General Information

An engineering degree provides an excellent background for seeking solutions to many of the problems in the development and management of technology related to urban demands, the enhancement of our living environment, and the effective utilization of our nonrenewable resources. Engineering curricula include both general and theoretical course work designed to enable graduates to meet the challenges of a technology-oriented society. In addition to classic disciplines of engineering, students may also delve into the fundamentals of sustainability, nanotechnology, microscopic simulation, and other state-of-the-art subjects. College curricula encourage the independent study of novel engineering processes. Particular emphasis is placed on problems related to energy and the preservation and enhancement of the environment.

Engineering has been a major program of study at this institution since its founding in 1907. UH Mānoa has granted more than 6,500 engineering degrees, and many of the professional engineers practicing in industry, consulting firms, and governmental agencies throughout the state are graduates of UH Mānoa.

Accreditation

The undergraduate curricula in civil, electrical, and mechanical engineering are accredited by the Engineering Accreditation Commission of ABET, Inc.

Degrees and Certificates

Bachelor’s Degrees: BS in civil engineering, BS in computer engineering, BS in electrical engineering, BS in mechanical engineering

Master’s Degrees: MS in civil engineering, MS in electrical engineering, MS in mechanical engineering

Doctoral Degrees: PhD in civil engineering, PhD in electrical engineering, PhD in mechanical engineering

For information on programs in biological engineering, refer to the “College of Tropical Agriculture and Human Resources” section of the Catalog. For information on programs in ocean and resources engineering, refer to the “School of Ocean and Earth Science and Technology” section of the Catalog.

Advising

Student Services
Holmes 250
2540 Dole Street
Honolulu, HI 96822
Tel: (808) 956-8404

All students in the College of Engineering must receive approval of their program of courses from their advisors prior to registration each semester.

Updated curriculum check sheets summarizing all of the requirements for each undergraduate curriculum are available online at: www.eng.hawaii.edu/current-students/undergraduate-students/curricula-check-sheets/check-sheets.

Undergraduate engineering students who are well-qualified academically are encouraged to participate in the UH Mānoa Honors Programs (see the “Special Programs” section within the Colleges of Arts and Sciences).

New Students

An orientation session for new students is held each semester before classes begin. Incoming students receive approval of their program of courses at that time. In addition, incoming students with waived course work (e.g., advanced placement examination) must still fulfill credit hour requirements and should contact the College’s Student Academic Services Office in Holmes 250 for more information.
Undergraduate Programs

Each of the curricula offered by the College of Engineering provides a fundamental science-oriented university education with coverage of communications, the humanities, and social sciences, as well as the basic physical sciences of mathematics, physics, and chemistry. The curricula also encompass engineering sciences common to all engineering disciplines and project courses that introduce the engineering method of design.

Admission Requirements

Requirements for admission to UH Mānoa are described in the “Undergraduate Education” section of the Catalog. High school students applying to the College of Engineering should have completed trigonometry, physics, and chemistry. The college also uses aptitude tests and high school records in its screening procedure.

Transfer students must have completed ENG 100, MATH 241 and 242, PHYS 170/170L, and CHEM 161/161L and 162 or their equivalents, and have an overall cumulative GPA of 3.0 or higher.

Students who do not meet entry requirements may enroll in Pre-engineering in Arts and Sciences and transfer into an engineering major at a later time. Pre-engineering students are advised by the College of Engineering and may enroll in lower division engineering courses with no additional approvals needed.

College Requirements

Course work in each curriculum consists of a set of required courses common to all engineering majors and additional courses to satisfy departmental requirements. The courses required of all engineering students, which also satisfies the General Education Core Requirements of UH Mānoa, consist of the following 51 credits:

Written Communication
- ENG 100 Composition I (3) (FW) or approved FW course

Arts, Humanities and Literature
- COMG 251 Principles of Effective Public Speaking (3) (DA)
- One elective (3) (DH or DL)

Social Sciences
- ECON 120 Introduction to Economics (3), ECON 130 Principles of Microeconomics (3), or ECON 131 Principles of Macroeconomics (3) (DS)
- One elective (3) (DS)

Global and Multicultural Perspectives
- Two approved FG electives (6)

Symbolic
- MATH 241 Calculus I (4) (FS)
- MATH 242 Calculus II (4)
- MATH 243 Calculus III (3)
- MATH 244 Calculus IV (3)

Natural Sciences
- CHEM 161/161L and 162 General Chemistry/Lab (3/1/3) (DP/DY)
- PHYS 170/170L General Physics I/Lab (4/1) (DP/DY)
- PHYS 272/272L General Physics II/Lab (3/1) (DP/DY)

In addition, a student must complete the Focus Graduation Requirements, 1H, 1E, 1O, and 5W courses. The Hawaiian or Second Language is not required for the engineering degree.

BS Degree Requirements

The undergraduate curricula are designed to be completed in eight semesters.

To receive a bachelor of science degree in engineering, a student must adhere to the following:
1. Complete the course work for one of the engineering curricula, which also satisfies all UH Mānoa requirements;
2. Maintain a minimum GPA of 2.0 for all registered credit hours; and
3. Maintain a minimum GPA of 2.0 for all upper division courses (numbered 300-499) in mathematics, science, and engineering.

Major Requirements

See appropriate departments for specific major requirements leading to a bachelor’s degree.

Other Requirements

Undergraduate engineering students are subject to the policies of academic probation, suspension, and dismissal of UH Mānoa as specified in the Catalog. In addition, engineering students with either a cumulative GPA of less than 2.0 or an upper division GPA of less than 2.0 may be placed on academic probation. The student must maintain a semester GPA of 2.0 or higher for each probationary semester. Failure to meet any of the above conditions may result in suspension or dismissal. Engineering undergraduates may also be suspended when they fail to achieve a cumulative GPA of at least 1.7 after attempting 24 credit hours.

Students who are suspended must reapply for admission to the Office of Admissions within specified deadlines. Students who do not take courses after being suspended for the required one semester are eligible to be readmitted to the College of the Engineering. Suspended students who attend another institution (including other UH system campuses) will be considered “transfer” students when reapplying to UH Mānoa and must meet the transfer requirements of the College of Engineering.

Graduate Programs

See appropriate department for specific description and requirements.
Student Organizations

Student chapters of professional engineering societies are active at the college, and all students are encouraged to participate. Honorary societies are represented in all three departments.

Honors and Awards

The College of Engineering and its departments provide scholarships and awards to exceptional students. For a list of these scholarships, see the “Tuition, Fees, and Financial Aid” section of this Catalog or at www.eng.hawaii.edu/prospective-students/financial-aid-and-scholarships/.

Programs

Hawaiʻi Center for Advanced Communications

The Hawaiʻi Center for Advanced Communications (HCAC) is a multidisciplinary research center established by the legislature and approved by the Board of Regents in 2000. Currently, with federal, state, and private funding, HCAC continues on its mission to be the leading center for innovative research in the broader areas of wireless communication and radar technologies with joint research and educational activities that promote national and international collaboration and partnership with industry. The center has tenured faculty, several full-time collaboration and partnership with industry. The center has tenured faculty, several full-time researchers, and graduate students working towards their MS and/or PhD degrees in Electrical Engineering.

Research activities in the center are funded by federal agencies including the National Science Foundation (NSF), Army Research Office, Office of Naval Research, Army CERDEC, as well as by large umbers of corporate sponsors including Agilent Technologies, BAE, L-3, Motorola, and Raytheon.

Faculty in the center have been recognized with several national and international awards including the 2012 IEEE AP-S Distinguished Educator Award, 2013 IEEE MTT-S Distinguished Educator Award, and both the UH Regents Medal for Excellence in Research and the UH Regents Medal for Excellence in Teaching.

National and International Collaboration: The center is a member of the NSF Industry/University Cooperative Research Center (I/U CRC), and has international partnership agreements with The State Key Lab on Microwave & Digital Communications, Tsinghua University, China; The Centre National De La Recherche Scientifique, University of Nice-Sophia Antipolis, France; Communication Research Center, Yuan Ze University, Taiwan; and Department of Signal Theory and Communications, Universitat Politècnica de Catalunya, Barcelona, Spain.

Research Areas: Research areas include advanced multifunction and ultra wideband antenna designs, propagation modeling and characterization of wireless communication channels, digital signal processing (DSP) for smart antennas, Ground Penetrating Radar technologies for UXO and IED detection and classification, microwave methods for biomedical applications (in collaboration with JABSOM), and the development of Radio Frequency tunable devices for reconfigurable antennas cognitive radio, and solar energy harvesting applications. Recent research projects include microwave stethoscope for vital signs monitoring and measuring changes in lung water content, the development of antennas for directional networks, use of Genetic Programming for the design of ultra wideband metamaterials, and the development of textile antennas for medical and military applications.

STEM Outreach: HCAC has received significant grants from the State of Hawaiʻi, National Science Foundation, and corporate sponsors to launch its STEM outreach program for middle schools in Hawaiʻi (Research Experience for Teachers, RET).

Laboratory Facilities: HCAC has developed four state-of-the-art laboratories to support the ongoing research activities. This includes an indoor antenna range, a wireless communications testbed, microwave measurements lab, and the RF devices fabrication and characterization lab.

For graduate studies, all students/applicants need to fulfill the requirements of the Graduate Division, manoa.hawaii.edu/graduate/, as well as those of the Electrical Engineering Department. For availability of research opportunities, visiting scholar and graduate fellowships at HCAC, contact Teri Imanaka at imanaka@hawaii.edu.

Hawaiʻi Space Flight Laboratory

The Hawaiʻi Space Flight Laboratory (HSFL) was established in 2007 as a multidisciplinary research and education activity bringing together individuals from diverse areas to explore, study, and advance the understanding of the space environment. Among HSFL’s goals are to provide the infrastructure for collaborative space and science research, encourage entrepreneurship and industrial relations, and provide students with a rich and exciting education for careers in space science and engineering.

Hawaiʻi is located in a unique location to become a low-cost gateway to space and positions UH Mānoa as the only university in the world to have both satellite fabrication capabilities and unique, direct access to orbital space. This will enable many experiments that study the earth’s oceans and continents, as well as test numerous engineering experiments in the hostile environment of space. The HSFL expands the Small-Satellite Program established at UH Mānoa, College of Engineering in 2001 by merging research interests in both the College of Engineering and the School of Ocean and Earth Sciences and Technology.
Civil and Environmental Engineering

Holmes 383
2540 Dole Street
Honolulu, HI 96822
Tel: (808) 956-7550
Fax: (808) 956-5014
Web: www.cee.hawaii.edu

Faculty
*C. S. Papacostas, PhD (Chair)—transportation, systems engineering
*A. R. Archilla, PhD—transportation and infrastructure systems engineering
*R. W. Babcock, PhD—environmental engineering
*S. Bateni, PhD—hydraulics
*H. Brandes, PhD—geotechnical engineering
*O. P. Francis, PhD—coastal engineering and sustainable infrastructure; design, observations, numerical methods
*G. Johnson, PhD—structural engineering
*A. S. Kim, PhD—environmental engineering and physics, parallel computing
*D. Ma, PhD—structures
*P. G. Nicholson, PhD—geotechnical engineering
*P. Ooi, PhD—geotechnical engineering
*P. D. Prevedouros, PhD—transportation engineering
*C. Ray, PhD—groundwater hydrology, water quality and environmental engineering
*H. R. Riggs, PhD—structural engineering, numerical methods
*I. N. Robertson, PhD—structures, earthquake engineering
*L. Shen, PhD—structural engineering
*A. Singh, PhD—construction and cost engineering, project management, quality control, construction safety, housing, coastal protection, energy analysis
*M. H. Teng, PhD—hydrodynamics, coastal and hydraulic engineering
*T. Yan, PhD—environmental engineering, environmental microbiology

Adjunct Faculty
A. A. Yee, MS—structural engineering
G. Fischer, PhD—structural engineering

Cooperating Graduate Faculty
A. I. El-Kadi, PhD—groundwater hydrology
R. C. Ertekin, PhD—naval architecture, offshore engineering, hydrodynamics, computational methods
A. Fares, PhD—tropical soil, watershed hydrology
W. W. W. Su, PhD—biochemical engineering, plant cell culture, molecular biotechnology

Degrees Offered: BS in civil engineering, MS in civil engineering, PhD in civil engineering

The Academic Program

Civil engineering is concerned with the activities of people and the environment. The civil engineer conceives, plans, designs, constructs, operates, and maintains the physical works necessary for the environmental needs of people. Students who enter the program today can look forward to one of the most rewarding careers open to men and women—rewarding in personal fulfillment, enduring service to humankind, and financial reward. The curriculum is uniquely designed to meet the demands of business, industry, and government.

The mission of the Department of Civil and Environmental Engineering is to 1) educate civil engineers that meet the requirements of the profession, committed to life-long learning, and have the potential to be the future leaders of the profession; 2) create, develop, and disseminate new knowledge through high quality, innovative research; 3) provide service to various agencies of the state and counties of Hawai‘i and the engineering community; and 4) provide leadership to the civil engineering profession in the Asia/Pacific Region.

Undergraduate Study

Bachelor’s Degree

The department’s educational objective is to produce graduates who in the first few years following graduation will:
1. Possess technical and non-technical knowledge/skills that will contribute to personal and employer success and benefit the communities they serve;
2. Adhere to accepted professional ethical standards;
3. Practice civil engineering in one or more of the following areas: construction, environmental, geotechnical, hydraulics/hydrology, structural, transportation;
4. Accept responsibility as engineers in the private and public sectors in Hawai‘i, the Asia-Pacific region, and elsewhere.

The BS degree requires completion of at least 125 credit hours of course work, the equivalent of four years of full-time work. These requirements include 65 credit hours of civil and environmental engineering courses from the following areas: applied mechanics, structural analysis and design, hydraulics, transportation, construction, soil mechanics, hydrology, water resources, and environmental engineering. There are additional required courses in mathematics, physics, and chemistry, as well as courses required by UH Mānoa in humanities and social sciences. The curriculum provides a broad-based background of fundamentals with coverage of the humanities and social sciences, basic sciences, mathematics, and the engineering design method. Course enrollment for all CEE majors is subject to the approval of an advisor. The requirements are described below and reflected on the check sheet and the list of course prerequisites.

All electives are subject to the approval of the instructor.

The student learning outcomes (SLOs), also known as program outcomes, describe a skill set that students are expected to have at the time of graduation. The SLOs are:

a. An ability to apply knowledge of mathematics, science, and engineering;
b. An ability to design and conduct experiments, as well as to analyze and interpret data;
c. An ability to design a system, component, or process to meet desired needs;
d. An ability to function on multi-disciplinary teams;
e. An ability to identify, formulate, and solve engineering problems;
f. An understanding of professional and ethical responsibility;
g. An ability to communicate effectively;
h. A broad education necessary to understand the impact of engineering solutions in a global, societal, and environmental context;
i. A recognition of the need for, and an ability to engage in, life-long learning;
j. A knowledge of contemporary issues; and
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice, particularly recognizing the integral role of computers in engineering and the rapid expansion of resources on the internet.
**College Requirements**

Students must complete the College Requirement courses for engineering (see "Undergraduate Programs" in this section).

**Departmental Requirements**

Students must complete the following courses as well as one course in engineering math and two technical electives, (specific options are provided on the curriculum check sheet):
- EE 160 or ICS 111
- CEE 270 Applied Mechanics I (3)
- CEE 271 Applied Mechanics II (3)
- CEE 305 Applied Probability and Statistics (3)
- CEE 320 Fluid Mechanics Fundamentals (4)
- CEE 330 Environmental Engineering (4)
- CEE 355 Geotechnical Engineering I (4)
- CEE 361 Fundamentals of Transportation (3)
- CEE 370/370L Mechanics of Materials and Lab (3/1)
- CEE 375 Construction Materials (3)
- CEE 381 Structural Analysis (3)
- CEE 421 Engineering Hydraulics (3) and 431 Water & Wastewater Engineering (3)
- CEE 455 Geotechnical Engineering II (3)
- CEE 461 Pavement Engineering (3) or 462 Traffic Engineering (3) or 464 Urban and Regional Transportation Planning (3)
- CEE 471 Construction Methods (3) or 472 Construction Management (3) and 485 Reinforced Concrete Design (4) or 486 Structural Steel Design (3))
- CEE 489B Surveying and AutoCAD (2)
- CEE 489C Professional Ethics (1)
- CEE 490 Senior Design Project (3)
- ME 403, GG 312 or MATH 302 or 307

Other important requirement:
1. C grade or better (C-minus is not acceptable) is required for CEE 270.

For information on a Bachelor Degree Program Sheet, go to www.manoa.hawaii.edu/ovca/programsheets/.

**Specialty Tracks**

Students who want to pursue a structures track should refer to the curriculum check sheet for alternative senior year course work.

**Graduate Study**

**Master’s Degree**

The department offers a graduate program leading to the MS degree in civil engineering with several areas of concentration under Plan A (thesis) or Plan B (non-thesis). Close cooperation is maintained with other departments and the Water Resources Research Center. Details and requirements of each plan may be obtained from the department office or on the web.

Applicants must present a BS in civil engineering or the equivalent as determined by the application review committee (and/or may be required to fulfill deficiencies) and must submit a Statement of Objectives form and evidence of passing the FE (Fundamentals of Engineering) exam or the results of the GRE General Test. If so required by the Graduate Division, applicants must supply the TOEFL score.

**Requirements**

Both Plan A and Plan B require a minimum of 30 credit hours, exclusive of seminars. Plan A includes 9 credit hours of thesis research and a minimum of 12 credit hours in graduate civil and environmental engineering courses, exclusive of thesis, seminar, and directed reading. Plan B includes a minimum of 18 credit hours of graduate civil and environmental engineering courses, exclusive of seminar and directed reading, as well as a technical report. Both plans require a minimum of 1 credit of seminar.

**Doctoral Degree**

Applicants to the PhD program must have fulfilled the requirements for the MS in civil engineering at UH Mānoa or its equivalent as determined by the application review committee. Those who have earned the MS at universities other than UH Mānoa must furnish the results of the GRE General Test or submit evidence of passing either the FE (Fundamentals of Engineering) or the EIT (Engineer-in-Training) or PE (Professional Engineer) exam. All applicants must furnish official transcripts of all previous undergraduate and graduate studies and three letters of reference clearly indicating that they are capable of completing a rigorous PhD program. Applicants must also supply a letter explaining in detail their career goals, specific area of concentration, work experience, and reasons for applying to the program. If so required by the Graduate Division, applicants must supply the TOEFL score.

**Requirements**

Candidates for a PhD are required to pass a qualifying examination consisting of oral and written components. The examination will be confined to basic topics in civil engineering. One purpose of the qualifying examination is to identify possible deficiencies in the student’s background with a view toward remedial measures. In addition, the examination serves as a means of assessing the student’s potential for doctoral studies.

Students attain the status of doctoral candidate only after passing the qualifying examination and submitting a dissertation proposal that receives the unanimous approval of the dissertation committee.

To earn a PhD in civil engineering, a student must satisfactorily complete a minimum of 50 credit hours in course work beyond the BS and a minimum of 1 credit hour in civil and environmental engineering graduate seminar as a PhD student. Students must also complete and successfully defend a satisfactory doctoral dissertation. Based on a written recommendation of the student’s dissertation committee and with the approval of the chair of graduate studies in civil engineering, students entering the PhD program may be granted an equivalence of up to 30 credit hours earned as part of the student’s master’s program. The 30 credit hour equivalents may include up to 9 credit hours for the previous MS thesis work but exclude graduate seminar credit hours taken as part of the MS program.

The courses that a student undertakes to fulfill the PhD credit hour requirements must be approved by the student’s dissertation committee. At least 27 credit hours must be from graduate-level civil engineering courses. The remaining courses may include graduate and 400-level courses offered by the civil and environmental engineering department or other appropriate departments of UH Mānoa.
**Comprehensive Examination**

Every PhD student must pass a comprehensive examination. The purpose of this examination is to ascertain the student’s advanced knowledge in the chosen specialty. Examinations are given when, in the judgment of the dissertation committee, the student has had sufficient preparation, but not sooner than six calendar months after the student has passed the qualifying examination.

Students pass the examination if no more than one committee member opposes such an action. Students who fail may, at the discretion of the graduate faculty, repeat the test once at least six months later. Students who fail the examination a second time are dropped from the program.

**Dissertation Defense**

PhD candidates are required to take a final oral examination in defense of their dissertation. The examination is conducted by the candidate’s dissertation committee. Students pass upon the favorable recommendation of the majority of the committee.

---

**Electrical Engineering**

Holmes 483  
2540 Dole Street  
Honolulu, HI 96822  
Tel: (808) 956-7586  
Fax: (808) 956-3427  
Email: eeoffice@hawaii.edu  
Web: www.ee.hawaii.edu

**Faculty**

*W. A. Shiroma, PhD (Chair)—electromagnetic theory, microwaves*  
*G. Arslan, PhD—distributed systems, Markov decision problems, nonlinear and robust control, game theory, learning and adaptive control*  
*O. Boric-Lubecke, PhD—RFICs for wireless communications, millimeter-wave and microwave devices, circuits and systems and biomedical applications*  
*P. E. Crouch, PhD (Dean)—nonlinear systems and control*  
*T. P. Dobry, PhD—digital systems, computers*  
*Y. Dong, PhD—computer networks and network security, distributed systems, computer architecture*  
*M. Fripp, PhD—power systems, smart grids, renewable energy*  
*N. T. Gaarder, PhD—communication theory, information theory*  
*D. Garmire, PhD—M/NEMS, CAD for M/NEMS, computer vision, computational biology*  
*A. Host-Madsen, PhD—communications signal processing, CDMA communications, multi-user communications, equalization*  
*M. Iskander, PhD (Director of HCAC)—computational electromagnetics, antennas, radar, and wireless communications*  
*A. Kavcic, PhD—communications, signal processing, information theory, magnetic recording*  
*A. Kuh, PhD—signal processing, machine learning, energy*  
*V. M. Lubecke, PhD—MEMS, microwave/terahertz radio, remote sensing technology and biomedical applications*  
*V. Malhotra, PhD—physical electronics, solid-state devices*  
*A. Ohta, PhD—devices, MEMS, biomedical microdevices, microfluidics*  
*T. R. Reed, PhD—signal and image processing, computer vision*  
*N. Santhanam, PhD—communications, signal processing, information theory, source coding*  
*G. H. Sasaki, PhD—computer communication networks, performance evaluation, optimization algorithms*  
*V. L. Syrmos, PhD—linear system theory, control theory*  
*J. R. Yee, PhD—computer communications networks, network optimization, stochastic models*  
*Z. Yan, PhD (HCAC)—wireless channel modeling, antennas and propagation*  
*R. Zhang, PhD—network and distributed system security and privacy*  
*X. Zhou, PhD—embedded systems computer architecture, hardware/software co-design and reconfigurable computing*

**Emeritus Faculty**

N. Abramson, PhD—wireless data networks  
J. W. Holm-Kennedy, PhD—applied physics, sensors, biomedical sensors, innovation, innovation training  
B. Kinarivala, PhD—computer engineering  
F. Koide, PhD—biomedical engineering, operational amplifiers, electronic circuits  
S. Lin, PhD—coding theory, coded modulation, multi-user communications and error coding techniques  
K. Najita, PhD—solid-state devices  
E. J. Weldon, PhD—computer networks  
D. Y. Y. Yun, PhD—computational intelligence, biomedical informatics, parallel and networked computing

**Adjunct Faculty**

D. Nakafuji, PhD—renewable energy, distribution systems, smart grid

**Cooperating Graduate Faculty**

W. L. Ditto, PhD—applied chaos theory  
T. Ernst, PhD—neuroscience, MRI research  
R. Rocheleau, PhD—photovoltaics, sensors, thin films  
L. R. Roose, JD—integration and analysis of energy technologies and power systems  
S. K. Sharma, PhD—thin films, amorphous materials and ceramics, instrumentation development  
V. A. Stenger, PhD—neuroscience, MRI research  
G. Varner, PhD—experimental particle physics, instrumentation electronics

**Degrees Offered:** BS in electrical engineering, BS in computer engineering, MS in electrical engineering, PhD in electrical engineering

**The Academic Program**

Electrical engineering and computer engineering are concerned with the exciting fields of electronics, computers, information technology, and the basic forms of energy that run our world. Electronics continue to bring forth new breakthroughs in solid-state technology (transistors, integrated circuits, VLSI chips, microprocessors, lasers, optical fibers), which in turn fuel the unprecedented revolution in telecommunications (World Wide Web, wireless, and digital signal processing), computers (neural network, distributed, and intelligent), instrumentation (biomedical, intelligent), and many other areas.

The undergraduate and graduate programs focus on three major areas: computers (architecture, algorithms, networking, hardware and software), electro-physics (solid-state devices and sensors, analog, circuit design, and microwaves and photonics), and systems (telecommunications, automatic controls, and signal processing).

The culmination of the undergraduate program is the capstone design project; this is a significant project that integrates the design content of previous courses while satisfying realistic constraints.
Mission Statement

The mission of the Department of Electrical Engineering is to provide quality education, research, and service to our constituents. Major goals of the department are to:
1. Educate a new generation of electrical and computer engineers to meet the challenges of the future;
2. Create, develop, and disseminate new knowledge;
3. Promote a sense of scholarship, leadership, and service among our graduates; and
4. Contribute to the development of diversity within the profession through the education of women, indigenous, and other minority students.

Undergraduate Study

Design Experience Statement

A key aspect of electrical engineering and computer engineering education is a significant and meaningful design experience that is integrated throughout the curriculum. The design experience is necessary to prepare students in becoming professionals.

At UH Mānoa, the electrical engineering and computer engineering curricula assign design credits to each course. A student graduating in electrical engineering or computer engineering is required to have a minimum of 14 design credits with 3 design credits coming from EE 496, the Capstone Design Project. Students can check their progress in obtaining design credits by checking with their advisor and looking at design credits and the Curriculum Flow Chart. EE 496 places significant design responsibility on the students as they must plan and execute a major design problem. To prepare students for EE 496, students must take at least 1 credit of EE 296 Sophomore Project, and 2 credits of EE 396 Junior Project. The project courses help students in getting design experience outside the classroom as they learn engineering concepts in the classroom. The project courses and capstone project give students opportunities to work in teams, develop leadership skills, and work on open-ended design projects similar to industrial experience.

Bachelor of Science Degrees

The bachelor of science degree program in electrical engineering and computer engineering requires a minimum of 122 credit hours. The departmental requirements consist of 48 credit hours of basic courses. The electrical engineering program requires 24 credit hours of technical electives. The computer engineering program requires an additional 17 credit hours of basic courses, and 6 credit hours of technical electives.

All electives are subject to the approval of an advisor. Enrollment in EE courses requires a grade of C- or better in all prerequisite courses.

College Requirements

Students must complete the college requirement courses for engineering (see “Undergraduate Programs” within this section).

Departmental Requirements

Electrical engineering and computer engineering students must complete the following 48 credit hours of courses:

- EE 160, 211, 213, 260, 315, 323/323L, 324, 342, 371, 495, Projects (296, 396, 496), PHYS 274, MATH 307, EB*
- EE 160 may be substituted with EE 110 for the electrical (but not computer) engineering program, in which case there are 47 credit hours.

*Engineering Breadth (EB) is satisfied by CEE 270, ME 311, or a CEE, ME, OE, or BE course that is at the 300 level or higher. It may also be satisfied by a physical, biological, or computer science course that is at the 300 level or higher and approved by the department’s undergraduate curriculum committee.

Projects

There is a requirement of EE 296, 396, and 496, which is the capstone design experience. A minimum of, respectively, 1, 2, and 3 credits are required of each.

Bachelor of Science in Electrical Engineering

Objectives

Program educational objectives for the electrical engineering program:

1. Electrical engineering graduates should be engaged in the practice of electrical engineering in industry, education, and public service.
2. Graduates should contribute to the technological and economic development of Hawai‘i, the U.S., and beyond.
3. Graduates should be prepared for admission to top graduate programs.
4. Graduates should be motivated toward and engaged in continuous professional development, through individual effort and advanced professional education.
5. Graduates should provide technical leadership, with an understanding of the broader ethical and societal impact of technological developments, and the importance of diversity in the workforce.

Outcomes

All graduates of the electrical engineering program are expected to have demonstrated:

1. An ability to apply knowledge of mathematics, science, and engineering. This includes probability and statistics, including applications appropriate to electrical engineering; mathematics through differential and integral calculus, and advanced mathematics, such as differential equations, linear algebra, complex variables, and discrete mathematics; sciences (defined as biological, chemical, or physical science); and engineering topics (including computing science) necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4. An ability to function on multidisciplinary teams.
5. An ability to identify, formulate, and solve engineering problems.
6. An understanding of professional and ethical responsibility.
7. An ability to communicate effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
9. A recognition of the need for, and an ability to engage in life-long learning.
10. A knowledge of contemporary issues.
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Electrical engineering students must complete a minimum of 24 credit hours of technical electives.

**Technical Electives**

A minimum of 17 credits is in one of the major tracks (electro-physics and systems), which includes all courses in Group I and the remaining courses from Group II.

A minimum of 7 additional credits is required from the following list, of which 3 credits must be from outside the major track, and 1 credit must be a laboratory.

**Electro-Physics Track:**

- **Group I:** EE 326/326L, 327, 372/372L
- **Group II:** EE 328/328L, 422/422L, 423, 425, 426, 427, 435, 438, 470, 471, 473, 474, 475, 477, 480

**Systems Track:**

- **Group I:** EE 343/343L, 351/351L, 415
- **Group II:** EE 344, 416, 417, 435, 442, 446, 449, 452, 453

The following Computer Engineering courses may also be used as technical electives: EE 205, 361/361L, 366, 367/367L, 406, 461, 467, 468, 469. EE 491 can also be used as a technical elective, but the track designation is determined on a case-by-case basis.

A student, along with a faculty member, may propose an alternate track. This alternate track must be (1) equivalent in rigor and breadth to the existing tracks, (2) endorsed by another faculty member, and (3) approved by the department’s undergraduate curriculum committee.

For information on a Bachelor Degree Program Sheet, go to www.manoa.hawaii.edu/ovcaa/programsheets/.

**Bachelor of Science in Computer Engineering**

**Objectives**

Program educational objectives for the computer engineering program:

1. Computer engineering graduates should be engaged in the practice of computer engineering in industry, education, and public service.
2. Graduates should contribute to the technological and economic development of Hawai‘i, the U.S., and beyond.
3. Graduates should be prepared for admission to top graduate programs.
4. Graduates should be motivated toward and engaged in continuous professional development, through individual effort and advanced professional education.
5. Graduates should provide technical leadership, with an understanding of the broader ethical and societal impact of technological developments, and the importance of diversity in the workforce.

**Outcomes**

All graduates of the computer engineering program are expected to have demonstrated:

1. An ability to apply knowledge of mathematics, science, and engineering. This includes probability and statistics, including applications appropriate to computer engineering; mathematics through differential and integral calculus, and advanced mathematics, such as differential equations, linear algebra, complex variables, and discrete mathematics; sciences (defined as biological, chemical, or physical science); and engineering topics (including computing science) necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4. An ability to function on multidisciplinary teams.
5. An ability to identify, formulate, and solve engineering problems.
6. An understanding of professional and ethical responsibility.
7. An ability to communicate effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
9. A recognition of the need for, and an ability to engage in life-long learning.
10. A knowledge of contemporary issues.
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Computer engineering students must complete the following 23 credit hours of courses:

- **ICS 141, EE 205, 361/361L, 367/367L, 468, 6 credits of technical electives**

The set of courses EE 160, 205, 367, and 367L may be substituted with the set of courses ICS 111, 211, and 212.

**Technical Electives**

A minimum of 6 credit hours of technical electives is required, from the following list of EE and ICS courses. One TE may be any other EE course at the 300 level or higher.

- EE 344 (or ICS 451), 366, 406, 449 (or ICS 451), EE 461 or (ICS 431), EE 467, 469, 491 (E, F, G), ICS 311, 313, 314, 321, 414, 415, 421, 424, 425, 432, 441, 442, 461, 464, 465, 466, 469, 481

Note that ICS courses from the list may have prerequisite courses that are not part of the computer engineering curriculum. These courses used as technical electives will lead to more credit hours to complete the program.

For information on a Bachelor Degree Program Sheet, go to www.manoa.hawaii.edu/ovcaa/programsheets/.

**Graduate Study**

**Outcomes**

The Department of Electrical Engineering adheres to the student learning outcomes of the Graduate Division:

“In general, a student who has successfully completed the graduate degree requirements should be able to

1. Demonstrate mastery of the methodology and techniques specific to the field of study.
2. Communicate both orally and in writing at a high level of proficiency in the field of study.
3. Conduct research or produce some other form of creative work.
4. Function as a professional in the discipline.”

**Master’s Degree**

Intended candidates for the MS degree in electrical engineering must present the BS degree in electrical engineering or its equivalent. Plan A (thesis) and Plan B (non-thesis) options are offered. However Plan B is only for Intern Plus Program students.

**Requirements**

**Plan A (thesis):** This program requires 30 credit hours in approved technical courses including one graduate seminar in electrical engineering or a related field. This plan requires 9 credit hours in EE 700 Thesis Research and a minimum of 12 credit hours in 600-level courses in a major track (computers, electro-physics, or systems), 6 credit hours in 400- or higher-level courses outside of the major track (engineering, mathematics, science), and 3 credit hours of electives in 400- and higher-level courses. A maximum of 6 credit hours in 400 level courses is allowed.

**Plan B (non-thesis):** A minimum of 30 credit hours is required with a grade of B or better (not B-minus). Students will be required to take at least 12 credits (600 level and above) in their major track, at least 6 credits (400 level and above) outside the major track, and 6 credits (600 level and above) as university-wide electives that are related to the student’s major track of study. A maximum of 6 credits will be counted towards EE 699. As part of the curriculum, attendance at 12 departmental or college seminars, or the equivalent is required. The final exam includes a written report and a seminar presentation (based on independent reading or research).

**Doctoral Degree**

Intended candidates for the PhD degree in electrical engineering must present the BS degree in electrical engineering or its equivalent. Applicants are encouraged to submit the GRE General Test scores. PhD students are required to achieve a good, broad understanding of electrical engineering fundamentals and a thorough knowledge, up to its present state, in a chosen speciality. Students must perform research in their special field under the guidance of a faculty advisor and present a dissertation that is an original contribution to electrical engineering. The dissertation must be a scholarly presentation suitable for publication.

**Requirements**

PhD students are required to specialize in a major track (computers, electro-physics, or systems) and show competence in a minor track. In addition to the MS course credit requirements, 9 credit hours of 600-level course work in the major track and 3 credit hours of 600-level course work in a minor track are required. All PhD students must also participate in a substantial teaching project and demonstrate competence in teaching.

**Qualifying Examination**

Intended candidates for the PhD degree register for three credits of a directed reading course under their advisor’s direction during their first semester in the PhD program. By the end of the following semester, the candidate takes an oral qualifying examination that tests the candidate’s research potential and knowledge of pertinent fundamentals. Three graduate faculty members form the examining committee; one member of the committee is the candidate’s advisor; the graduate committee selects the final two committee members. At least one of the committee members selected by the graduate committee must be from the student’s major track of specialization. At least two committee members must pass the intended candidate; else, the candidate repeats the exam by the end of his/her third semester in the program. A candidate who does not pass the qualifying exam by the end of the third semester is dropped from the PhD program.

The candidates starting in the fall semester can petition to take the qualifying exam by the end of their first summer semester. In unusual circumstances (including an advisor change), the candidates can petition to postpone their qualifying exams up to a semester.

The candidates are requested to complete and submit the EE PhD Qual form, which can be picked up from the EE office. Candidates who enter the PhD program in the fall semester are requested to submit the form by the following March 1; while candidates who enter the PhD program in the spring semester are requested to submit the form by the following October 1.

After passing the qualifying examination, students are advanced to candidacy and must have a doctoral committee appointed within two semesters. The committee should consist of at least five members, one of whom must be in a department other than electrical engineering. After appointment of the committee, students should work out a tentative program of courses that meets with the committee’s approval.

**Comprehensive Examination**

When students have completed most of their course work, they must pass a comprehensive examination before research is undertaken. This consists of an oral examination given by the entire committee; it may be preceded, at the discretion of individual committee members, by an additional oral or written examination. Students who fail may repeat the examination only once, no sooner than three months after the first examination. Once students pass the comprehensive examination, they may proceed with dissertation research.

**Final Examination**

At the conclusion of the research, students write a dissertation that must be approved by a majority of the doctoral committee. Finally, students must pass another oral examination covering primarily the dissertation.
Mission Statement

To prepare graduates for successful engineering and professional careers and leadership roles with lifelong learning and ethical conduct that will lead them to be engaged good citizens, engineers, and professionals in their community and the world.

Objectives

- Our graduates will be accomplished professionals by being able to formulate, communicate, and solve problems using engineering principles, methodologies, and modern tools;
- Our graduates will be professionals and leaders in industry, national laboratories, academia, and society by employing engineering fundamentals, design skills, thinking creatively, communicating effectively, working collaboratively, and implementing emerging and innovative technologies;
- Our graduates will be professionals and leaders who accept and practice their professional and ethical responsibilities, respect diversity of opinion and culture, and have a proper understanding and consideration for a healthy and aesthetic environment.

The Academic Program

Mechanical engineering (ME) is concerned with the design of all types of machines, conversion of energy from one form to another, instrumentation and control of all types of physical and chemical processes, the manufacturing and utilization of engineering materials, and control of human and machine environments. Mechanical engineers conceive, plan, design, and direct the manufacture, distribution, and operation of a wide variety of devices, machines, instruments, materials, and systems used for energy conversion, heat and mass transfer, biomedical applications, environmental control, control of human and machine environment, physical and chemical process control, materials processing, transportation, manufacture of consumer products, materials handling, and measurements. Mechanical engineers also employ Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Aided Testing (CAT), Computational Fluid Dynamics (CFD), computer modeling and simulations, novel materials, robotics, and mechatronics (integration of computers with electromechanical systems) in their day-to-day activities. Mechanical engineers find opportunities for employment in every branch of industry and in a variety of government agencies. Work may involve research, development, design, analysis, manufacture, testing, marketing, or management.

Undergraduate Study

Outcomes

- An ability to apply knowledge of mathematics, science, and engineering
- An ability to design and conduct experiments, as well as to analyze and interpret data
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- An ability to function on multi-disciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- A recognition of the need for and an ability to engage in lifelong learning

Degrees Offered:

- BS in mechanical engineering
- MS in mechanical engineering
- PhD in mechanical engineering
A knowledge of contemporary issues
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Professional Components
A culminating design experience that integrates knowledge and skills acquired throughout the curriculum
The application of engineering standards and realistic constraints, including consideration of economics, environmental sustainability, manufacturability, ethics, health, safety, society, and politics

Bachelor's Degree
The BS degree requires completion of at least 124 credit hours of course work. The curriculum consists of a group of required courses chosen to provide students with the basic tools for the professional practice of mechanical engineering and to assist students in developing a sense of responsibility as professionals. The objectives of the lower division curriculum are to build a foundation in the basic sciences and mathematics, provide an introduction to engineering design and professional ethics, develop communications and computer programming skills, and acquire an appreciation for the humanities and social sciences. The objectives of the upper division program are to provide a sound foundation in the engineering sciences; build on that foundation for applications in the areas of energy conversion, mechanical systems and control, experimentation, and manufacturing; and encourage creativity culminating in a capstone design experience. To provide sufficient flexibility, technical elective courses enable students to acquire additional competence in areas compatible with their career objectives.

All electives are subject to the approval of an advisor.

College Requirements
Students must complete the college requirement courses for engineering (see “Undergraduate Programs” within the College of Engineering).

Departmental Requirements
Students must complete the following coursework:
- ME 213 Introduction to Engineering Design (3)
- CEE 270 Applied Mechanics I (3)
- CEE 271 or ME 271 Applied Mechanics II (3)
- MATH 190 Introduction to Programming (1) or EE 160 Programming for Engineers (4)
- MATH 302 Introduction to Differential Equations I (3) or MATH 307 Linear Algebra and Differential Equations (3)
- EE 211 Basic Circuit Analysis I (4)
- ME 311 Thermodynamics (4)
- ME 312 Applied Thermodynamics (3)
- ME 322 Mechanics of Fluids (3)
- ME 331 Materials Science and Engineering (3)
- ME 341/342 Manufacturing Processes/Lab (3/2)
- ME 360 Computer Methods in Engineering (3) or MATH 407 Numerical Analysis (3) or PHYS 305 Computational Physics (3)
- ME 371 Mechanics of Solids (3) or CEE 370 Mechanics of Materials (3)
- ME 372 Component Design (3)
- ME 374 Kinematics/Dynamics Machinery (3)
- ME 375 Dynamics of Machines and Systems (3)
- ME 402 Dynamics Systems Laboratory (2)
- ME 422 Heat Transfer (3)
- ME 480 Thermofluid Measurements and Design (3)
- ME 481 Design Project I (3)
- ME 482 Design Project II (3)
- Technical electives (9): Three courses that can be selected from ME 400-level technical electives (3), one that can be replaced with a non-ME course (3) (with approval from chair), or PHYS 274 or BIOL 171 without approval; and a second that can be replaced with an ME 600-level course (3) (3.0 GPA minimum and approval from chair) or ME 499 (3)

For information on a Bachelor Degree Program Sheet, go to www.manoa.hawaii.edu/ovcaa/programsheets/.

Graduate Study
Outcomes
- Demonstrate mastery of the methodology and techniques specific to the field of study.
- Communicate both orally and in writing at a high level of proficiency in the field of study.
- Conduct research or produce some other form of creative work.
- Perform in their field of study at a professional level.

The department offers graduate programs leading to MS and PhD degrees in mechanical engineering, with areas of concentration in thermal and fluid sciences conversion (heat and mass transfer, thermodynamics, combustion, thermal environmental engineering, biotechnology), in materials/manufacturing (nano, composite and smart materials, mechanical properties, failure analysis, electrochemistry and corrosion, processing, marine materials), and in mechanics design, systems, and controls (robotics, structures, dynamics, control, continuum mechanics, renewable energy, autonomous systems, biomedical). For qualified graduate students, teaching assistantships, research assistantships, and scholarships are available.

Master's Degree
Applicants for admission to the MS program must have completed a BS degree in engineering or its equivalent from a reputable institution.

Requirements
Students are required to follow the Plan A (thesis) program. However, under special circumstances, a petition to follow Plan B (non-thesis) may be granted by the graduate faculty. A minimum of 30 credit hours is required for graduation, including 1 credit hour for seminar. Plan A students must take 8 credit hours for thesis, 12 credit hours in the ME 600 course series, and 9 credit hours in technical electives. Technical elective courses must be at the 400 level or above, selected from engineering, mathematics, or physical sciences approved by the student’s thesis committee.

For graduation, each candidate must present an acceptable thesis (research report for Plan B) and must pass a final oral examination based on the thesis for Plan A or on the course work and the research report for Plan B.
**Doctoral Degree**

Applicants for admission to the PhD program must have completed the requirements for the MS in mechanical engineering at UH Mānoa or an equivalent degree from a reputable institution.

**Requirements**

Intended candidates for the PhD are required to pass an oral qualifying examination within the prescribed period of time, by taking 4 credits of ME 699. The purpose of the qualifying examination is to judge students’ ability to pursue research. After passing the qualifying examination, the student will be admitted to the status of candidate in the PhD program. At the discretion of the qualifying examination committee, students who fail the qualifying examination will be dropped from the program.

Students must satisfactorily complete a minimum of 50 credit hours in course work beyond the BS level. They are required to select a major within the following three areas of concentration: materials/manufacturing, mechanics/design/systems/controls, or thermal/fluid sciences.

Students who enter the program may, with the approval of the graduate chair, be credited with up to 30 credits for equivalent work to be counted toward their PhD-credit-hour requirement. Up to 8 of these 30 credit hours may be assigned for prior MS thesis work. Students who possess a second MS degree may be credited with up to 9 additional credit hours for equivalent work. Up to 9 credit hours may be assigned for course work taken as an unclassified graduate student. All courses shall be selected by students but must be approved in writing by their committees. These courses must form an integrated education plan. A minimum of 2 credit hours in ME 691 or its equivalent must be included in every PhD program.

Students who desire teaching experience may, with the approval of the PhD committee chair, request that the department chair assign them teaching responsibility for a particular undergraduate course. The department chair will determine whether students are qualified to teach the course in question, and, if they are deemed qualified, they may be given the teaching assignment. Students who teach a course or courses will be assigned a maximum of 3 credit hours toward their PhD course work requirements.

**Comprehensive Examination**

PhD candidates must pass an oral comprehensive examination to demonstrate their comprehension of the chosen areas of study relevant to their dissertation proposals and basic knowledge of courses taken at graduate level. Students who fail the comprehensive examination may, at the discretion of the graduate faculty concerned, repeat it once after at least six months. Students who fail the examination a second time will be dropped from the program.

**Final Examination**

Students are required to complete a satisfactory doctoral dissertation and to pass an oral final examination based primarily upon the dissertation. The final examination will be administered by the respective PhD committee. A student passes the final examination upon the favorable recommendation of a majority of the PhD committee.