four of the courses in the 20 unit requirement must be taken at Pacific.* ***2)*** *All courses must be taken for a letter grade.* ***3)*** ENGR 025 *may be used to provide 1 additional unit.*

Minor in Project Management (for Non-Engineering Students Only)

Non-engineering major students may seek a Minor in Project Management in order to gain understanding of the specific issues and approaches to management in an engineering or high technology context. This minor requires a tightly knit suite of at least six engineering, computer science and business courses, providing complementary insights into technology and the challenges of project management within an engineering or technical organization. Though some courses are open to engineering and computer science majors, the nature of the material is such that non-engineering students are able to understand the material and successfully complete course requirements.

The Minor in Project Management is particularly useful to those students anticipating a career in organizations having a:

- Significant number of engineers
- Project orientation
- Reliance on technology, or
- Emphasis on manufacturing

Minor in Project Management Requirements

Students must complete a minimum of 21 units and 6 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in project management.

EMGT 170	Project Decision Making	4
EMGT 174	Engineering Project Management	3
EMGT 176	Systems Engineering Management	4
Select three of the following:		10-12
BUSI 031	Principles of Financial Accounting	
BUSI 109	Management and Organizational Behavior	
COMP 025	Computers and Information Processing	
COMP 051	Introduction to Computer Science	
Select one of the following:		3
CIVL 015	Civil Engineering Graphics	
MECH 015	Mechanical Engineering Graphics	

Note: 1) *Students must not be majoring in engineering.* ***2)*** *All courses that count toward the minor must be taken for a letter grade.*

Minor in Sustainability

Sustainability requires that short and long-term social, economic, and environmental impacts of products and processes be considered. With globalization of the world's economies, continuing challenges with depletion of resources and increased global pollution, the well-being of society requires application of the principles of sustainability. The Minor in Sustainability is suggested for students who desire an understanding of sustainability or those who anticipate working for trans-national or development organizations. The interdisciplinary Minor in Sustainability is open to students of all majors.

Objectives:

- Students are able to identify and explain concepts and application of sustainability principles at the global, national, and local levels.
- Students are able to apply an interdisciplinary and systems approach to solving a problem or meeting a need.

Minor in Sustainability Requirements

Students must complete a minimum of 20 units with a Pacific minor grade point average of 2.0 in order to earn a minor in sustainability.

Note*: Prerequisites of each course must be met.*

Select at least one of the following technology courses:		3-4
CIVL 171	Water and Environmental Policy	
CIVL 173	Sustainable Engineering	
EMGT 176	Systems Engineering Management	
MECH 155	Solar Energy Engineering	
Select at least one of the following economics and society courses: *		4
ECON 071	Global Economic Issues	
ECON 157	Environmental and Natural Resource Economics	
GESC 103	Earth's Changing Climate	
INTL 077	Contemporary World Issues	
POLS 174	Global Environmental Policy	
Select at least one of the following environment and ethics courses:		4
BIOL 035	Environment: Concepts and Issues	
BUSI 053	The Legal and Ethical Environment of Business	
ENGL 126	Environmental Health and Literature	
GESC 043	Environmental Science for Informed Citizens	
HIST 136	American Environmental History	
PHIL 035	Environmental Ethics	
SOCI 111	Environmental Health & Justice	
Sustainability Research and Practice (optional) **		1-4

* The same course may not be used to satisfy course requirements.

** Engineering Synthesis, Senior Project/Thesis, Senior Design, undergraduate research, internshipo, or independent study related to sustainability may be used to provide up to four additional units.

Technological Innovation and Entrepreneurship Minor

Students must take two core courses and 12 units of elective courses.

Minor in Technological Innovation and Entrepreneurship Requirements

Students must complete a minimum of 20 units with a Pacific minor grade point average of 2.0 in order to earn a minor in technological innovation and entrepreneurship.

EMGT 142	Design and Innovation	3
ENGR 150	Engineering and Science-Based Entrepreneurship	4
Select 12 units of the following:		12
BENG 108	Engineering Physiology	
BENG 195	Senior Project	
CIVL 015	Civil Engineering Graphics	
CIVL 173	Sustainable Engineering	
CIVL 180	Engineering Synthesis	
COMP 127	Web Applications	
COMP 129	Software Engineering	
COMP 135	Human-Computer Interface Design	
COMP 155	Computer Simulation	
COMP 159	Computer Game Technologies	
COMP 195	CS Senior Project	
ECPE 172	Microcontrollers	
ECPE 174	Advanced Digital Design	
ECPE 195	Senior Project I	
ECPE 196	Senior Project II	
EMGT 170	Project Decision Making	
EMGT 174	Engineering Project Management	
EMGT 195	Engineering Management Synthesis	
MECH 015	Mechanical Engineering Graphics	
MECH 100	Manufacturing Processes	
MECH 140	Engineering Design/Senior Project I	
MECH 141	Engineering Design/Senior Project II	

Minor in Technology (For Non-Engineering Students Only)

Engineering and technology are integral parts of many careers and fields of study. As “technology” has become so prevalent in our lives

and careers, more and more companies are demanding that their employees have a working knowledge in such areas as design, graphics, communications, hardware and software advances, etc. Consequently, college students majoring in non-technical disciplines are well advised to consider taking advantage of technology-related courses to bolster their skills, knowledge, and awareness in any of these areas. In order to provide a structure and formal recognition towards this end, the School of Engineering and Computer Science offers a Minor in Technology.

Minor in Technology Requirements

Students must complete a minimum of 20 units and 5 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in technology.

a. Students must not major in engineering.
b. Students must complete a program that consists of a minimum of twenty units with a minimum of five courses from the list of approved courses. A minimum of twelve units must be taken at Pacific.
c. Courses towards a minor cannot be taken on a "pass/no credit" basis.
d. Students must maintain a minimum GPA of 2.0 in a minor program.

Course requirements include:

Students must complete a minimum of three courses from the School of Engineering & Computer Science (i.e., CIVL, ECPE, EMGT, ENGR, or MECH department prefixes) which add up to a minimum of eight units. (It is strongly recommended that students take ENGR 010 as one of these three classes. This course is intended for the freshman year.)

Students must take at least one, and no more than two of the "Computing Classes".

Technology Minor Application: The student submits a Change of Program Form which is available on the registrar's website.

Approved Courses for the Technology Minor

Engineering Classes		
CIVL 015	Civil Engineering Graphics	3
CIVL 022	Geomatics	3
CIVL 132	Environmental Engineering	4
CIVL 171	Water and Environmental Policy	3
COMP 041	Great Ideas in Computing	4
ECPE 041	Circuits	3
ECPE 041L	Circuits Laboratory	1
ECPE 071	Digital Design	3
ECPE 071L	Digital Design Lab	1
EMGT 170	Project Decision Making	4
EMGT 172	Engineering Economy	3
EMGT 174	Engineering Project Management	3
ENGR 010	Dean's Seminar	1
ENGR 020	Engineering Mechanics I (Statics)	3
ENGR 025	Professional Practice Seminar	1
ENGR 181	Professional Practice	1-16
ENGR 182	Professional Practice	1-16
ENGR 183	Professional Practice	1-16
ENGR 184	Professional Practice	1-18
MECH 015	Mechanical Engineering Graphics	3
MECH 100	Manufacturing Processes	3
General Technology Classes		
BIOL 035	Environment: Concepts and Issues	4
COMP 041	Great Ideas in Computing	4
PHIL 035	Environmental Ethics	4
RELI 146	Technology, Ethics, and Religion	4
Computing Classes		
Select at least one and no more than two of the following:		3-8
BUSI 100	Management Information Systems	
COMP 025	Computers and Information Processing	
COMP 051	Introduction to Computer Science	
ENGR 019	Computer Applications in Engineering	
MCOM 019	Music and Computer Technology	
Basic Math and Science Classes		
Select no more than two of the following: *		4-10
CHEM 024	Fundamentals of Chem	
CHEM 025	General Chemistry	
MATH 041	Pre-calculus	
MATH 045	Introduction to Finite Mathematics and Calculus	
MATH 051	Calculus I	
MATH 053	Calculus II	
MATH 055	Calculus III	
PHYS 053	Principles of Physics I	

* These courses serve as prerequisites for some of the above courses.

Courses are numbered in accordance with the general University system.

Courses labeled "ENGR" are intended for all engineering students, while courses labeled "BENG," "CIVL," "ECPE," "EMGT" or "MECH" are primarily intended for majors in the Bioengineering, Civil (CE), Electrical and Computer (ECE), Engineering Management (EMGT), and Mechanical (ME) departments. Courses labeled "COMP" are taught in the Computer Science Department.

All engineering and computer science course prerequisites must be passed with a C- or higher grade.

** Fundamental skills are a prerequisite to all upper-division engineering and computer science courses.*

** Note: Transfer courses must be graded C or better.*

Minor in Structural Engineering

The minor in Structural Engineering is intended for students in engineering who desire additional knowledge in the structural or geotechnical engineering areas and whose current major is complementary to these topics.

The minor in Structural Engineering is not open to students pursuing the Civil Engineering degree.

Minor in Structural Engineering Requirements

Students must complete a minimum of 20 units and 5 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in structural engineering. At least 10 units must be taken at Pacific.

CIVL 100	Structural Engineering	4
ENGR 121	Mechanics of Materials	3
Select one of the following: *		4

CIVL 164	Structural Timber Design	
CIVL 165	Structural Steel Design	
CIVL 166	Reinforced Concrete Design	
Select at least two of the following:		8
CIVL 140	Geotechnical Engineering	
CIVL 141	Earth Structure Design	
CIVL 145	Engineering Geology	
CIVL 151	Construction Engineering	
CIVL 160	Structural Analysis	
CIVL 163	Introduction to Earthquake Engineering	
CIVL 164	Structural Timber Design	
CIVL 165	Structural Steel Design	
CIVL 166	Reinforced Concrete Design	
CIVL 173	Sustainable Engineering	
ENGR 110	Instrumentation and Experimental Methods	
MECH 129	Vibrations	

* Up to three units related independent study, undergraduate research, or senior project may be used to meet requirements of the minor.

Minor in Environmental Engineering

The minor in Environmental Engineering is intended for students in engineering who desire additional knowledge in the environmental or water resources engineering areas and whose current major is complementary to these topics.

The minor in Environmental Engineering is not open to students pursuing the Civil Engineering degree.

Minor in Environmental Engineering Requirements

Students must complete a minimum of 20 units and 5 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in environmental engineering. At least 10 units must be taken at Pacific.

CIVL 060	Water Quality	4
CIVL 130	Fluid Mechanics I	3
CIVL 130L	Fluid Mechanics I Lab	1
CIVL 132	Environmental Engineering	4
Select at least two of the following: *		8
BENG 130	Biotransport	
CIVL 133	Water Resources Engineering	
CIVL 134	Groundwater	
CIVL 136	Design of Water Quality Control Facilities	
CIVL 138	Solid Waste Systems Design and Management	
CIVL 171	Water and Environmental Policy	
CIVL 173	Sustainable Engineering	
MECH 155	Solar Energy Engineering	

* Up to three units related independent study, undergraduate research, or senior project may be used to meet requirements of the minor.

Minor in Computer Engineering

Computer hardware is fundamental to modern technological systems. The minor in Computer Engineering is intended for students who seek to understand computer systems at the hardware level.

The minor in Computer Engineering is not open to students pursuing the Computer Engineering or Electrical Engineering degrees.

Minor in Computer Engineering Requirements

Students must complete a minimum of 20 units and 7 courses with a Pacific minor grade point average of 2.0 in order to earn a minor in Computer Engineering.

ECPE 071	Digital Design	3
ECPE 071L	Digital Design Lab	1
ECPE 170	Computer Systems and Networks	4
ECPE 174	Advanced Digital Design	4
Select three of the following:		
ECPE 155	Autonomous Robotics	
ECPE 172	Microcontrollers	
ECPE 173	Computer Organization and Architecture	
ECPE 177	Computer Networking	
ECPE 226	Computational Intelligence	
ECPE 251	High-Performance Computing	
COMP 173	Operating Systems	
COMP 177	Computer Networking	

Bioengineering Courses

BENG 005. Introduction to Bioengineering. 2 Units.
This course introduces students to the various sub-disciplines (medical, chemical, electrical, mechanical, and computation) of bioengineering.

BENG 103. Biomaterials. 4 Units.
This course discusses biomaterials and lays the ground work for topics such as mechanical chemical, and thermal properties of replacement materials and tissues. Implantation of materials in the body are studies studied from the biological point of view. Prerequisites: Completion of all Fundamental Skills; CHEM 24 or CHEM 025 or CHEM 027; BIOL 061 with a "C-" or better.

BENG 104. Biomedical Imaging. 4 Units.
This course discusses major medical imaging modalities in radiology, including X-ray, CT, nuclear medicine, ultrasound, and MRI. Specific contents include physical principle of each imaging modality; instrumentation and data acquisition/image reconstruction strategy, clinical applications and imaging techniques. Prerequisites: MATH 055, PHYS 055, COMP 051 or ENGR 019.

BENG 108. Engineering Physiology. 5 Units.
This course is a lecture and lab-based review of the functions of the major organ systems of vertebrates with emphasis on the human body. Lectures cover basic anatomy, function and regulation of the nervous, endocrine, sensory, muscular, cardiovascular, respiratory, and excretory systems, with the underlying theme of maintaining homeostasis while responding to physiological disturbances. Lab exercises demonstrate basic physiological processes and emphasize techniques of instrument-based data acquisition and data presentation. Prerequisites: Completion of all Fundamental Skills; BIOL 61; CHEM 24 or CHEM 25 all with a "C-" or better or permission of instructor.

BENG 110. Bioinstrumentation and Experimental Design. 4 Units.
Introduction to engineering aspects of the detection, acquisition, processing, and display of signals from living systems; Experimental techniques for measurement of biomedical quantities such as biopotentials, force, pressure, and temperature are discussed. The course introduces statistical analysis including confidence intervals, hypothesis testing, analysis of variance, and linear regression as well as errors in measurement. Use of instruments in the laboratory; a measurement project. Corequisites: BENG 124 or ENGR 121. Prerequisites: MATH 057; ECPE 041 with a "C-" or better.

BENG 121. Biomedical Signal Processing. 4 Units.
Students analyze discrete-time signals and systems using z transforms and Fourier transforms, the fast Fourier transform and its applications, digital filters and their applications and implementation of DSP algorithms using Matlab and Simulink. Also listed as ECPE 121.

BENG 124. Biomechanics. 4 Units.
This course discusses concepts of engineering mechanics including stress, strain, deformation, and analysis of structures with application to biomechanical phenomena over a range of biological length scales. Engineering mechanics concepts are used to evaluate forces and moments acting on human joints, forces in musculoskeletal tissue, material properties of biological tissues, and disease state conditions. Prerequisites: Completion of all Fundamental Skills; ENGR 020 with a "C-" or better. Prerequisite may be taken concurrently: MATH 057 with a "C-" or better.

BENG 130. Biotransport. 4 Units.
This course focuses on momentum transport (viscous flow) and mass transport (diffusion and convection) in living systems. The fundamental principles of momentum and mass transfer are explored and laws of conservation applied to develop mathematical descriptions of physiological and engineering systems across a range of length scales. Students develop technical writing skills and learn to use computation fluid dynamics simulation tools. Prerequisites: Completion of all Fundamental Skills; MATH 057; PHYS 053 with a "C-" or better.

BENG 140. Introduction to Tissue Engineering. 4 Units.
Tissue engineering is a multidisciplinary and collaborative field that applies the principles of engineering and biology toward the development of biological substitutes that restore, maintain, and improve tissue function. In this course, there will be an overview of tissue engineering, including discussion of cell sources, cell-material interactions, and assessment of engineering outcome through destructive and nondestructive means with case studies of specific types of tissue engineering including skin, bone, cartilage, bladder, and liver. Finally, ethical standards for different techniques in tissue engineering will be discussed. Prerequisites: Completion of all Fundamental Skills; BIOL 061; BENG 103 all with a "C-" or better or permission of instructor.

BENG 154. Introduction to Magnetic Resonance Imaging. 4 Units.
Introduction to the physics, techniques, and applications of magnetic resonance imaging (MRI) in basic sciences and the clinic. Basics of nuclear magnetic resonance physics, and Fourier transform, MRI hardware, and MR imagining principles including signal generation, detection, and spatial localization techniques. Applications of MRI including tissue relaxometry measurement and diffusion weighted imaging of biological tissues, imagining of anatomy, and function. Prerequisites: Completion of all Fundamental Skills; BENG 104 with a "C-" or better of permission of instructor.

BENG 171. Bioelectricity. 4 Units.
This course provides the student with an understanding of the origins, function, and measurement of electrical potentials and currents within biological tissues, such as nerve, muscle, and heart. Topics include: the bioelectrical properties of ion channels, neurons, the synapse and neuromuscular junction, adaptation and learning in small networks of neurons, the functional organization of bioelectrical systems, and bioelectrical measurement and stimulation of tissues such as the heart and brain. Prerequisites: Completion of all Fundamental Skills; ECPE 041/ECPE 041L; Prerequisite may be taken concurrently: MATH 057 with a "C-" or better.

BENG 175. Human/Brain Machine Interface. 3 Units.
Human/Brain Machine interface (HMI/BMI) is a direct communication pathway between human signals such as heart activity, electro dermal activity, and brain with an external device. Bioelectrical activity can be employed directly to provide information or predict the human alertness, stress level, health or control external devices such as an external keyboard and robotic arm. This topic includes the physiology of generation of human vital signals, designing interface device, and developing offline and real-time computational algorithms for controlling external devices. Prerequisite: Completion of all Fundamental Skills; ENGR 19 or COMP 51 or COMP 61 with a "C-" or better; MATH 53 or COMP 157 with a "C-" or better; and junior standing.

BENG 187. Professional Practice. 1-18 Units.

BENG 191. Independent Study. 1-4 Units.
Special individual projects are undertaken under the direction of one or more faculty members who are knowledgeable in the particular field of study. Permission of department chairperson and faculty members involved.

BENG 194. Bioengineering Project Proposal. 3 Units.
This course provides an introduction to the engineering design process. Students apply basic sciences, mathematics, and engineering topics to meet a stated objective. Students will write a proposal for a comprehensive design project, in which they establish design objectives and criteria, analyze solution alternatives, and synthesize a problem. Consideration for engineering standards, realistic constraints, ethics, and safety is included. Prerequisites: Completion of all Fundamental Skills, Junior or Senior standing, BENG 124 or BENG 103, may be taken concurrently, with a "C-" or better or permission of instructor.

BENG 195. Senior Project. 3 Units.
In this course, students will complete the engineering design process. Students will design and evaluate an engineering solution to an existing problem. Students apply basic sciences, mathematics and engineering topics to implement a solution that meets stated design objectives and criteria. Students will also test prototypes to evaluate design performance. Design documentation and demonstration are required. Includes both written and oral reports and presentations. Prerequisite may be taken concurrently: BENG 194 with a "C-" or better or permission of instructor.

BENG 197. Undergraduate Research. 1-4 Units.
This course is applied or basic research in bioengineering under faculty supervision. Permission of faculty supervisor and department chair. Students must be in good academic standing.

BENG 197D. Undergraduate Research. 1-4 Units.

Civil Engineering Courses

CIVL 015. Civil Engineering Graphics. 3 Units.
Coverage of the principles and applications of graphics in engineering design. Pictorial and isometric sketching and orthographic projection and use of auxiliary views and sections are used. Drafting standards and conventions, dimensioning and tolerances. Layout and assembly drawings, detail drawings and production drawings using AutoCAD software. Laboratory work is included. Prerequisite may be taken concurrently: ENGR 010 with a "C-" or better.

CIVL 022. Geomatics. 3 Units.
This course is an introduction to geomatics engineering which includes in depth coverage of plane surveying and an introduction to Global Navigation Satellite Systems (GNSS), geodetics and geospatial sciences. Fundamental surveying methods and equipment will be presented in both a lecture and a hands-on laboratory section. Topics include: error theory, leveling, traverse computations, topography, coordinate systems, construction surveying, geometric design, Global Navigation Satellite Systems (GNSS), photogrammetry and the presentation of other emerging and relevant technologies. Prerequisite: MATH 041 with a "C-" or better or a passing score on the University's trigonometry placement test.

CIVL 060. Water Quality. 4 Units.
Students examine chemical reactions and processes in aquatic systems with engineering applications. Topics include chemical equilibrium and kinetics associated with acid-base, dissolution-precipitation, complexation, and reduction-oxidation reactions in natural and engineered environments. Laboratory work is included. Prerequisites: AP Chem with score of 4 or 5, CHEM IB Higher Level (score of 5, 6, or 7), CHEM 024 or CHEM 025 or CHEM 027; and MATH 051 with a "C-" or better.

CIVL 100. Structural Engineering. 4 Units.
Students examine the theory and applications of structural analysis and design. Topics include determination of loads, analysis of beams, trusses and frames, influence lines and indeterminate structures. Laboratory is included. Prerequisites: Completion of all Fundamental Skills; CIVL 15 or MECH 15; ENGR 19; Prerequisite can be taken concurrently: ENGR 121 with a "C-" or better (Spring).

CIVL 130. Fluid Mechanics I. 3 Units.
Students study the physical properties of fluids, statics and dynamics of incompressible fluids that include hydrostatics, conservation of mass, energy and momentum principles, laminar and turbulent flow with emphasis on pipe flow. Prerequisite: Completion of all Fundamental Skills and ENGR 120 with a "C-" or better. Corequisite: CIVL 130L.

CIVL 130L. Fluid Mechanics I Lab. 1 Unit.
Experimental analysis of concepts are discussed in CIVL 130. Prerequisite: Completion of all Fundamental Skills and ENGR 120 with a "C-" or better. Corequisite: CIVL 130.

CIVL 132. Environmental Engineering. 4 Units.
Students are introduced to the physical, chemical, and biological processes associated with water quality in natural environments and engineering systems. Topics include operation and design of water and wastewater treatment facilities as well as the occurrence, behavior and control of indoor and regional air pollution. Laboratory is included. Prerequisites: Completion of all Fundamental Skills; CIVL 015 or MECH 015; CIVL 060 with a "C-" or better.

CIVL 133. Water Resources Engineering. 4 Units.
Hydraulic and hydrologic analysis and design including pipe flow, open channel flow, elements of the hydrologic cycle, analysis of rainfall-runoff data, design applications, and the application of computers in hydrologic and hydraulic design. Laboratory is included. Prerequisites: Completion of all Fundamental Skills; CIVL 015 or MECH 015; CIVL 130 with a "C-" or better.

CIVL 134. Groundwater. 4 Units.
Aquifer properties, groundwater hydraulics in confined and unconfined aquifers under steady and unsteady flow conditions. Well hydraulics under ideal and non-ideal conditions. Constituent transport and fate in groundwater. Prerequisites: Completion of all Fundamental Skills; CIVL 130; MATH 057 with a "C-" or better.

CIVL 136. Design of Water Quality Control Facilities. 4 Units.
This advanced course covers the physical, chemical, and biological processes that are involved in the design of water and wastewater treatment plant facilities as well as applicable design standards and regulations. Prerequisites: Completion of all Fundamental Skills, CIVL 130, CIVL 132 with a "C-" or better.

CIVL 138. Solid Waste Systems Design and Management. 3 Units.
This is an introductory course to solid waste systems, that analyzes of problems associated with storage, collection, transport, processing, and disposal of solid wastes. Students review of current and expected regulatory requirements and the planning and design of solid waste management components that include systems and processes for solid waste prevention, recycling/composting, incineration, and landfilling. Prerequisite: Completion of all Fundamental Skills and CIVL 132 with a "C-" or better.

CIVL 140. Geotechnical Engineering. 4 Units.
This course covers the fundamentals of geotechnical engineering including the characterization of soils and their behavior as an engineering material. Topics include classification of soils, compaction, permeability, and consolidation. Design applications include settlement predictions, strength characterization, soil exploration programs, and an overview of shallow and deep foundations. The course includes laboratory work. Prerequisites: Completion of all Fundamental Skills; CIVL 015 or MECH 015; ENGR 121 with a "C-" or better.

CIVL 141. Earth Structure Design. 4 Units.
Evaluation of drained and undrained field conditions and the relationship between temporary and permanent design conditions over time. In-situ tests, including SPT and CPT. Analysis of lateral stresses in soil masses. Design of slopes, cantilever retaining walls, sheet piles, anchored bulkheads, and mechanically-stabilized earth walls. Design includes analysis of effects of water and seismic conditions, including liquefaction. Prerequisite: CIVL 140.

CIVL 145. Engineering Geology. 4 Units.
This introductory course to is the study of geology in which geologic principles, data and techniques are applied to civil engineering problems. Also listed as GEOS 145. Prerequisites: Completion of all Fundamental Skills; GEOS 051 or GEOS 061 or CIVL 140 with a "C-" or better.

CIVL 150. Transportation Engineering. 4 Units.
Students study the considerations and procedures in the planning, design, and operation of various transportation systems with primary emphasis on highways. Prerequisites: Completion of all Fundamental Skills. Junior or Senior standing.

CIVL 151. Construction Engineering. 3 Units.
An introduction to construction engineering and construction management. Construction engineering topics include construction processes and construction econometrics. Construction management topics include estimating, planning, bidding, and scheduling. Prerequisites: Completion of all Fundamental Skills. Junior or Senior standing.

CIVL 160. Structural Analysis. 3 Units.
Students analyze the behavior of trusses and framed structures under gravity and lateral loads. Other topics include analysis of shear walls, the use of structural analysis software, and the buckling of frames. Prerequisites: Completion of all Fundamental Skills; CIVL 100 and MATH 057 with a "C-" or better.

CIVL 163. Introduction to Earthquake Engineering. 3 Units.
Determination of loads on structures due to earthquakes. Overview of seismology. Methods of estimating equivalent static lateral forces; response spectrum and time history analysis. Concepts of mass, damping and stiffness for typical structures. Design for inelastic behavior. Numerical solutions and code requirements. Prerequisites: Completion of all Fundamental Skills, ENGR 019, ENGR 121 with a "C-" or better.

CIVL 164. Structural Timber Design. 4 Units.
Students will study the design of timber structural members, specifically tension, compression, flexural, and beam-column elements and connections to satisfy design code requirements. Prerequisite, may be taken concurrently: CIVL 100.

CIVL 165. Structural Steel Design. 4 Units.
Students study the design of steel structural members, specifically tension, compression, flexural, and beam-column elements and connections to satisfy design code requirements. Prerequisite: Completion of all Fundamental Skills. Prerequisite may be taken concurrently: CIVL 100 with a "C-" or better.

CIVL 166. Reinforced Concrete Design. 4 Units.
Students study the design and proportioning of structural members, specifically beams, columns, one-way slabs, footings, and walls to satisfy design criteria for reinforced concrete systems. Prerequisite: Completion of all Fundamental Skills. Prerequisite may be taken concurrently: CIVL 100 with a "C-" or better.

CIVL 171. Water and Environmental Policy. 3 Units.
This course introduces students to Federal and State of California environmental regulations pertaining to air, water, hazardous wastes, and toxic substances. Topics include an overview of water rights and environmental impact assessment, relevant case studies, and examples of monitoring and enforcement issues. Prerequisite: Completion of all Fundamental Skills. Must have Junior or Senior standing.

CIVL 173. Sustainable Engineering. 3 Units.
This interdisciplinary course provides an introduction to principles and practice of sustainable engineering. Topics include the analysis of economic, social, and environmental factors, life cycle assessment, resource use and waste generation in engineering products and processes. The course also examines case studies, readings, and class discussion emphasizes analysis and development of sustainable solutions. Prerequisite: Completion of all Fundamental Skills. Junior or Senior standing.

CIVL 180. Engineering Synthesis. 4 Units.
This course is a culminating experience wherein a group of students synthesize their previous class work into one project. Both technical and non-technical concerns are addressed. One or more faculty members and/or professional engineers are involved depending upon the fields covered in the project. Prerequisites: Completion of all Fundamental Skills; EMGT 170 and 2 of the following: CIVL 100, CIVL 132, CIVL 133, CIVL 140 with a "C-" or better. Senior standing.

CIVL 191. Independent Study. 1-4 Units.
Students undertake special individual projects under the direction of one or more faculty members. Permission of department chairperson and faculty member involved.

CIVL 193. Special Topics. 4 Units.

CIVL 197. Undergraduate Research. 1-4 Units.
This course is applied or basic research in civil engineering under faculty supervision. Permission of faculty supervisor and department chair. Student must be in good academic standing.

Computer Science Courses

COMP 025. Computers and Information Processing. 4 Units.
This introductory information technology course focuses on computer architecture, networking, internet technologies and the integration of productivity software. Lectures, readings, hands-on projects and lab assignments give a variety of learning experiences. Specific topics include computer architecture, digital data, networking, file management, spreadsheets, database systems and presentation applications. Students are exposed to JavaScript and Visual Basic scripting. Particular emphasis is placed on HTML programming and creating an interactive student website for homework and lab linking throughout the semester. Prerequisite: Fundamental Math Skills requirement. **(GE3B, GEQR)**

COMP 041. Great Ideas in Computing. 4 Units.
This course is a broad introduction to the field of computing. The concepts that are the foundation of computing are presented and placed in historical context. Discussion topics include the ways of thinking and working that make computing effective, and the future of the field. Example topics include number representation, architecture of computing systems, intelligent computing systems, and the use of computing in art and games. Prerequisite: Fundamental Math Skills requirement. **(GE3C, GEQR)**

COMP 047. Discrete Math for Computer Science. 4 Units.
This course is designed to develop skills in deductive reasoning and to apply concepts of discrete mathematics to computer science. Topics include logic, deductive reasoning, introduction to analysis of algorithms, mathematical induction, set theory, functions, recurrence relations, combinatorics and probability, graphs, and trees. Prerequisite: Fundamental Math Skills requirement. **(GE3B, GEQR)**

COMP 051. Introduction to Computer Science. 4 Units.
The course emphasizes program design and problem solving techniques that use a high-level programming language. The course introduces basic concepts such as assignment, control flow, iteration, and basic data structures in addition to a supervised lab. Credit for this course is not given if a student has credit for COMP 061. Prerequisite: Fundamental Math Skills requirement. **(GE3B, GEQR)**

COMP 053. Data Structures. 4 Units.
The course continues the development of program design and problem solving techniques. Topics include development of fundamental data structures and their associated algorithms as well as array-based algorithms, recursion, lists, generics, dynamic memory, binary trees, and associative structures. Prerequisite: COMP 051 or COMP 061 with a "C-" or better.

COMP 055. Application Development. 4 Units.
This course develops the skills and techniques required for the creation of contemporary software applications. Contemporary software applications are complex systems that involve the interaction of multiple subsystems that require teams of developers working together for extended periods of time. Topics include teamwork and communication skills, current development methodologies, analysis and design documentation and the use of libraries. This course is intended to prepare students to transition to upper division courses. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better.

COMP 061. Introduction to Programming for Data Science. 4 Units.
This course introduces programming concepts and program design using topics in data science as examples. Basic concepts such as assignment, control flow, iteration, and simple as well as object-oriented data types and structures are developed. The course includes a supervised lab. Credit for this course is not given if student has credit for COMP 051. Prerequisite: Fundamental Math Skills requirement. **(GE3B, GEQR)**

COMP 093. Special Topics. 3 or 4 Units.

COMP 127. Web Applications. 4 Units.
The World-Wide Web consists of client-server applications operating over the Internet. This course introduces the skills and techniques for designing and developing web applications. Topics include: client-server architectures, web servers and web browsers, server-side programming, client-side programming, form processing, state management and multimedia. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better or permission of instructor. (Fall, even years).

COMP 129. Software Engineering. 4 Units.
Students gain practical experience in dealing with medium to large scale software systems. Students learn how current analysis and design methodologies are used to develop the abstractions necessary to understand large systems. Students also learn how such methodologies and abstractions are used to communicate with coworkers and clients about the analysis and design. Because communication is an essential skill in large system development, students are expected to produce documents and presentations of professional quality and depth. Prerequisites: Completion of all Fundamental Skills and COMP 055 with a "C-" or better. (Spring, every year).

COMP 135. Human-Computer Interface Design. 3 Units.
Human-Computer Interface (HCI) Design focuses on the relationship between humans and computers or other physical devices. This course helps students develop an understanding of the common problems in designing these interfaces and presents a set of design techniques to ensure that designs are both useful and useable. Prerequisite: Completion of all Fundamental Skills. Junior standing. (Spring, every year).

COMP 137. Parallel Computing. 3 Units.
Parallel computing is a science which solves a large problem by giving small parts of the problem to many computers to solve and then combining the solutions for the parts into a solution for the problem. This course introduces architectures and implementation techniques to support parallel computation. Students are expected to design and implement an original parallel application as a term project. Prerequisite: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. Corequisite: ECPE 170. (Spring, every year).

COMP 141. Programming Languages. 4 Units.
Topics in evaluation, design, and development of programming languages. Topics include type systems, variables and scope, functions, parameter passing, data hiding and abstractions, recursion, memory allocation, grammars and parsing, compiler architecture, programming paradigms, and comparison of programming languages and environments. Prerequisites: Completion of Fundamental Skills and COMP 053 with a "C-" or better.

COMP 147. Computing Theory. 4 Units.
Students study automata, formal languages and computability. Topics include finite state automata, regular languages, pushdown automata, context-free languages, Turing machines; decidability, reducibility, and time complexity that includes NP-completeness and intractability. Prerequisites: Completion of all Fundamental Skills; COMP 047 or ECPE 071 or MATH 074 with a "C-" or better.

COMP 151. Artificial Intelligence. 3 Units.
Students study fundamental concepts, techniques and tools used in Artificial Intelligence. Topics include knowledge representation, search techniques, machine learning and problem solving strategies. Also listed as ECPE 151. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a “C-“ or better. (Fall, odd years).

COMP 152. Machine Learning. 3 Units.
This course provides an introduction to machine learning using Python, the open source, programming language extensively adopted by the machine learning community and industry. In this course, you will use Python to learn machine learning concepts, terms and methodology, and gain an intuitive understanding of the mathematics underlying it by building actual applications. The techniques you'll learn can be a starting point to build real-world applications such as search engines, image analysis, bioinformatics, industrial automation, speech recognition, and more. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a “C-“ or better.

COMP 153. Computer Graphics. 3 Units.
An introduction to two and three dimensional computer graphics. Basic representations and mathematical concepts, object modeling, viewing, lighting and shading. Programming using OpenGL and other computer graphics applications. Also listed as ECPE 153. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. (Fall, even years).

COMP 155. Computer Simulation. 4 Units.
This course explores digital simulation, in which a model of a system is executed on a computer. The course focuses on modeling methodologies, mathematical techniques for implementing models, and statistical techniques for analyzing the results of simulations. Students develop simulations using both simulation development toolkits and general-purpose programming languages. Also listed as EMGT 155. Prerequisites: Completion of all Fundamental Skills; MATH 037 or MATH 039; MATH 045 or MATH 051, COMP 051 or ENGR 019 with a "C-" or better. (Fall, even years).

COMP 157. Design and Analysis of Algorithms. 4 Units.
Topics for this course include complexity analysis, algorithms for searching, sorting, pattern matching, combinatorial problems, optimization problems, backtracking, algorithms related to number theory, graph algorithms, and the limitations of algorithm power. Prerequisites: Completion of all Fundamental Skills; COMP 047 or MATH 074; COMP 053; MATH 045 or MATH 051 with a "C-" or better.

COMP 159. Computer Game Technologies. 4 Units.
This course surveys the technologies and processes used for modern video game development. Course topics include software engineering, media creation and management, hardware interfaces, user interaction, 3D mathematics and common algorithms and data structures to support graphics, physics and artificial intelligence. Prerequisite: Completion of all Fundamental Skills and COMP 055 with a "C-" or better. (Fall, odd years).

COMP 162. Data Analytics Programming. 4 Units.
This course develops programming skills for computational data analysis. The course emphasizes programming for statistical analysis, machine learning and predictive modeling. Other topics include programming packages for handling, preparation, and manipulation of data, as well as visualization tools for exploration and presentation of data and results. The course emphasizes hands-on data and analysis using a variety of real-world data sets and analytical objectives. Prerequisites: Completion of all Fundamental Skills; COMP 051 or COMP 061.

COMP 163. Database Management Systems. 4 Units.
A database management system (DBMS) is a computer application designed for the efficient and effective storage, access and update of large volumes of data. This course looks at such systems from two perspectives. The user-center perspective focuses on how a DBMS is used to build support for a data intensive application. This perspective includes examination of common data models, query languages and design techniques. The system implementation perspective focuses on the policies, algorithms and data structures used to design and implement a DBMS. Prerequisites: Completion of all Fundamental Skills and COMP 053 with a "C-" or better. Corequisite: COMP 047 or MATH 074. (Spring, every year).

COMP 173. Operating Systems. 4 Units.
Students are introduced to the fundamental concepts of modern operating systems. Topics include an overview of computer architecture and organization, process management, threads, and CPU scheduling. Students also study process synchronization that uses primitive and high-level languages, virtual memory management, file systems, system protection, and parallel and distributed computing. Prerequisites: Completion of all Fundamental Skills; COMP 053; COMP 175 or ECPE 170 with a "C-" or better or permission of instructor.

COMP 175. System Administration and Security. 3 Units.
This course provides an introduction to system administration of modern network servers and applications. Techniques to provide for data confidentiality, integrity, and availability are presented, both at the network security level and host security level, in order to resist common attacks and vulnerabilities. Topics include virtualization methods, resource provisioning in a cloud environment, command-line usage, installation and configuration of common network applications, containerized application deployment, password security and auditing, network configuration and firewalls, scripting, change management, and IT automation tools. Prerequisites: Completion of all fundamental skills and familiarity with console-based operating systems commands. Junior Standing.

COMP 177. Computer Networking. 4 Units.
Topics examined in this course include computer networks and the internet, LAN and WAN architectures, and packet switched networks and routing. Students learn about the internet protocol stack, socket programming and client/server systems, wireless networking and security. Also listed as ECPE 177. Prerequisites: Completion of all Fundamental Skills; COMP 053 and ECPE 170 with a "C-" or better. Junior or Senior standing. (Fall, every year).

COMP 178. Computer Network Security. 3 Units.
This course is an examination of computer security from a defensive and offensive perspective. Topics include attack methods used by threat actors (including scanning, exploits, privilege escalation, malware, and social engineering methods), their detection, and their prevention by network and host-based techniques. Additionally, cryptographic techniques are introduced in order to provide secure communications channels that guarantee message confidentiality, authenticity, and integrity. Prerequisites: Completion of all Fundamental Skills and ECPE 170 or COMP 175 with a “C-“ or better.

COMP 180. Fundamentals of Computer Science. 3 Units.
The course emphasizes program design and problem solving techniques that use a high-level programming language. The course introduces basic concepts of programming and then applies them to discrete math concepts and data structures through supervised labs. Credit will not be given for this course if a student has received credit for COMP 051, COMP 061, COMP 053, COMP 047, or ENGR 019.

COMP 187. Internship in Computer Science. 1-4 Units.
This internship course offers cooperative employment in a professional computer science environment. The internship requires satisfactory completion of the work assignment and written reports. Prerequisites: Completion of all Fundamental Skills; COMP 055 and ENGR 025 with a "C-" or better. Grading is Pass/No Credit only.

COMP 191. Independent Study. 1-4 Units.
Students create student-initiated projects that cover topics not available in regularly scheduled courses. A written proposal that outlines the project and norms for evaluation must be approved by the department chairperson.

COMP 195. CS Senior Project. 4 Units.
In this course, students synthesize their cumulative computer science knowledge through the development of a computer application. Students will establish design objectives and criteria, analyze solution alternatives and evaluate design performance. Students will then implement, test and evaluate the system. Results will include analysis and design documents, the implemented system, test reports and a presentation and demonstration of the project. Prerequisites: Completion of all Fundamental Skills, Senior Standing, COMP 055 with a “C-“ or better.

COMP 197. Undergraduate Research. 1-4 Units.
Students conduct supervised research that contributes to current active topics in Computer Science. Topics may be selected by the student, related to faculty research, or provided by industrial sponsors. Permission of Undergraduate Research Coordinator.

Electrcl Computer Engr Courses

ECPE 005. Introduction to Electrical and Computer Engineering. 1 Unit.
This course introduces students to various sub-disciplines of Electrical and Computer Engineering and to the tools, both hardware and software, that are used in Electrical & Computer Engineering. Prerequisite that may be taken concurrently: ENGR 010 with a "C-" or better.

ECPE 041. Circuits. 3 Units.
Students study concepts of voltage, current, power, energy. Topics include ideal circuit elements and their I/V characteristics, Kirchhoff's laws, circuit analysis using node voltage and mesh current methods Thevenin's and Norton's theorems, maximum power transfer, and operational amplifier circuits. The course examines step response of 1st order (RC, RL) and 2nd order (RLC) circuits, phasor analysis, impedance calculations, sinusoidal steady state response, instantaneous, average, and reactive power, frequency response, bandwidth of first order, and lowpass and highpass filters. Prerequisites: PHYS 055; MATH 055; COMP 061 or COMP 051 or ENGR 019 with a "C-" or better. Prerequisites that may be taken concurrently: PHYS 55, MATH 55.

ECPE 041L. Circuits Laboratory. 1 Unit.
Students study the use of standard test equipment to make DC and AC measurements and characterize electric circuits. Circuit simulation is taught with software tools, and data analysis is emphasized. Corequisite: ECPE 041.

ECPE 071. Digital Design. 3 Units.
Students study number systems, binary arithmetic, and Boolean logic. Topics include the analysis and synthesis of combinational and sequential circuits and the use of FPGA devices. Prerequisites: Fundamental Math Skills requirement, and Sophomore or Junior or Senior standing.

ECPE 071L. Digital Design Lab. 1 Unit.
This course involves laboratory treatment of the concepts discussed in ECPE 071. Corequisites: ECPE 071. Prerequisites: Fundamental Math Skills requirement; COMP 051 or COMP 061 or ENGR 019 with a "C-" or better.

ECPE 121. Digital Signal Processing. 4 Units.
Students analyze discrete-time signals and systems using z transforms and Fourier transforms, the fast Fourier transform and its applications, digital filters and their applications and implementation of DSP algorithms using Matlab and Simulink. Also listed as BENG 121. Prerequisites: ECPE 041 and MATH 057 with a "C-" or better.

ECPE 124. Digital Image Processing. 4 Units.
This course is the analysis and design of algorithms in digital image processing. Topics include: image formation, file format, pixel-based processing, object recognition, filtering and edge detection, image transforms, segmentation, stereo-vision, and motion tracking. Prerequisites: COMP 053, ECPE 121 with a "C-" or better. Prerequisite that may be taken concurrently: ECPE 121.

ECPE 127. Random Signals. 3 Units.
This course is an introduction to probability and statistics in engineering applications. Students will become familiar with discrete and continuous random variables and their probability models. Topics include counting methods, reliability problems, probability mass functions (PMF), probability density functions (PDF), cumulative distribution functions (CDF), conditional PDF's, expected value and variance, joint and marginal PDF's and CDF's, functions of two random variables, sampling distributions, population parameter estimation, hypothesis testing using statistical software. Prerequisites: Completion of all Fundamental Skills, MATH 055 with a "C-" or better.

ECPE 131. Electronics. 4 Units.
Introduction to semiconductor physics, devices, and their circuit models. Analysis, design, implementation, testing, and verification of practical analog and digital circuits containing diodes, bipolar junction transistors, and field effect transistors. Extensive use of computer-aided analysis and design software. The course includes a laboratory. Prerequisites: Completion of all Fundamental Skills; ECPE 041, ECPE 041L, ECPE 071, ECPE 071L, MATH 055, PHYS 055, with a "C-" or better; AP CHEM with score of 4 or higher, or IB CHEM Higher Level with score of 5 or higher, or one year of high school chemistry with a "B-" or better, or appropriate score on the Pacific Diagnostic Chemistry test or CHEM 023 with a "C-" or better. Prerequisite that may be taken concurrently: ECPE 071, ECPE 071L.

ECPE 133. Solid State Devices. 4 Units.
This course introduces concepts related to the crystal structure of semiconductors and electronic, optical, and magnetic properties of semiconductors. Dynamics of carriers under equilibrium and non-equilibrium conditions are presented as a frame work for understanding the behavior of a number of devices including Metal-Oxide-Semiconductor (MOS) and Hetero-junction Bipolar (HBT) devices. On such a background, the course builds an understanding of the latest advances in the field. This course is cross listed with EPHY 133 and PHYS 170. Prerequisite: PHYS 055 with a "C-" or better. Prerequisite that may be taken concurrently: MATH 057 with a "C-" or better.

ECPE 135. Power Electronics. 4 Units.
Switch-Mode DC-DC converters, Feedback control of converters, Rectifiers and power factor correction circuits, switch mode DC power supplies, applications to motor control and renewable energy integration to the grid. Includes laboratory. Prerequisites: Completion of all Fundamental Skills; ECPE 131 with a "C-" or better. Prerequisites that may be taken concurrently: ECPE 121 or ECPE 141 with a "C-" or better.

ECPE 136. VLSI Design. 4 Units.
Students examine issues in VLSI design. Topics include logic families, sizing, timing models, fabrication, layout, high speed and low power design tradeoffs, circuit simulation and device modeling. (Spring odd years). Prerequisites: Completion of all Fundamental Skills; ECPE 071, ECPE 071L, ECPE 131 with a "C-" or better.

ECPE 141. Advanced Circuits. 4 Units.
Analysis and design of circuits in the continuous time domain. Topics include: frequency response, Laplace transforms, Fourier transforms, stability and feedback. Applications include high-order filter design and controls. Prerequisites: ECPE 041, ECPE 041L, and MATH 057 with a "C-" or better.

ECPE 144. Applied Electromagnetics. 4 Units.
The purpose of this course is for students to gain an understanding of transmission lines and field theory as it applies to communication circuits and systems. Electromagnetic wave propagation, reflection, and transmission through common materials are examined. This course is cross listed with EPHY 144. Prerequisites: Completion of all Fundamental Skills; PHYS 055, MATH 057, with a "C-" or better.

ECPE 155. Autonomous Robotics. 4 Units.
This course is an overview of the design of autonomous robotics. Students study architectures for robot organization and control, configurations of fixed and mobile robots, sensors and actuators. Students also study the design of algorithms and knowledge representations. Prerequisites: Completion of all Fundamental Skills; COMP 053 and ECPE 172 with a "C-" or better or permission of instructor.

ECPE 161. Automatic Control Systems. 4 Units.
Students study component and system transfer functions, open and closed loop response; stability criteria; applications to engineering systems. this course include a laboratory. Prerequisites: Completion of all Fundamental Skills; Prerequisite that may be taken concurrently: ECPE 121 or ECPE 141.

ECPE 162. Communication Systems. 4 Units.
Students examine signal characterization in time and frequency domains. Topics include baseband communication, pulse code modulation, multiplexing, complex envelope representation of bandpass signals. AM, FM, and digital modulations. Students also examine applications to radio, television, telephone, and cellular phone systems. A laboratory is included. Prerequisites: Completion of all Fundamental Skills and ECPE 121 with a "C-" or better. (Spring).

ECPE 163. Energy Conversion. 4 Units.
Students study three phase power systems. Topics include magnetic circuits, transformers, rotating machines: DC, induction, and synchronous machines as well as equivalent circuits and characteristic curves of transformers and rotating machines, renewable energy sources and technologies. the course includes a laboratory. Prerequisites: Completion of all Fundamental Skills; ECPE 041 and ECPE 041L; PHYS 055 with a "C-" or better.

ECPE 165. Power System Analysis. 3 Units.
Students study electrical power generation and transmission, Three-phase systems, power system component models, per-unit system and single line diagrams, power flow analysis. Prerequisites: Completion of all Fundamental Skills and ECPE 041 with a "C-" or better. Junior standing.

ECPE 170. Computer Systems and Networks. 4 Units.
The course investigates the operation of a modern computer system and its components. Students examine the processor data path and memory hierarchy by writing assembly programs and high-level simulations. The course also provides an introduction to computer networks and socket programming. Prerequisites: Completion of all Fundamental Skills; ECPE 071 or COMP 047 with a "C-" or better; COMP 053 with a "C-" or better.

ECPE 172. Microcontrollers. 4 Units.
Students study the design and implementation of digital monitoring and control systems that use micro-controllers. Topics include hardware and software development, interfacing input and output devices, assembly and C programming as well as representative applications. The course includes a laboratory. Prerequisites: Completion of all Fundamental Skills; COMP 053, ECPE 071, and ECPE 071L with a "C-" or better.

ECPE 173. Computer Organization and Architecture. 3 Units.
The objective of this course is to give students a deeper understanding of how a complete modern computer system operates. Students learn about design of a processing unit, pipelining, memory hierarchy, parallelism, and more advanced architecture topics. Prerequisites: Completion of all Fundamental Skills; ECPE 071L and ECPE 170 with a "C-" or better.

ECPE 174. Advanced Digital Design. 4 Units.
Students learn how to analysis, design, and implement synchronous state machines using programmable logic devices. Topics include CAD-based simulation and development that use schematic capture and hardware description languages, and representative applications. The course includes a laboratory. Prerequisites: Completion of all Fundamental Skills; ECPE 071 and ECPE 071L with a "C-" or better.

ECPE 177. Computer Networking. 4 Units.
Topics examined in this course include computer networks and the internet, LAN and WAN architectures, and packet switched networks and routing. Students learn about the internet protocol stack, socket programming and client/server systems, wireless networking and security. Also listed as COMP 177. Junior or Senior standing. Prerequisites: Completion of all Fundamental Skills; COMP 053 and ECPE 170 with a "C-" or better.

ECPE 178. Computer Network Security. 3 Units.
This course is an examination of computer security from a defensive and offensive perspective. Topics include attack methods used by threat actors (including scanning, exploits, privilege escalation, malware, and social engineering methods), their detection, and their prevention by network and host-based techniques. Additionally, cryptographic techniques are introduced in order to provide secure communications channels that guarantee message confidentiality, authenticity, and integrity. Prerequisites: Completion of all Fundamental Skills and ECPE 170 or COMP 175 with a “C-“ or better.

ECPE 191. Independent Study. 1-4 Units.
Special individual projects are undertaken under the direction of one or more faculty members knowledgeable in the particular field of study. Permission of department chairperson and faculty members involved.

ECPE 195. Senior Project I. 2 Units.
This first semester capstone design course instructs students in the application of design processes and interdisciplinary teamwork. Student teams select a project and develop requirements, test, and design documents. Projects incorporate consideration of engineering standards and realistic constraints such as economics, the environment, sustainability, manufacturability, or safety. Components are evaluated and selected. Feasibility is analyzed through prototyping or simulation and results are presented via oral and written reports. This course is cross listed with EPHY 195. Prerequisites: Completion of all Fundamental Skills; ECPE 131 with a "C-" or better.

ECPE 196. Senior Project II. 2 Units.
This second-semester capstone design course, interdisciplinary teams complete the design of their projects. Full implementation is completed, including iteration, optimization, and refinement; justifications for design decisions are analyzed. Testing is performed and results are evaluated to demonstrate satisfaction of specifications. Final oral and written reports, complete documentation, and a project demonstration are required. This course is cross listed with EPHY 196. Prerequisites: Completion of all Fundamental Skills; ECPE 195 with a "C-" or better.

ECPE 197. Undergraduate Research. 1-4 Units.
This course offers applied or basic research in electrical and/or computer engineering under faculty supervision. Permission of faculty supervisor and department chair. The student must be in good academic standing.

Engineering Management Courses

EMGT 115. Building Information Modeling. 4 Units.
This course provides the basics of design, modeling, scheduling, resource allocation, time/cost tradeoffs, task coordination, team-building, progress monitoring, and post project assessment while using the latest BIM technologies. Students study the lean construction and how to integrate BIM into the project delivery processes. Prerequisite: Completion of all fundamental skills.

EMGT 142. Design and Innovation. 3 Units.
This course brings buyers, sellers and end-users of design, prototyping and testing together in an educational and real problem environment. Students will learn how to identify innovation, and develop, design and market new product or service. Students will also learn the nature and importance of technological innovation in commercial organizations with particular reference to bringing a new product or service off the drawing board, through virtual development, and into a modern pre-sales promotional environment in weekly project deliverables. Prerequisite: Upper division standing in engineering.

EMGT 142L. Design and Innovation Lab. 1 Unit.
The laboratory component of EMGT 142, course provides the basics of Industrial Design techniques including drawing, graphical, presentation and design communication skills. Students learn how to design functional objects, sculpture and use a variety of 2D and 3D applications to produce those models as physical objects. A variety of rapid prototyping methods include: 3D Printing, Vacuum Forming, and Laser Cutting is used in weekly project deliverables. Prerequisite: Upper division. Corequisite: EMGT 142.

EMGT 145. Product Design & Additive Manufacturing. 3 Units.
In this course students learn the scientific principles of additive manufacturing (AM). The course covers, how to design and prototype to meet a specific need. Next, explore how AM can apply to the identified opportunity, from product planning and modeling to development and evolution. Prerequisites: Junior Standing, MECH 015 or CIVL 015.

EMGT 155. Computer Simulation. 4 Units.
This course explores digital simulation in which a model of a system is implemented and executed on a computer. The course focuses on modeling methodologies, mathematical techniques for implementing models, and statistical tecniques for analyzing the results of simulations. Students develop simulations that use both simulation development toolkits and general-purpose programming languages. Also listed as COMP 155. Prerequisites: Completion of all Fundamental Skills; MATH 037 or MATH 039; MATH 045 or MATH 051, COMP 051 or COMP 061 or ENGR 019 with a "C-" or better.

EMGT 162. Introduction to Data Analytics for Engineers and Computer Scientists. 3 Units.
This course introduces students to state-of-the-art topics involving large collection of data. Particular emphasis is made on data collection, data storage and processing, extracting structured data from unstructured data, analytics, visualization, and a number of specific applications. Students explore large amounts of complex, digital data and learn about the tools and skills they need to solve knowledge from voluminous data sets. Prerequisites: ENGR 019 or COMP 051; upper division standing.

EMGT 170. Project Decision Making. 4 Units.
Project decision-making based upon engineering economy studies. This area covers techniques for economic evaluation of alternatives including time value of money, risk costs, effects of inflation, compound interest calculation, minimum attractive rate of return, capital budgeting, break-even analysis, sensitivity analysis, and risk analysis. A second facet of the course covers the fundamental aspects of project management within an engineering context. This area covers the project procurement process, project management and project scheduling. (Summer, Fall).

EMGT 172. Engineering Economy. 3 Units.
This course examines decision-making based upon engineering economy studies. This course covers techniques for economic evaluation of alternatives that includes time, value of money, risk cost, effects of taxation, monetary inflation, compound interest calculations, minimum attractive rate of return, capitol budgeting, break-even analysis, sensitivity analysis and risk analysis. Prerequisite: Completion of all Fundamental Skills.

EMGT 174. Engineering Project Management. 3 Units.
Students study the fundamentals of project management that are used in estimating, planning, coordinating and controlling engineering projects. Topics include fundamentals of specifications and contracts, and the scheduling of projects. Prerequisites: Completion of all Fundamental Skills.

EMGT 176. Systems Engineering Management. 4 Units.
This course provides an introduction to the concepts and process of systems engineering. It uses interactive lectures, participatory class exercises and case studies to illustrate the framing and solution of problems through a systems engineering approach. The course stresses an understanding of the interdisciplinary aspects of systems development, operations and support. Prerequisites: Completion of all Fundamental Skills; MATH 055 with a “C-“ or better, or permission of instructor.

EMGT 191. Independent Study. 1-4 Units.
Special individual projects are undertaken under the direction of one or more faculty members knowledgeable in the particular field of study. Permission of faculty member involved. The student must be in good academic standing.

EMGT 192. Professional Practice. 8 Units.

EMGT 195. Engineering Management Synthesis. 4 Units.
The capstone course is for Engineering Management majors. Emphasis on integration and application of management concepts. including project proposal and design, with periodic reviews and written and oral reports. Prerequisites: Completion of all Fundamental Skills.

EMGT 197. Undergraduate Research. 1-4 Units.
This course offers applied or basic research in focused topics within Engineering Management under faculty supervision. Permission of faculty supervisor and department chair.

General Engineering Courses

ENGR 010. Dean's Seminar. 1 Unit.
This course is a survey of the profession and practice of engineering and computer science. It is an overview of the programs and methodologies of the School of Engineering and Computer Science that includes educational requirements, professional and career opportunities, introduction to the history of engineering and computing, and entrepreneurship. Hands-on activities and guest lecturers are included to complement the discussion sessions. The course provides basic skills, tools, and techniques applied to problem solving, teamwork and communication necessary for academic and professional success. Students are required to complete a design project, write a basic technical report and present their results.

ENGR 019. Computer Applications in Engineering. 3 Units.
This course introduces students to binary arithmetic,; numerical methods applicable to engineering problems and their solution that use a programming language and computation tools. Topics include root finding, solving systems of equations, curve fitting and interpolation, numerical integration and differentiation, and numerical solution of ordinary differential equations. Students develop programming skills in a high level language and learn to use mathematical computation tools including and spreadsheets. Prerequisite may be taken concurrently: MATH 053 with a "C-" or better.

ENGR 020. Engineering Mechanics I (Statics). 3 Units.
Students study the fundamental principles of static equilibrium that results from the application of forces on particles and bodies. Prerequisites: MATH 053 and PHYS 053 with a "C-" or better.

ENGR 025. Professional Practice Seminar. 1 Unit.
This course is designed to prepare students for the Cooperative Education experience. Presentations are from representatives of industry, government, education and former Co-op students. Topics include engineering ethics, professionalism, time management and mock interviewing.

ENGR 030. Engineering and Computing Ethics in Society. 3 Units.
Major engineering achievements are explored with an emphasis on ethical principles and the global impact these achievements have on society and the environment. Topics include societal needs, personal rights, whistle blowing, conflicts of interest, professional autonomy, risk assessment, sustainable development and the application of engineering codes of ethics. Contemporary technological controversies are examined along with future developments that require engineers to stay current in their field. Student participation is expected in classroom discussions, oral presentations, and written analyses. Prerequisite: Fundamental Writing Skills requirement. **(DVSY, GE2B, GEDI, GEWE)**

ENGR 040. Engineering Design thinking. 3 Units.
In this course students learn engineering innovation and entrepreneurship practices. Students experience driving a process or product to launch using design thinking and lean startup approaches. **(GEAP)**

ENGR 045. Materials Engineering. 3 Units.
Students examine the dependency of physical, chemical and mechanical properties on microscopic and macroscopic structure of materials. Laboratory experiments involve properties of materials such as metals, polymers, composites and ceramics. Prerequisites: AP CHEM with score of 4 or 5, CHEM IB Higher Level (score of 5, 6, or 7), CHEM 024, CHEM 025, or CHEM 027 and MATH 53 with a "C-" or better. Co-Requisite: ENGR045L.

ENGR 045L. Materials Engineering Lab. 1 Unit.
Experimental analysis of concepts are discussed in ENGR045. Prerequisites: AP CHEM with score of 4 or 5, CHEM IB Higher Level (score of 5,6, or 7), CHEM 024, CHEM 025, or CHEM 027 and Math 53 with a "C-" or better. Co-Requisite: ENGR045.

ENGR 093. Introduction to Engineering. 1 Unit.

ENGR 110. Instrumentation and Experimental Methods. 2 Units.
Students study experimental techniques in the measurement of quantities such as biopotentials, force, pressure, sound, flow, temperature, strain and motion. Topics include statistical analysis and errors in measurement,; data analysis and transmission. Students also use of instruments in the laboratory, and prepare a measurement project. Prerequisites: Completion of all Fundamental Skills; MATH 057; BENG 124 or ENGR 121 with a "C-" or better or permission of instructor. Co-Requisite: ENGR 110L.

ENGR 110L. Instrumentation and Experimental Methods Lab. 1 Unit.
Experimental analysis of concepts are discussed in ENGR 110. Prerequisites: Completion of all Fundamental Skills; MATH 057; BENG 124 or ENGR 121 with a "C-" or better or permission of instructor. Co-Requisite: ENGR 110.

ENGR 120. Engineering Mechanics II (Dynamics). 3 Units.
Students examine the fundamental principles of particles and bodies in motion under the action of external forces. Prerequisites: Completion of all Fundamental Skills and ENGR 020 with a "C-" or better.

ENGR 121. Mechanics of Materials. 3 Units.
Students study concepts of stress, strain and deformation, analysis and design of simple elements of structures and machines. Prerequisites: Completion of all Fundamental Skills and ENGR 020 with a "C-" or better. Prerequisite, may be taken concurrently: MATH 057 with a "C-" or better.

ENGR 122. Thermodynamics I. 4 Units.
Students examine the first and second laws of thermodynamics for open and closed systems. Topics include properties of gases and liquids, including entropy and availability. Students are also introduced to the Carnot and ideal Rankine cycles. Prerequisites: Completion of all Fundamental Skills; AP Chem with score of 4 or 5, CHEM IB Higher Level (score of 5, 6, or 7), CHEM 024 or CHEM 025 or CHEM 027 and PHYS 053 with a "C-" or better.

ENGR 150. Engineering and Science-Based Entrepreneurship. 4 Units.
Entrepreneurial businesses are increasingly based on new products, processes and services derived from the realms of engineering and/or science. In this hands-on course a multidisciplinary team of students will develop a business plan around a prototype for an original product or service created by students and/or faculty in engineering or the sciences. The plan will focus on the market, technical, operational, financial and organization/administrative dimensions of the business. Prerequisite: Senior standing.

ENGR 181. Professional Practice. 1-16 Units.
This course offers cooperative employment in a professional engineering environment. Students may register for a variable number of credits that depend upon the length of the work period. The course requires a satisfactory completion of the work assignment and a written report. Grading is on a Pass/Fail basis. Prerequisites: Completion of all Fundamental Skills.

ENGR 182. Professional Practice. 1-16 Units.
This course offers cooperative employment in a professional engineering environment. Students may register for a variable number of credits that depend upon the length of the work period. The course requires a satisfactory completion of the work assignment and a written report. Grading is on a Pass/Fail basis. Prerequisites: Completion of all Fundamental Skills.

ENGR 183. Professional Practice. 1-16 Units.
This course offers cooperative employment in a professional engineering environment. Students may register for a variable number of credits that depend upon the length of the work period. The course requires a satisfactory completion of the work assignment and a written report. Grading is on a Pass/Fail basis. Prerequisites: Completion of all Fundamental Skills.

ENGR 184. Professional Practice. 1-18 Units.
This course offers cooperative employment in a professional engineering environment. Students may register for a variable number of credits that depend upon the length of the work period. The course requires a satisfactory completion of the work assignment and a written report. Grading is on a Pass/Fail basis. Prerequisites: Completion of all Fundamental Skills.

ENGR 185. Professional Practice. 1-18 Units.
This course offers cooperative employment in a professional engineering environment. Students may register for a variable number of credits that depend upon the length of the work period. The course requires a satisfactory completion of the work assignment and a written report. Grading is on a Pass/Fail basis. Prerequisites: Completion of all Fundamental Skills.

ENGR 191. Independent Study. 1-4 Units.

ENGR 192. Professional Practice. 8 Units.

ENGR 192P. Engineering Co-Op Placeholder. 12 Units.

ENGR 197. Undergraduate Research. 1-4 Units.

Engineering Physics Courses

EPHY 133. Solid State Devices. 4 Units.
This course introduces concepts related to the crystal structure of semiconductors and electronic, optical, and magnetic properties of semiconductors. Dynamics of carriers under equilibrium and non-equilibrium conditions are presented as a frame work for understanding the behavior of a number of devices including Metal-Oxide-Semiconductor (MOS) and Hetero-junction Bipolar (HBT) devices. On such a background, the course builds an understanding of the latest advances in the field including quantum and nano devices. This course is cross listed with ECPE 133 and PHYS 170. Pre-requisites: PHYS 055 with a “C-“ or better. Prerequisite that may be taken concurrently: MATH 057 with a “C-“ or better.

EPHY 144. Applied Electromagnetics. 4 Units.
The purpose of this course is for students to gain an understanding of transmission lines and field theory as it applies to communication circuits and systems. Electromagnetic wave propagation, reflection, and transmission through common materials are examined. This course is cross listed with ECPE 144. Prerequisites: MATH 057; PHYS 055 with a "C-" or better.

EPHY 195. Senior Project I. 2 Units.
This course instructs students in the application of design processes and teamwork. Topics include multiple interdisciplinary team design experiences of increasing complexity. Projects incorporate consideration of engineering standards and realistic constraints such as economics, the environment, sustainability, manufacturability, and safety. Students are given instruction and practice in documentation and as well as oral and written communication skills. This course is cross listed with ECPE 195. Prerequisites: Completion of all Fundamental Skills; ECPE 131 with a "C-" or better.

EPHY 196. Senior Project II. 2 Units.
This capstone design course integrates earlier studies, including EPHY 195, to perform interdisciplinary team design projects. Student design teams define a requirements document, a test document, and a design document for a prescribed product, then design, build and test a prototype. Complete documentation is expected. Final oral and written reports and project demonstrations are required. This course is cross listed with ECPE 196. Prerequisites: EPHY 195 or ECPE 195 with a "C-" or better.

Interd Design Entrep Courses

IDEA 010. Interdisciplinary Design and Success. 2 Units.
The first course in the Interdisciplinary Design and Entrepreneurship in Action (IDEA) series that aims at providing students with a unified cohort experience and skills for college success. The students are exposed to various SOECS disciplines via multidisciplinary design projects where they apply computational and mathematical concepts for problem solving. Students actively participate in their curriculum planning, explore techniques for college and career success, and implement strategies for continuous improvement.

IDEA 020. Interdisciplinary Design and Innovation. 2 Units.
The second course in the Interdisciplinary Design and Entrepreneurship in Action (IDEA) series aims at providing students with a unified cohort experience and skills for college and professional success. The students delve into engineering and computer science disciplines via multidisciplinary design projects where they apply engineering design processes, mathematical modeling, and engineering/computational tools to address real-life problems. Throughout the course, students reflect on their skills, abilities, interests, and opportunities for growth and how those align with their chosen major. Prerequisites: IDEA 010 with a "D" or better.

IDEA 040. Engineering Design Thinking. 3 Units.
In this course students learn engineering innovation and entrepreneurship practices. Students experience driving a process or product to launch using design thinking and lean startup approaches. Prerequisites: Sophomore standing. **(GEAP)**

IDEA 130. Introduction to Mobile Robotics. 4 Units.
This course is an overview of mobile robotics and introduces fundamentals of robot modeling and design of wheeled mobile robots including locomotion and kinematics with constraints. It includes several examples of robot sensing such as ultrasonic, IR, Lidar, IMU, or vision sensors. Includes laboratory. The lab provides students relevant experiential learning to strengthen theoretical aspects of robotics and robotics-related algorithms such as line tracking, obstacle avoidance, object following, distance control with encoders, basic analog/digital circuits, electronics, microcontrollers, motor controls, and robot programming. Prerequisites: Completion of all Fundamental Skills; COMP 053 or ENGR 019 with a "C-" or better.

IDEA 131. Autonomous Mobile Robotics. 4 Units.
This course emphasizes the design of autonomous robots. Students study architectures for robot organization and mechanisms for mobile robots, actuators, sensors to develop localization, perception, cognition, mapping, navigation, and control utilizing sensing technologies. The course covers multi-agent systems, human-robots interaction, and heterogeneous systems including ground robots and drones. Students also study the design of algorithms, knowledge representations, and decision-making with a single board computer. Includes laboratory. The lab provides students relevant experiential learning to strengthen theoretical aspects of robotics and the development of algorithms. Prerequisites: Completion of all Fundamental Skills; IDEA 130 with a "C-" or better or Junior or Senior standing with COMP 53 or ENGR 019 with a "C-" or better.

IDEA 132. Robotics, Telematics and AI Seminar. 1 Unit.
This interdisciplinary seminar is open to undergraduate and graduate students, especially students majoring in engineering and computer science. The course studies current research in the areas of robotics, telematics (data acquisition, tracking, communications, and informatics), and artificial intelligence in a seminar format led by both the instructor and students. Prerequisites: Completion of all Fundamental Skills; COMP 053 or ENGR 019 with a "C-" or better.

IDEA 193. Special Topics. 1-4 Units.

IDEA 197. Undergraduate Research. 1-4 Units.

Mechanical Engineering Courses

MECH 010. Introduction to Mechanical Engineering. 3 Units.
Students will be introduced to the many subdisciplines of Mechanical Engineering, future career paths, and what essential skill sets are needed for each subdiscipline. Students will learn how to work collaboratively and equitably in diverse groups. The ethics of working in groups in a mechanical engineering context will be discussed as students learn how to perform experimentation, technical writing skills, data analysis, statistics, and are trained on common instrumentation/apparatuses used by Mechanical Engineers.

MECH 015. Mechanical Engineering Graphics. 3 Units.
This course covers the principles and applications of graphics in engineering design. Topics include pictorial and isometric sketching and orthographic projection, the use of auxiliary views and sections, drafting standards and conventions, dimensioning and tolerances, in addition to layout and assembly drawings, detail drawings and production drawings with SolidWorks.

MECH 100. Manufacturing Processes. 3 Units.
This course is a study of traditional manufacturing processes such as formatting, cutting, joining, casting, and heat treating as well as advanced processing methods; manufacturing with polymers, composites, and ceramics in addition to metals, tribology, nondestructive evaluation, and quality control. Laboratory projects involve manufacturing skills, reverse engineering, automated machines, geometric dimensioning and tolerancing, and statistical process control. Prerequisites: Completion of all Fundamental Skills; MECH 015; and ENGR 045 or PDEP 046 with a "C-" or better. Corequisite: MECH 100L.

MECH 100L. Manufacturing Process Lab. 1 Unit.
Experimental analysis of concepts are discussed in MECH 100. Prerequisites: Completion of all Fundamental Skills; MECH 015; and ENGR 045 or PDEP 046 with a "C-" or better.

MECH 104. Introduction to Mechatronics. 3 Units.
A broad understanding of the main components of mechatronic systems; Understanding of the general principles involved in computer controlled machinery, including sensing, actuation and control; Practical knowledge of the development of simple embedded computer programs; Understanding of the practical application of mechatronic systems in applications such as manufacturing, automobile systems and robotics. Prerequisites: Completion of all Fundamental Skills and ENGR 019 with a "C-" or better.

MECH 120. Machine Design and Analysis I. 4 Units.
This course builds on fundamental principles learned in statistics, dynamics, and mechanics of materials, and applies them to the design and analysis of machines. Methods for performing load and stress analysis are learned along with analytical methods for solving deflection and stability problems. Static, impact, and fatigue failure theories for machines are also studied. Statistical methods for solving machine design problems are presented, and engineering design practices are integrated throughout the course. Prerequisites: Completion of all Fundamental Skills; ENGR 045, ENGR 120, ENGR 121; MECH 015 with a "C-" or better.

MECH 123. Kinematics and Dynamics of Machinery. 3 Units.
Students learn how to design, analyze and prepare a simulation of complex mechanisms with emphasis on high speed and precision applications. Topics include kinematics and dynamics of planar and three dimensional mechanisms; gyroscopic forces in machines and balancing, and applications to robotics. Prerequisites: Completion of all Fundamental Skills; ENGR 120 and ENGR 121 with a "C-" or better.

MECH 125. Machine Design and Analysis II. 3 Units.
Students learn how to design, analyze, and incorporate a variety of standard parts and devices into machines. These parts and devices include fasteners, gear systems, belt drives, chain drives, shafts, couplings, bearings, springs, clutches, and brakes. Principles of tribology (friction, wear, and lubrication) are introduced and applied to the design of machines. Engineering design practices are integrated throughout the course. Prerequisites: Completion of all Fundamental Skills and MECH 120 with a "C-" or better.

MECH 129. Vibrations. 4 Units.
Students study models of physical systems with lumped and distributed parameters. The studies include free and forced vibrations of machines and structures as well as excitation and response of single degree of freedom systems. The course introduces multiple degrees of freedom systems, finite element formulations and mode superposition techniques. Prerequisites: ENGR120, MATH 057, ENGR 019 with a "C-" or better.

MECH 140. Engineering Design/Senior Project I. 4 Units.
This course discusses methods of initiating, planning, conceptualizing, and configuring engineering designs. The student uses these methods to develop an engineering design for a product or process that involves mechanical engineering. Product realization methods, project management, materials selection, design thinking, rapid prototyping, manufacturing for designers, guided iteration, communication skills, economics, ethics, liability, and safety issues are put into practice through class activities. Prerequisites: Completion of all Fundamental Skills; ENGR 122 with a "C-" or better; and Prerequisite that may be taken concurrently: MECH 120 or MECH 150 with a "C-" or better.

MECH 141. Engineering Design/Senior Project II. 4 Units.
The student completes the design phase of their project. Guided iteration and optimization are used to complete the detailed design of a product or process involving mechanical engineering. Manufacturing and rapid prototyping are used to complete the fabrication of a product or process. Failure modes and effects analysis, safety, and liability are considered. Regular oral and written progress reports are required along with final comprehensive oral and written reports. Prerequisites: Completion of all Fundamental Skills; MECH 100 and MECH 140 with a "C-" or better.

MECH 150. Heat Transfer. 3 Units.
Students study heat transfer by conduction in one, two and three dimensions in transient and steady state and heat transfer in extended surfaces. Topics include solutions by numerical methods and simulation techniques, convection in external and internal flow, free convection, and radiation. Prerequisites: Completion of all Fundamental Skills; ENGR 122 and MATH 057 with a "C-" or better.

MECH 151. Applied Heat Transfer. 3 Units.
Applications and extensions of the topics in MECH 150. Multimode heat transfer; heat exchangers. Heat transfer with phase change. Prerequisites: Completion of all Fundamental Skills and MECH 150 with a "C-" or better.

MECH 155. Solar Energy Engineering. 3 Units.
This course introduces students to solar energy, sun-earth geometry, radiation measurement, insulation on surfaces, principles of solar collectors, applications such as space heating and solar ovens, and photovoltaics. Laboratory experiments are included. Prerequisites: Completion of all Fundamental Skills and ENGR 122 with a "C-" or better.

MECH 157. Thermodynamics II. 3 Units.
Students examine the thermodynamics of cycles for power and refrigeration. Other topics include the thermodynamics of gas mixtures, chemical reactions, chemical equilibrium, combustion, fuels, and processes involving air and water mixtures relating to heating, cooling, and ventilating for human comfort. The course includes experimental activities and written laboratory reports. Prerequisites: Completion of all Fundamental Skills and ENGR 122 with a "C-" or better.

MECH 158. Air Conditioning. 3 Units.
Students are introduced to air conditioning purpose, terminology and typical systems. Students study the analysis and design of air conditioning as applied to residential and small commercial buildings, and they learn the codes and standards applicable to this field. Prerequisites: Completion of all Fundamental Skills; ENGR 122 with a "C-" or better.

MECH 160. Fluid Dynamics. 3 Units.
Students study equations of continuity, energy, and momentum as applied to fluid flow. Topics include one dimensional compressible flow, and the introduction to more advanced topics, such as turbomachinery, viscous flow and potential flow. Prerequisites: Completion of all Fundamental Skills; CIVL 130 and ENGR 122 with a "C-" or better.

MECH 175. Systems Analysis and Control. 3 Units.
Students study dynamic analysis and control of systems composed of mechanical, electrical, hydraulic and thermal components. Students use of system modeling and simulation techniques to predict transient and steady state response, lumped parameter approximations and linearization. Students also use feedback to enhance system performance and stability and they study design of linear control systems in the time and frequency domains. Prerequisites: Completion of all Fundamental Skills; ECPE 041, ECPE 041L, MECH 129 with a “C-“ or better.

MECH 178. Finite Element Methods. 3 Units.
This course introduces the finite element method for engineering problems. Topics include matrix formulation of finite element models for problems in solid mechanics, heat transfer and fluid flow as well as solution of finite element equilibrium equations. Students study the development of computer algorithms and applications that use commercial finite element computer programs. Some familiarity with matrix methods is desirable. Prerequisites: Completion of all Fundamental Skills; ENGR 121 and ENGR 122 with a "C-" or better. Prerequisite, may be taken concurrently: CIVL 130 with a "C-" or better.

MECH 191. Independent Study. 1-4 Units.
Special individual projects are undertaken under the direction of one or more faculty members knowledgeable in the particular field of study. Permission of department chairperson and faculty members involved.

MECH 197. Undergraduate Research. 1-4 Units.
This course includes applied or basic research in mechanical engineering under faculty supervision. Projects may be experimental, mathematical or computational in nature. Permission of faculty supervisor and department chairperson. Student must be in good academic standing.