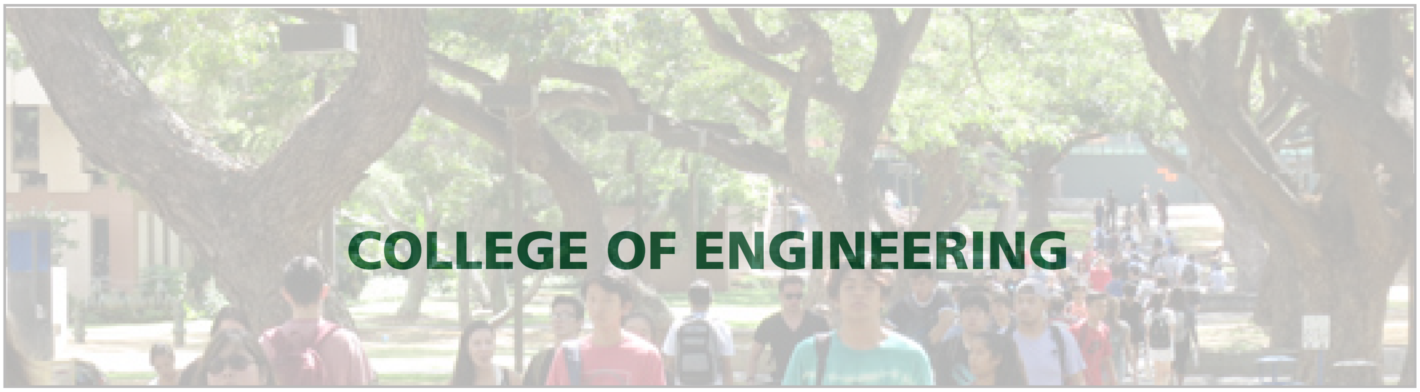

COLLEGE OF ENGINEERING

Administration

Holmes 240
2540 Dole Street
Honolulu, HI 96822
Tel: (808) 956-7727
Fax: (808) 956-2291
Web: www.eng.hawaii.edu

Dean: Brennon T. Morioka
Interim Associate Dean: Tianwei David Ma
Assistant Dean of Student Services: Song K. Choi

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, artificial intelligence, machine learning, and other state-of-the-art subjects. College curricula encourage the independent study of novel engineering processes, integrating entrepreneurship, and innovation. Particular emphasis is placed on problems related to sustainability, resilience, 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 close to 12,000 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 programs in civil, computer, electrical, and mechanical engineering are accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

Degrees and Certificates

Bachelor's Degrees: BS in civil engineering, BS in computer engineering, BS in construction engineering, BS in electrical engineering, BS in engineering science, 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 and Academic Affairs Office
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 faculty 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/students/current-students/curriculum/.

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

New Students

Incoming students are encouraged to meet with an engineering academic advisor by scheduling an appointment with the Student and Academic Affairs Office in Holmes 250.

Undergraduate Programs

Each of the curricula offered by the College of Engineering provides a fundamental science-oriented university education

Contents

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 and are expected to be calculus ready upon enrollment. The college also uses aptitude tests and high school records in its screening procedure. Successful applicants are initially accepted into Pre-engineering prior to further screening.

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 the College of Engineering and declare 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 college participates actively in UH Mānoa Honors Program. The courses required of all engineering students, which also satisfies the General Education Core Requirements of UH Mānoa, consist of the following:

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) (FQ), MATH 242 Calculus II (4), MATH 243 Calculus III (3), and MATH 244 Calculus IV (3);
- or MATH 251A Accelerated Calculus I (4), MATH 252A Accelerated Calculus II (4), and MATH 253A Accelerated Calculus III (4)

Natural Sciences

- CHEM 161/161L General Chemistry I/Lab and 162 General Chemistry II (3/1/3) or CHEM 171/171L Principles of Chemistry (4/1) or CHEM 181/181L Honors General Chemistry (4/1) (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 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.

Combined Bachelor's & Master's Degree (BAM) Pathways

Combined Bachelor's & Master's Degree (BAM) Pathways afford a way for highly motivated students to efficiently complete a Bachelor's degree and Master's degree in a shorter time frame by double-counting course work, up to 3 courses, at the undergraduate tuition rate. In most cases, pathway students graduate with the Bachelor's degree and Master's degree within 5 years (total).

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*.

Programs

Hawai'i Advanced Wireless Technologies Institute

The Hawai'i Advanced Wireless Technologies Institute (HAWT Institute) 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, HAWTI continues on its mission to be the leading center for innovative research in the broader areas of wireless technologies with joint research and educational activities that promote national and international collaboration and partnership with industry. The institute has tenured faculty, full-time researchers, collaboration and partnership with industry; and graduate students working towards their MS and/or PhD degrees in electrical engineering.

Past and current sponsors of the research activities in the institute include federal agencies such as the National Science Foundation (NSF), Army Research Office, Office of Naval Research, Army CERDEC, SPAWAR, as well as a large number of corporate sponsors, such as Raytheon, Agilent Technologies, BAE, L-3 Communications, Motorola, L3 Technologies, Orbital ATK, and Hawaiian Electric Company (HECO).

Faculty in the institute 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. The institute director is the founding Editor·ln·Chief of *Computer Applications In Engineering Education* by Wiley, was the 2002 President of the IEEE Antennas and Propagation Society, and he has received the ASEE Curtis W McGrew Award for Research and the ASEE George Westinghouse Award for teaching excellence. Some of the institute's ongoing research is included in the recent book, *The World of Applied Electromagnetics* by Springer.

National and International Collaboration: The institute is a member of the NSF Industry-University Cooperative Research Center (IUCRC), 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 Politecnica 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), the development of radio frequency tunable devices for reconfigurable antennas cognitive radio, solar energy harvesting applications, reinforcement learning and optimization with applications in renewable energy and smart grids. Recent research projects include a 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, the development of textile antennas for medical and military applications, optimization of Hawai'i electric power grids using reinforcement learning, and development and application of genetic programming in electromagnetlcs.

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

Laboratory Facilities: HWATI 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 and network analysis lab, and the RF devices fabrication and probe station for characterization lab.

For graduate studies, all students/applicants need to fulfill the requirements of Graduate Division, manoa.hawaii.edu/graduate/, as well as those of the Department of Electrical Engineering. For availability of research opportunities, visiting scholar and graduate fellowships at HAWTI, contact Magdy Iskander, Director of HAWTI and professor of electrical engineering at magdy@hawail.edu.

Hawai`i Space Flight Laboratory

The Hawai'i 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.

Hawai'i 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 merges research interests in the College of Engineering and the School of Ocean and Earth Sciences and Technology.

Native Hawaiian Science & Engineering Mentorship Program (NHSEMP)

The Native Hawaiian Science & Engineering Mentorship Program (NHSEMP) began in 2001 as a joint initiative between UH Mānoa, College of Engineering, and Kamakakūokalani Center for Hawaiian Studies. NHSEMP serves over 100 students annually, providing assistance, opportunities, and community for students to excel in the STEM fields with a goal of creating leaders in the Native Hawaiian and Pacific Island communities through academic excellence in STEM.

NHSEMP utilizes the successful longitudinal model created by the Alaska Native Science & Engineering Program to provide a suite of opportunities at the K-12, pre-college, and university levels including STEM engagement days, summer bridge programs, tutoring, financial assistance, a STEM Center, and other student support services. NHSEMP partners with UH departments, federal organizations, and industry to provide undergraduate research experiences and internships. Additionally, NHSEMP's ʻOi Ka Naʻauao Workshop series provides opportunity for professional development, mentorship, and cultural awareness, understanding, and identity.

Vertically Integrated Projects (VIP) Program

University of Hawaiʻi (UH) is part of the Vertically Integrated Projects (VIP) Consortium, which was started by Georgia Institute of Technology. VIP programs seek to foster project-based learning to engage students and better prepare them for future careers. VIP teams are vertically integrated: they consist of a faculty mentor, graduate student researchers, and undergraduates of all levels. The teams are large (10 to 20 undergraduates), the projects are long-term (at least 5 years in scope), and are based on an externally funded research topic. Undergraduates in VIP teams earn academic credit for their participation.

Our VIP efforts are organized around the following themes:

- The College of Engineering robotics program spans microrobotics to marine (submersible and surface) robotics to aerospace (drones and small satellites) and surgical robotics;
- UH Mānoa has an exceptionally strong astronomy program, with access to real telescope time for developing astronomical instruments. Student-built nanosatellites have been built and launched three times since 2006, our third VIP focus area is in rapid prototyping. Goals and objectives include cultivating and promoting innovation and entrepreneurship at UH Mānoa by providing the learning resources, tools and facilities to cultivate innovation and entrepreneurship; and
- The UH System has also made it a priority for its students to be part of the "Maker Movement," inspiring our third VIP focus area to be in rapid prototyping and re-manufacturing. Goals and objectives include cultivating and promoting innovation and entrepreneurship at UH Mānoa by providing the learning resources, tools and facilities to cultivate innovation and entrepreneurship and serving as a conduit to the local startup ecosystem.
- Our fourth focus area is in sustainability. As the most isolated land mass in the world, Hawaiʻi has a vested interest in sustainability in many areas: architecture, energy, food, water, and transportation. Indeed, this focus allows rich cross-disciplinary VIP opportunities across many academic disciplines across campus.

Civil and Environmental Engineering

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Faculty

*P. D. Prevedouros, PhD (Chair)—transportation engineering, sustainability, autonomous transportation
*A. R. Archilla, PhD—transportation and infrastructure systems engineering
*R. W. Babcock, PhD—environmental engineering
*S. Bateni, PhD—hydraulics
*H. Brandes, PhD—geotechnical engineering
*R. Chen, PhD—transportation and smart cities
*C. Cho, PhD—structural engineering
*O. P. Francis, PhD—coastal engineering and sustainable infrastructure; design, observations, numerical methods
*N. Jiang, PhD—geoenvironmental engineering, biomediated and bio-inspired geotechnics
*A. S. Kim, PhD—environmental engineering and physics, parallel computing
*J. H. Lee, PhD—groundwater monitoring, computational hydrology, uncertainty quantification, optimal control
*D. Ma, PhD—structures
*D. Moon, PhD—structural engineering
*P. Ooi, PhD—geotechnical engineering
*H. Park, PhD—coastal and hydraullic engineering
*I. N. Robertson, PhD—structures, earthquake engineering
*L. Shen, PhD—structural engineering
*A. Singh, PhD—construction and cost engineering, project management, quality control
*T. Yan, PhD—environmental engineering, environmental microbiology
*G. Zhang, PhD—transportation engineering

Adjunct Faculty

G. Johnson, PhD—structural engineering
M. Kirs, WRRC—water resources

Cooperating Graduate Faculty

A. I. El-Kadi, PhD—groundwater hydrology
S. Khanal, PhD—bioenergy and biobased products; waste to energy heat and mass transport in chemically reacting ecosystems, energy conversion, bioremediation
M. Kirs, PhD—microbial water quality and related public health issues
N. Lautze Maresca, PhD—geothermal/sustainable energy physical volcanology
W-W. W. Su, PhD—biochemical engineering, plant cell culture, molecular biotechnology
S. Q. Turn, PhD—thermo chemical energy conversion, fuels processing, energy systems

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

* Graduate Faculty

The Academic Program

Civil engineering is concerned with the activities of people and the environment. The civil and construction 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 construction engineer has knowledge of the fundamentals of civil engineering and specialized expertise in the processes of material and supply flows, scheduling, crew management, site compliance and safety, construction law, etc. Construction engineers work with architects and civil engineers to build projects and manage on-site construction activities. Construction engineers deliver building and infrastructure projects.

The mission of the Department of Civil and Environmental Engineering is to 1) educate civil engineers that meet the requirements of the profession, are 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 in Civil Engineering

The program’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 BSCE degree requires completion of at least 121 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:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors;
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives;
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

College Requirements

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

Departmental Requirements

Students must complete specific civil (CEE) and non-CEE courses as listed on the CEE Curriculum Check Sheet corresponding to the year in which they are admitted to the program; see www.cee.hawaii.edu/undergraduate-study-2-2/. The check sheet also lists additional details about the program of courses to be followed. Most courses have prerequisites that have to be completed before enrollment. These are listed in the catalog of courses. Important requirements include the following:

- C grade or better is required for PHYS 170.
- C grade or better within two attempts is required for CEE 270.
- C grade or better is required for CEE 370.
- Must maintain a minimum GPA of 2.0 for all registered credit hours.
- Must maintain a minimum GPA of 2.0 for all upper division courses (numbered 300-400) in mathematics, science, and engineering.

Academic probation, suspension, and dismissal.

- Must take one Technical Elective in Sustainability (TES) course from the course options listed on the check sheet.

Specialty Tracks

The department offers two specialty senior year tracks, one in structural engineering and another in sustainability and innovation. Students who want to pursue a specialty track should refer to the curriculum checksheet for alternative senior year course work.

Bachelor's Degree in Construction Engineering

The program's educational objective is to produce graduates who in the first few years following graduation will:

1. Practice construction engineering in the private and public sectors in Hawaii, the Asia/Pacific region, and elsewhere.
2. Obtain technical and non-technical knowledge/skills that contribute to personal and employer success, and benefit the communities they serve.
3. Recognize conflicts and adhere to professional ethical standards.
4. Apply sustainability principles in their construction engineering projects and designs.
5. Continue their professional development, and aim for professional licensure and advanced degrees.

The BSCNST degree requires completion of 120 credit hours of course work, the equivalent of four years of full-time work. These requirements include 65 credit hours of civil and construction engineering courses from the following areas: applied mechanics, structural analysis, hydraulics, transportation, soil mechanics and various aspects of construction (project management, methods, safety, law, etc.) The undergraduate experience culminates in a senior capstone course in which students apply the knowledge they have gained throughout their undergraduate course work toward the planning and design of a comprehensive construction project.

There are three basic components to the undergraduate program:

1. The university-wide General Education Core and Graduation requirements, which are usually substantially completed during the first two years of the university experience.
2. The College of Engineering requirements; and,
3. The CEE Department requirements. These are discussed below.

Students must maintain a minimum GPA of 2.0 for all registered credit hours and a minimum GPA of 2.0 for all upper division courses (numbered 300-499) in mathematics, science, and engineering.

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:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply the engineering design process to produce solutions that meet specified needs with consideration for public health and safety, and global, cultural, social, environmental, economic, and other factors as appropriate to the discipline.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and creates a collaborative and inclusive environment.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to recognize the ongoing need to acquire new knowledge, to choose appropriate learning strategies, and to apply this knowledge.

Advising is an important element of the undergraduate program. All students are assigned an advisor prior to their first semester. Students must receive approval of their program of courses prior to registration each semester and will not be able to register without it. Such advising takes place during the prior semester (for continuing students); the advising period will be listed on this website and posted throughout Holmes Hall prior to advising week.

Departmental Requirements

Students must complete specific civil and construction engineering (CEE) and non-CEE courses as listed on the CNST Curriculum Check Sheet corresponding to the year in which they are admitted to the program; see www.cee.hawaii.edu/undergraduate-study-2-2/. The check sheet also lists additional details about the program of courses to be followed. Most courses have prerequisites that have to be completed before enrollment. These are listed in the catalog of courses. Important requirements include the following:

- C grade or better is required for PHYS 170.
- C grade or better within two attempts is required for CEE 270.
- C grade or better is required for CEE 370.
- Must maintain a minimum GPA of 2.0 for all registered credit hours.
- Must maintain a minimum GPA of 2.0 for all upper division courses (numbered 300-400) in mathematics, science and engineering Academic probation, suspension, and dismissal.
- Must take one Technical Elective in Sustainability (TES) course from the course options listed on the check sheet.

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 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.

Combined Bachelor's & Master's Degrees

BAM is a fast track program designed to allow qualified students to receive both BS and MS degrees in 5 years by allowing the double-counting of 6 credits of course work in both degrees. CEE juniors who have achieved a grade of B or better in the gateway class (CEE 361); and have a cumulative GPA of 3.0 or higher are eligible to apply to the Fast-Track BAM program.

Double counted courses must be taken in the senior year after admission into the program: three (3) credits for CEE 490, and three (3) credits for one 600+ course that depends on the student's area of emphasis, as follows:

- Construction: CEE 602 or 604
- Environmental: CEE 633 or 635
- Geotechnical: CEE 655
- Structures: CEE 681
- Transportation: CEE 661, 664, or 665

Students apply to the BAM program after their fifth semester (Junior year). Upon approval of the graduate chair, students then submit the regular online MS application documents. Early admission to the MS program occurs in the senior year when the two double counted courses are taken. BAM students must maintain a cumulative GPA of 3.0 or higher during MS studies. Students in the BAM program can choose either Plan A (Thesis) or Plan B (Non-Thesis) options to fulfill the MSCE program requirements to receive the MSCE degree in the 5th year.

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 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 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.

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 repeat the test once at least six months later. Students who fail the examination a second time are dismissed 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

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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
*D. Carlson, PhD—cyber-physical systems, internet of things, ubiquitous computing, mobile computing and interactive media systems
*I Y. Chun, PhD—machine learning & AI with big data, optimization, compressed sensing, adaptive signal processing, medical imaging, computational photography, neuroscience
*Y. Dong, PhD—cyber security and privacy, network systems and internet applications (such as drones and internet of things)
*M. Fripp, PhD—power systems, smart grids, renewable energy
*A. Host-Madsen, PhD—communications signal processing, CDMA communications, multi-user communications, equalization

* Graduate Faculty

*M. Iskander, PhD (Director of HAWTI)—computational electromagnetics, antennas, radar, and wireless communications
*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
*N. Santhanam, PhD—statistical learning, information theory, signal processing and communications
*G. H. Sasaki, PhD—computer communication networks, performance evaluation, optimization algorithms
*V. L. Syrmos, PhD—linear system theory, control theory
*J. Weldon, PhD—nanoscale device design, heterogeneous integration with CMOS for data-intensive applications, applications of nanotechnology to biomedical devices
*Y. Xiao, PhD (HAWTI)—deep learning, reinforcement learning, game theory, optimization, wireless communications, power systems, economics and computation
*J. R. Yee, PhD—computer communications networks, network optimization, stochastic models
*Z. Yun, PhD (HAWTI)—wireless channel modeling, antennas and propagation
*J. Zhang, PhD—signal processing, complex networks and network science, bioinformatics, stochastic models
*Y. Zheng, PhD—information (data) privacy, cybersecurity

Emeritus Faculty

N. Abramson, PhD—wireless data networks
*N. T. Gaarder, PhD—communication theory, information theory
F. Koide, PhD—biomedical engineering, operational amplifiers, electronic circuits
S. Lin, PhD—coding theory, coded modulation, multi-user communications and error coding techniques
E. J. Weldon, PhD—computer networks
D. Y. Y. Yun, PhD—computational intelligence, biomedical informatics, parallel and networked computing

Cooperating Graduate Faculty

K. L. Davies, PhD—real-time data analytics, physics-based modeling, model-based controls, electric grid, renewable energy, distributed energy resources, fuel cells, power hardware-in-the-loop, systems engineering
N. Gaillard, PhD—theory-guided materials design, solid/liquid interface phenomena and light/matter interaction in films and nanostructures
R. Ghorbani, PhD—renewable energy, dynamics, controls, design
D. Pavlovic, PhD—pure mathematics, quantum info theory, theoretical computer science and software engineering
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

Affiliate Graduate Faculty

R. C. Gough, PhD—low-voltage, low-power electrical manipulation of non-toxic liquid metal alloys for use in reconfigurable microwave and radio frequency (RF) devices

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 (internet, wireless, and digital signal processing), computers (software, security, and networking), instrumentation (biomedical, intelligent), and many other areas.

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

The culmination of the undergraduate programs 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 to become 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, 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 get 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 requires a minimum of 122 credit hours, unless accelerated chemistry and mathematics courses are taken, in which case the minimum is 118 credit hours. The bachelor of science degree program in computer engineering requires a minimum of 125 credit hours, unless accelerated chemistry and mathematics courses are taken, in which case the minimum is 121 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 20 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.
- MATH 307 may be substituted with EE 345, in which case there are 49 credit hours.

*Engineering Breadth (EB) is satisfied by a CEE, ME, OE, or BE course at the 300-level or higher; CEE 270; or a physical, biological, or computer science course that is at the 300-level or higher and approved by the department's undergraduate curriculum committee. EB for computer engineering may be replaced with a computer engineering technical elective.

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. ENGR 296 and 396 may be substituted for EE 296 and 396, respectively.

Bachelor of Science in Electrical Engineering

Program Educational Objectives

The expected attainment of graduates are:

1. Electrical engineering graduates will practice electrical engineering in industry, education, and public service.
2. Graduates will contribute to the technological and economic development of Hawai'i, the U.S., and beyond.
3. Graduates will be prepared for admission to top graduate programs.
4. Graduates will continue their professional development, through individual effort and advanced professional education.
5. Graduates will 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 identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors;
3. An ability to communicate effectively with a range of audiences;
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives;
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Technical Electives

Electrical engineering students must complete a minimum of 24 credit hours of 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, 445, 446, 449, 452, 453

The following courses may also be used as technical electives: EE 205, 361/361L, 362, 366, 367/367L, 368, 369, 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.

The following concentrations are examples of a pre-approved alternative track:

Biomedical Concentration: All Group I courses in either the Electrophysics or System Track, plus two biomedical-related Group II courses and an engineering breadth course approved by the department's undergraduate curriculum committee and listed on the EE website. EE 496 will be a biomedical project approved by concentration coordinator.

Group II courses satisfying biomedical concentration: EE 480, 481, 482, 680, 681, 682, 685; ME 620, 636, 645; MBBE 625, 650, 651.

Engineering breadth courses satisfying biomedical concentration: BIOC 341, 441; MICR 351, 485; MBBE 401, 402, 412.

Energy Concentration: All Group I courses from the Electrophysics or System Track, plus two energy-related Group II courses and an engineering breadth course approved by the department's undergraduate curriculum committee and listed on the EE website. EE 496 will be an energy project approved by concentration coordinator.

Group II courses satisfying energy concentration: EE 435, 438, 635.

Engineering Breadth courses satisfying energy concentration: ME 311, 610; ORE 330, 677; PHYS 430, 440; ATMO 302; BE 410, 610; GG 407.

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

Bachelor of Science in Computer Engineering

Program Educational Objectives

The expected attainment of graduates are:

1. Computer engineering graduates will practice computer engineering in industry, education, and public service.
2. Graduates will contribute to the technological and economic development of Hawai'i, the U.S., and beyond.
3. Graduates will be prepared for admission to top graduate programs.
4. Graduates will continue their professional development, through individual effort and advanced professional education.
5. Graduates will 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 identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors;
3. An ability to communicate effectively with a range of audiences;
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives;
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies;
8. A knowledge of discrete mathematics.

Computer engineering students must complete the following 26 credit hours of courses:

- EE 205, 361/361L, 362 (or ICS 141 and 241), 367/367L (or ICS 311), 467 (or ICS 314), 468, 6 credits of technical electives

The set of courses EE 160 and 205 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. Technical electives may be EE courses at the 300 level or higher or ICS courses from the following list:

- ICS 313, 321, 351, 355, 414, 415, 421, 423, 424, 425, 431, 432, 441, 442, 451, 455, 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

Degree Requirements

Students pursuing a graduate degree in EE must have a BS degree in EE or its equivalent; otherwise, the minimum course requirements listed in the next subsection must be met. The EE program has three major tracks of specialization: computers, electro-physics, and systems. Graduate students are required to specialize in a major track and have breadth outside the major track in EE. More rigorous courses from the other programs may be used to satisfy major track or breadth requirements subject to prior approval from the graduate chair. Elective courses must be from College of Engineering, College of Natural Sciences, SOEST, or Shidler College of Business. Relevant courses from other programs may be used to satisfy elective course requirements subject to prior approval from the graduate chair. Only one out of multiple courses with significantly overlapping contents (for example, cross-listed courses) can be used to satisfy any course requirement. Only courses with a grade of B or better (not B-minus) can count towards the course requirements.

Minimum Course Requirements for EE Graduate Students Without a BS Degree in EE

Those with an undergraduate degree in engineering or natural sciences are required to take the following courses depending on the major track selected for their graduate work (unless equivalent courses are taken in their undergraduate studies). The students might have to take courses that are prerequisites to these courses.

Systems:

- EE 213 Basic Circuit Analysis II or 345 Linear Algebra and Machine Learning or MATH 307 Linear Algebra and Differential Equations, and
- EE 315 Signal and Systems Analysis, and
- EE 342 Probability and Statistics

Electro-physics:

- EE 213 Basic Circuit Analysis II, and one of the following:

- EE 323 Microelectronic Circuits I, or
- EE 327 Theory and Design of IC Devices, or
- EE 371 Engineering Electromagnetics I

Computers:

- EE 342 Probability and Statistics (or discrete probability, or discrete math), and
- EE 205 Object Oriented Programming, and
- EE 361 Digital Systems and Computer Design, and
- EE 361L Digital Systems and Computer Design Lab

Those with an undergraduate degree not in any branch of engineering nor the natural sciences will be required to take a more extensive set of courses. This will be on a case-by-case basis.

Renewable Energy and Island Sustainability Graduate Certificate

The Renewable Energy and Island Sustainability (REIS) graduate certificate provides students an opportunity to get both breadth and depth in energy and sustainability curriculum. Students will take classes in different colleges to get a broad perspective on energy sustainability. In addition to taking courses and attending a REIS seminar class, students will conduct a capstone project to obtain greater depth in an energy research area. For more details please contact Anthony Kuh, kuh@hawaii.edu.

Master's Degree

Plan A (thesis) and Plan B (non-thesis) options are offered. In addition to the general degree requirements set by Graduate Division, the following requirements must be met by MS students in electrical engineering.

Requirements

Plan A (thesis): This option requires a minimum of 30 credits such that

- 12 credits must be in 600-level courses in the major track (6 credits must be in Category I courses and 3 credits must be in Category II courses)
- 6 credits must be in 400 or higher-level EE courses outside the major track
- 3 credits must be in 400 or higher-level elective courses
- 9 credits must be in EE 700 Thesis Research (1 credit of EE 700 during the semester of graduation); students can petition to convert their EE 699 credits to EE 700 credits
- at most 6 credits can be in 400-level courses.

The graduate seminar requirement in electrical engineering or a related field must also be fulfilled (see the seminar policy). In addition, MS Plan A students must produce a thesis and pass the final examination. The stages of the MS Plan A program are as follows.

MS Plan A students should find faculty advisors in research areas of mutual interest as early as possible. After the initial advising with the faculty advisor, Master's Plan A Form I (Pre-Candidacy Progress) is processed by the graduate chair. Under the advisor's guidance, the student takes courses necessary for background knowledge, and develops a thesis proposal which involves a literature survey and preliminary research on the thesis topic. Subsequently, the student forms the thesis committee, which approves the thesis proposal. The thesis committee must satisfy Graduate Division requirements and be pre-approved by the graduate chair. The graduate chair reports the approval of the thesis proposal to Graduate Division by using Master's Plan A Form II (Advance to Candidacy).

The candidate then carries out the thesis research and writes a thesis satisfying Graduate Division requirements. In particular, the thesis is expected to be a scholarly presentation of an original contribution to electrical engineering resulting from independent research. The candidate must keep the thesis committee informed of the scope, plan, and progress of the thesis research and manuscript. During this stage, the candidate completes the credit requirements. After completing the thesis research and writing a thesis, the candidate takes the final examination.

The final examination is administered by the thesis committee. The candidate submits the thesis to the committee and the EE office at least two weeks prior to the final examination. The examination starts with a presentation by the candidate on the thesis research, including the problems chosen, the approaches employed, and the results obtained. Throughout the examination, the candidate defends his or her thesis in response to the committee's questions on the correctness and the significance of the approaches and results.

A majority of the committee must approve of the content of the thesis and the candidate's ability to defend it in order for the candidate to pass. The committee members indicate their decisions on the final examination by signing Master's Plan A Form III (Thesis Evaluation). A candidate who passes may still be asked to make various corrections and revisions to the thesis. The candidate must make the requested changes and submit the revised thesis to the entire committee. Master's Plan A Form IV (Thesis Submission) is to be signed by the chair and a majority of the committee, including any committee members who may have been physically absent at the final examination. All those who sign must have read and approved the manuscript in its entirety. By signing this form, the committee members indicate approval of the content and the form of the finalized manuscript. A candidate who fails the final examination may repeat it only once with approval from both the graduate faculty concerned and Graduate Division. A candidate who fails the final examination twice is dismissed from the program. The graduate chair approves and reports the results of the final examination to Graduate Division by using Master's Plan A Form IV.

Plan B (non-thesis): This option requires a minimum of 30 credits such that

- 12 credits must be in 600-level courses in the major track (6 credits must be in Category I courses and 3 credits must be in Category II courses), and
- 6 credits must be in 400 or higher-level EE courses outside the major track.
- 6 credits must be in 600-level elective courses
- 6 credits of EE 699 (These 6 credits can be substituted by 6 credits in 600-level courses in EE.)

The graduate seminar requirement in electrical engineering or a related field must also be fulfilled (see the seminar policy). In addition, MS Plan B students must complete a final project that demonstrates the knowledge and skills acquired in the program. MS Plan B students should find supervising faculty advisors in areas of mutual interest as early as possible. The final project does not need to include original research results. Acceptable forms of final projects include a literature survey, critique of research papers, software implementation of an algorithm, or hardware testing or development, subject to the prior approval of the supervising faculty. The student must write a conference-style report to document the final project activities, and submit this report to the supervising faculty and the EE office at least a week prior to the final examination. The final examination is the evaluation of the final project by the supervising faculty. This evaluation includes an oral presentation by the student to an audience including the supervising faculty. The supervising faculty reports his or her approval of the final project by sending a signed copy of the EE MS Plan B Final Examination Form to the EE office along with the final project report.

Combined Bachelor's & Master's Degree (BAM) Pathway

BAM is a fast track program designed to allow qualified students to receive both BS and MS degrees in 5 years by allowing the double-counting of up to 9 credits of course work in both degrees.

The following courses taken while enrolled in the BAM program (typically in the fourth year) can be double counted:

- Computer Track: EE 468, 602 or 660, 607 or 609
- Electro-physics Track: EE 438 or 480, 671 or 624, 681 or 682
- Systems Track: EE 417 or 445, 640 or 650, 615 or 617

The students enrolled in the BS program can apply for admission to the BAM program after passing one of the following gateway courses with B+ or higher (typically at the end of the third year).

- Computer Track: EE 361
- Electro-physics Track: EE 371
- Systems Track: EE 315

For more information and how to apply, please visit ee.hawaii.edu/student/index.php?stc=2&stp=163.

Doctoral Degree

Doctoral 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 specialty. Doctoral students must also perform research in their special field under the guidance of a faculty advisor and write a dissertation that is a scholarly presentation of an original contribution to electrical engineering resulting from independent research. Participation in a substantial teaching project to develop competence in teaching is also required. In addition to the general degree requirements set by Graduate Division, the following requirements must be met by doctoral students in electrical engineering.

Requirements

Doctoral students must have an MS degree in EE or its equivalent; otherwise, the MS course requirements must be met (equivalent courses taken elsewhere can be counted toward this requirement subject to prior approval from the graduate chair). In addition, the following 40 credits are required:

- 9 credits of 600-level courses in the major track
- 3 credits of 600-level courses outside the major track
- 3 credits of EE 790 Directed Instruction
- 24 credits of EE 699 (6 credits can be substituted by 600 level courses in EE)
- 1 credit of EE 800 Dissertation Research during the semester of graduation.

The graduate seminar requirement in electrical engineering or a related field must also be fulfilled (see the seminar policy). Furthermore, doctoral students must pass the qualifying examination to advance to PhD candidacy, must pass the comprehensive examination for the approval of a dissertation proposal, and must pass the final examination for the approval of the dissertation itself. The stages of the doctoral program are as follows.

Pre-Candidacy Stage

The pre-candidacy stage covers the period from the admission until the qualifying examination is passed. Each doctoral student is assigned a faculty advisor upon entering the program. During the pre-candidacy stage, a doctoral student prepares for the qualifying examination to advance to candidacy by enrolling in a directed reading or research course under the advisor's direction. This preparation may be in the form of an initial exploration for a dissertation topic or it may be any other research effort on some topic of interest to demonstrate the student's research potential. As part of this preparation, the student produces a well-written three- to six-page conference-style extended abstract on his or her research efforts. In consultation with the advisor, the student also takes courses as necessary for background knowledge.

Each student completes and submits the EE Qualifying Examination Form to the EE office by the following deadlines: students who enter the program in a fall semester are to submit the form by the following **March 1**; students who enter the program in a spring semester are to submit the form by the following **October 1**. Each student must take the qualifying examination by the end of the second semester (spring or fall) in the program. A student starting in a fall semester can petition to take the qualifying examination by the end of the first summer semester. In unusual circumstances (including an advisor change), the student can petition to postpone the qualifying examination by up to a semester.

Qualifying Examination

The qualifying examination is an oral examination administrated by a committee of three graduate faculty members. One member of the committee is the student'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. The qualifying examination is closed to persons other than the student and the committee members.

The student submits the extended abstract to the committee and the EE office at least one week prior to the examination. The purpose of the qualifying examination is to determine the student's research potential and knowledge of pertinent fundamentals. It starts with a presentation where the candidate demonstrates his or her ability to conduct significant research. In particular, the student is expected to demonstrate ability to understand technical concepts of sufficient complexity and to produce and implement new ideas. Throughout the examination, the committee may ask any questions broadly related to the topic of presentation to observe the student's thought process in approaching a research problem. Any one of the following criteria is sufficient, but not necessary, to demonstrate research potential:

- producing a research result that could be accepted for presentation in a peer reviewed conference

- formulating a significant and well-motivated research problem, and proposing a well thought-out approach for solving the problem.

At least two committee members must pass the student; else, the student repeats the examination by the end of the third semester in the program. A student who does not pass the qualifying examination by the end of the third semester is dismissed from the program. The graduate chair reports the results of the qualifying examination to Graduate Division by using Doctorate Form I (Pre-Candidacy Progress).

Candidacy Stage

After passing the qualifying examination, the student is advanced to PhD candidacy. At this stage, the candidate develops a dissertation proposal and prepares for the comprehensive examination. During the development of the dissertation proposal, the candidate (in consultation with the advisor) acquires the necessary background knowledge through course work and literature survey, and conducts research on the proposed dissertation topic.

Comprehensive Examination

The candidate takes the comprehensive examination within three years of entering the PhD program. Prior to taking the comprehensive examination, the candidate completes the MS course requirements and most of the PhD course work in major track or outside major track EE courses (at least 6 of the required 12 credits), writes a dissertation proposal, and forms the doctoral committee. The doctoral committee must satisfy Graduate Division requirements and be pre-approved by the graduate chair. The comprehensive examination is an oral examination administered by the doctoral committee and is subject to the same rules as those set by Graduate Division for the final examination.

The candidate submits the dissertation proposal to the doctoral committee and the EE office at least two weeks prior to the comprehensive examination. The dissertation proposal must have a tentative title, a description of the problems considered, preliminary results, and the proposed research for the completion of the dissertation. The comprehensive examination may be preceded, at the discretion of the individual committee members, by additional oral or written examinations.

The purpose of the comprehensive examination is to critically evaluate the merit of the dissertation proposal as well as the candidate's ability and preparation for conducting the proposed research. It starts with a presentation where the candidate makes the case for the validity of the dissertation proposal. Throughout the examination, the committee questions the candidate on various aspects of the dissertation proposal including its scope, the significance of the problems chosen, and the approach. The committee also evaluates the candidate on the background knowledge necessary for the completion of the dissertation. In addition, the committee can suggest alternative approaches and additional topics for investigation, and can alert the candidate to new developments relevant to the proposed research. The presentation followed by a short question-and-answer session is open to the public; however, the rest of the comprehensive examination is closed to persons other than the student and the committee members.

A majority of the committee must approve the dissertation proposal in order for the candidate to pass. The committee members indicate their approval by signing the Advance to Candidacy Form (Form II). A candidate who fails the comprehensive examination may repeat it only once, no sooner than three months after the first examination. The candidate must pass the comprehensive examination within four years of entering the PhD program. A candidate who fails the comprehensive examination twice is dismissed from the program. The graduate chair reports the results of the comprehensive examination to Graduate Division by using Doctorate Form II (Advance to Candidacy).

Dissertation Stage

A candidate who passes the comprehensive examination proceeds with the proposed research and writes a dissertation. The dissertation must satisfy Graduate Division requirements. In particular, the dissertation is expected to be a scholarly presentation of an original contribution to electrical engineering resulting from independent research. The dissertation must be suitable for publication in respected academic journals. The candidate must keep the doctoral committee informed of the scope, plan, and progress of the dissertation research and manuscript. During this stage, the candidate also completes the credit requirements. After completing the dissertation research and writing a dissertation and no sooner than six months after passing the comprehensive examination, the candidate takes the final examination.

Final Examination

The final examination is administered by the doctoral committee. The candidate submits the dissertation to the doctoral committee and the EE office at least two weeks prior to the final examination. The examination starts with a presentation by the candidate on the dissertation research including the problems chosen, the approaches employed, and the results obtained. Throughout the examination, the candidate defends his or her dissertation in response to the committee's questions on the correctness and the significance of the approaches and the results.

A majority of the committee must approve the content of the dissertation and the student's ability to defend it in order for the candidate to pass. The committee members indicate their decisions on the final examination by signing Doctorate Form III (Dissertation Evaluation). A candidate who passes may still be asked to make various corrections and revisions to the dissertation. The candidate must make the requested changes and submit the revised dissertation to the entire committee. Doctorate Form IV (Dissertation Submission) is to be signed by the chair and a majority of the committee, including any committee members who may have been physically absent at the final examination. All those who sign must have read and approve the manuscript in its entirety. By signing this form, the committee members indicate approval of the content and the form of the finalized manuscript. A candidate who fails the final examination may repeat it only once with approval from both the graduate faculty concerned and Graduate Division. A candidate who fails the final examination twice is dismissed from the program. The graduate chair approves and reports the results of the final examination to Graduate Division by using Doctorate Form IV.

Seminar Policy

Students must attend at least twelve seminars from the department seminar series, thesis defenses, and/or technical conferences. A student receives a credit of three attended seminars for giving a seminar that is not his or her final public defense, or for giving a conference presentation. Attendance should be taken by the track coordinator for the departmental seminars and by the student's advisor for thesis defenses. Documentation should be provided by the student's advisor for conference attendance and conference presentations. Attendance lists and documentation should be submitted to the EE office.

Mechanical Engineering

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Faculty

*L. H. Hihara, PhD (Interim Co-Chair)—corrosion materials, mechanical behavior of materials
*W. Qu, PhD (Interim Co-Chair)—boiling and two-phase flow, microscale thermofluid transport phenomena
*J. S. Allen, PhD—acoustics, multiphase fluid dynamics, micro-biomechanics
*D. M. Azimov, PhD, DSc—guidance and control, autonomous space systems, space flight dynamics, optimal control
*P. J. Berkelman, PhD—haptic interfaces, surgical robotics, magnetic levitation
*J. J. Brown, PhD—nanomaterials, micro/nano devices, experimental mechanics, nanomanufacturing
*R. Ghorbani, PhD—renewable energy, dynamics, controls, design
*E. Jun, PhD—kinetic theory, numerical algorithms for non-equilibrium flow, hybrid computation for multiscale flow
*M. Kobayashi, PhD—computational fluid dynamics, aeroacoustics, dynamical systems, topology optimization
*B. Konh, PhD—medical devices, smart materials, mechatronics
*W. Lee, PhD—nanoscale thermal transport, nanotechnology, nanomaterials, quantum transport, energy conversion
*S. F. Miller, PhD—manufacturing, design of medical devices, tribology
*M. N. M. Ghasemi Nejhad, PhD—nanotechnology, composites, renewable energy, smart structures
*T. Ray, PhD—microfluidics/nanofluidics, novel microfluidic device fabrication-design, process development, device characterization, nanoparticle characterization, sensing technologies (optical, electrical, chemical), microassembly, acoustophoresis, graphical design.
*S. Shin, PhD—heat and mass transfer, energy conversion/storage/management
*Z. Song, PhD—autonomous robots, sensor fusion, multi-agent systems, marine robotics
*A. Z. Trimble, PhD—renewable energy, industrial automation, precision engineering
*W. E. Uspal, PhD—microhydrodynamics, statistical mechanics, soft matter
*Y. Zuo, PhD—colloids and surfaces, lung surfactants, AFM, biomedical applications

Adjunct Faculty

M. F. Young, PhD—rocket propulsion, mixed convection heat transfer, turbulence modeling, solar energy

* Graduate Faculty

Cooperating Graduate Faculty

M. Cooney, PhD—high rate waste water treatment & reactor design; sustainability analysis; bio-oil bearing biomass
M. Dubarry, PhD—battery testing, modeling and simulation; grid scale Li-ion energy storage systems, vehicle-to-grid strategies, and testing of emerging battery technologies
N. M. Gaillard, PhD—theory-guided materials design, solid/liquid interface phenomena, light/matter interaction in nanostructures
S. Higgins, PhD—air purification, battery separation, microbial fuel cells and anaerobic digestion technologies
H. A. Ishii, PhD—nanomaterials, cosmochemistry, materials analysis, electron and ion microscopy
A. Kim, PhD—environmental engineering; computer simulations
C. M. Kinoshita, PhD—combustion, energy systems, thermochemical systems
S. M. Masutani, PhD—combustion, turbulent transport phenomena, energy systems
M. Nunes, PhD—improving the development, launch and operations of new satellite architectures
R. Rocheleau, PhD—thin film ceramic materials
T. C. Sorensen, DE—space mission design and operations, space craft autonomy, design, orbital mechanics, guidance and control, space propulsion, software design and development, lunar missions, space history
J. St-Pierre, PhD—materials for electrochemical energy systems, membrane water purifiers
S. Q. Turn, PhD—thermo chemical energy conversion, fuels processing, energy systems
R. Woo, MD—medical design

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

Mission Statement

To provide quality education, research, and service to our graduates and prepare them for successful engineering and professional careers and leadership roles with lifelong learning and ethical conduct that will lead them to be engaged responsible 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 environments, 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

All graduates of the mechanical engineering program are expected to have demonstrated an ability to:

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental, and economic factors
- Communicate effectively with a range of audiences
- Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

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 120 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 required courses for engineering (see "Undergraduate Programs" within the College of Engineering).

Departmental Requirements

Students must complete the following course work:

- ME 213 Introduction to Engineering Design (3)
- CEE 270 Applied Mechanics I (3)
- CEE 271 or ME 271 Applied Mechanics II (3)
- EE 160 Programming for Engineers (4) or EE 110 Introduction to Engineering Computation (3) or ICS 111 Introduction to Computer Science I (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 322 Mechanics of Fluids and Lab (4)
- ME 331 Materials Science and Engineering (3)
- ME 341 Manufacturing Processes and Lab (4)
- 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 and Lab (4)
- ME 422 Heat Transfer and Lab (4)
- ME 481 Design Project I (4)
- ME 482 Design Project II (3)
- PHYS 274 General Physics III (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 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) (with approval from the department chair)

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 of Mechanical Engineering offers graduate programs leading to MS and PhD degrees in Mechanical Engineering with areas of concentration in Thermal and Fluid Sciences (heat and mass transfer, thermodynamics, biotechnology, alternative energy conversions, sustainability, boiling and two-phase flow, combustion, multidisciplinary design and analysis optimization, and high-performance computing); Mechanics, Systems, and Controls (robotics, mechanical design, mechatronics, control systems, dynamical systems, space and ocean science and exploration, biomedical engineering, rehabilitation engineering, and renewable energy systems); and Materials and Manufacturing (nanotechnology, composite and smart structures, electrochemistry and corrosion, precision machining, and joining of dissimilar materials). 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.

Combined Bachelor's & Master's Degree (BAM) Pathway

BAM is a fast track program designed to allow qualified students to receive both BS and MS degrees in 5 years by allowing the double-counting of up to 9 credits of coursework in both degrees. The BAM program in Mechanical Engineering allows for specific technical electives to count towards both degrees, thereby enabling completion of an MS in Mechanical Engineering within a single year following completion of the BS degree.

Doctoral Degree

Applicants for admission to the PhD program must have completed the requirements for the MS in engineering, science, or related areas from a reputable institution. A direct PhD degree option is also available for applicants with a BS degree in engineering, science, or related areas.

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 with a MS degree 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.

For direct PhD students with a BS degree, instead of 8 thesis credits, 4 credits should be taken as ME 799 (Directed Instruction) and the other 4 credits should be taken as ME 699 while taking the comprehensive examination.

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 the 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.