FAMU-FSU COLLEGE OF ENGINEERING

THE FAMU-FSU COLLEGE OF ENGINEERING

Undergraduate Overview

Dean: Suvranu De; **Associate Deans**: Zhiyong (Richard) Liang, Michelle Rambo-Roddenberry, Yassir Abdel Razig; **Assistant Deans**: Mark Dobek, Kari Evans, Kim Jacobs, Tisha Keller, Frederika Manciagli, Janine Welch

The accelerating pace of technological developments has created an ever-increasing demand for highly qualified, professional engineers to maintain the high-tech momentum already achieved and to extend and direct its course. Expanding population and corresponding demands for new products, structures, designs, and improved services have posed new challenges to present and future engineers. Accordingly, the College of Engineering, through its curricula, strives to educate and train engineers to use scientific knowledge and problem-solving skills to determine the best solutions to the problems of today and the future.

It is expected that students who conscientiously apply themselves and successfully complete one of the broad engineering programs will not only be technically trained, but also humanistically and socially educated, and thereby be well prepared to make a significant contribution to the world in which they work.

An engineering student can pursue any one of several career plans, according to personal ambitions, interest, and abilities. The student may pursue the Bachelor of Science degree or an advanced research-oriented graduate program leading to the Master of Science or Doctor of Philosophy degrees.

An engineer usually works as a member of a team to solve a problem or to design products or processes. The engineer's responsibility may include some of the following: (1) the conception of an idea, including a careful delineation of the problem; (2) the design of an item or process, including operational and production requirements; (3) the selection of materials; (4) the determination of markets; (5) the assessment of sociological effects and determination of methods for controlling these effects; (6) the design or selection of machines for production; and (7) the control of costs. Currently, over two-thirds of all technical positions and a large percentage of managerial positions in industry are occupied by engineers.

History and Joint College

The FAMU–FSU College of Engineering was authorized by the 1982 legislature as a joint program between Florida Agricultural and Mechanical University and Florida State University. The joint nature of the college allows a student to register at either Florida A&M University or Florida State University and receive a degree in any of the college's programs. A student entering the college applies for admission at one of the two universities and must satisfy the admission and general degree requirements of the university, college, and department. The degree is granted through the College of Engineering by the university where the student is enrolled while completing upper-division studies. All College of Engineering classrooms and administrative and faculty offices are housed in a modern engineering complex located at 2525 Pottsdamer Street in Innovation Park.

Mission

The mission of the College of Engineering is as follows: to provide an innovative academic program of excellence at both the undergraduate and graduate levels, judged by the highest standards in the field and recognized by national peers; to expand representation and participation across the student body in professional engineering, engineering teaching and research; and to attain national and international recognition of the college through the educational and research achievements and the professional service of its faculty and students.

Programs and Degrees

The college offers professional programs of study leading to the Bachelor of Science, Master of Science, and Doctor of Philosophy in biomedical, chemical, civil, electrical, industrial, and mechanical engineering; the Bachelor of Science in computer engineering; the Master of Science in systems engineering; the Master of Engineering in civil engineering; and the Master of Science and Doctor of Philosophy in Materials Science and Engineering and in Aerospace Engineering. All undergraduate degree programs are accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, the recognized accreditor for college and university programs in applied and natural science, computing, engineering, and technology. Some degree programs offer multiple majors including environmental engineering and materials engineering. More complete information can be found at the college website, https://www.eng.famu.fsu.edu, and in the department sections of this General Bulletin. Departments include the following: Chemical and Biomedical Engineering; Civil and Environmental Engineering; Electrical and Computer Engineering; Industrial and Manufacturing Engineering; Mechanical Engineering; and Materials Science and Engineering.

Facilities

The college occupies over 200,000 square feet of classroom, office, and laboratory space in a building complex especially designed for engineering education. It is located less than three miles from each main campus, in an area adjacent to Innovation Park, which also houses the following research facilities: the National High Magnetic Field Laboratory (NHMFL); the Aero-propulsion, Mechatronics and Energy Center (AME); the Center for Advanced Power Systems (CAPS); the High Performance Materials Institute (HPMI); and other university, public, and private organizations engaged in research, development, and entrepreneurship. The college also maintains other research centers, including the Applied Superconductivity Center (ASC); Center for Accessibility and Safety for an Aging Population (ASAP); Center for Intelligent Systems, Control, and Robotics (CISCOR); Center for Resilient Infrastructure and Disaster Response (RIDER); Center for Transportation and Public Safety (CTPS); Energy and Sustainability Center (ESC); and Florida Center for Advanced Aero-Propulsion (FCAAP).

Each department of the college operates specialized laboratories for teaching and research that are listed in the department chapters. In addition, the college operates computing facilities; a library and reading room; as well as machine shops and electronics shops for common use by all programs.

Library

The mission of the Engineering Library is to support and enhance the learning, teaching, research, and service activities of the FAMU-FSU engineering communities by providing organized access to quality information in all formats, promoting information literacy, preserving information, and engaging in collaborative partnerships to disseminate ideas for advancing intellectual discovery. The main book and journal collections for engineering are housed in the Dirac Science Library at Florida State University and in the Coleman Library at Florida A&M University. The Engineering Library is a satellite for both university libraries and houses a small collection along with extensive access to electronic collections. Materials not available at the library may be requested through Interlibrary Loan or U-Borrow.

The library is serviced by a full-time librarian and several assistants who offer research assistance in person, over the telephone, and via e-mail and text. Instruction in library and information literacy is available to classes and groups upon request.

Library services also include Flip video cameras, laptops, headphones, and other technology that are available for check out upon request. Modern group study tables, lounging stations, and tutoring areas are in the Engineering Library for student use.

Computing Facilities

Students have access to various computing resources at the College of Engineering. The college has over 2,000 computing devices connected to its local network, managed by College Computing Services (CCS). Computers connect to the college's network via high-speed wired and wireless LAN services. Over 200 high-end Intel-compatible workstations are provided for general student use, supplying a wide range of Engineering software applications. These computers are housed in four labs: one of the computer labs is open 24 hours a day when classes are in session, while the other three are used primarily as classrooms. The college also provides workstations in public areas that are available to students 24 hours a day, 365 days a year. Additionally, most of the same applications are available virtually through the myFSUVLab system. Behind the scenes, a number of servers and a Storage Area Network provide services to the college user community. CCS continues to evaluate and upgrade computer capabilities as computational needs grow. Additionally, both universities provide on-campus facilities that are available to all students. Research labs at the college contain dozens of computational systems to provide enhanced research capabilities, including complex number crunching for simulations. College researchers also take advantage of shared computational clusters located on the engineering campus and at each university. The college's computing infrastructure uses high-end core router/switches interconnected to edge switching via gigabit fiber. The college internet connection is a gigabit link connecting through the Florida State University backbone (Florida State University acts as the network manager and internet services provider for the college) allowing for fast access to the Internet2 and the LambdaRail network. Florida A&M University's computing facilities are also connected to the Tallahassee MAN, thus providing a link to the college for its students. The college has state-of-the-art instructional classrooms. The multimedia equipment in every classroom generally includes LCD projector, document camera, BluRay player, and sound system. The ceiling-mounted LCD projector is used for large-scale projection and is linked to the PC at the instructor's console. All regular classrooms are equipped to support hybrid and remote instruction via the internet. Some rooms have additional support for distance learning, including equipment to support synchronous and asynchronous instructional delivery and advance recording needs.

Distance delivery of classes to/from the FSU Panama City campus occurs regularly, and distance-learning collaborations with other universities are frequent. Live and recorded programs, classes, and events are streamed via the Internet to authorized viewers. Multi-point IP videoconferencing is also available.

Supporting Facilities

Other nearby resources include the following: FSU Information Technology Services; the National High Magnetic Field Laboratory (the 'Mag Lab'); the Center for Advanced Power Systems (CAPS); the High-Performance Materials Institute (HPMI); and the Aero-propulsion, Mechatronics and Energy Center (AME). Information on additional research centers affiliated with the College of Engineering is available at: https://eng.famu.fsu.edu/research. The college also operates the Tallahassee Challenger Learning Center, a K-12 STEM outreach facility serving the southeastern U.S. Located in downtown Tallahassee, the center houses a 3-D IMAX theatre, planetarium, and a Challenger Space Mission simulator with Control Center. Other supporting facilities are Northwest Regional Data Center (NWRDC), Florida Department of Transportation research facilities, WFSU Public Broadcasting television and radio stations, as well as FAMU Information Services.

Scholarships

Thanks to donations from industry partners, educational programs, and private donors, the College of Engineering offers a limited number of scholarships to qualified engineering students. Students can obtain scholarship information by visiting the college website at https://www.eng.famu.fsu.edu/scholarships.

Career Services

The college houses the Engineering Career Services Office to provide students with career-related services. The office assists students in career and employment advising, including résumé, cover letter, and personal statement writing, internship co-op opportunity, and permanent job searches nationwide. Career Services staff also aid in preparing engineering students for interviews and presentations at career expositions, such as the STEM Career & Internship Fair in the Fall and Spring terms.

Honors in the Major

The College of Engineering offers honors in the major in several departmental programs. For requirements and other information, see the "University Honors Office and Honor Societies" chapter of this *General Bulletin*.

Requirements for Admission and Retention in an Engineering Major

Engineering is a demanding discipline, and students majoring in engineering must follow a required sequence of courses and achieve a high level of proficiency. All engineering students are subject to a uniform set of academic requirements agreed to by both FAMU and FSU, in addition to any other academic requirements stated in the respective university catalog and bulletin. These requirements, which are reviewed and revised as needed by the College of Engineering, have been established to ensure that program graduates receive a quality education and make progress toward satisfying engineering major degree requirements.

Pre-Engineering Requirements

All first-year engineering students (first year in college or first-year transfer students) are initially coded as pre-engineering students until they satisfy the following pre-engineering requirements:

1. An overall GPA of 2.0 or better.
2. A grade of "C–" or better, from any institution attended, in EGN 1004L First-Year Engineering Laboratory, Calculus I, Calculus II, and General Physics I. Intended chemical and biomedical engineering majors shall replace General Physics I with General Chemistry I for the purpose of declaring the major. Only a single repeated attempt in only one of the four courses listed above is allowed.
3. Students who meet the following conditions may be eligible to receive an exemption from the First-Year Engineering Laboratory (FYEL) course: (1) students who are seeking a second bachelor's degree, (2) students who have transfer credit for a similar course taken at a higher education institution, (3) student veterans who have received an honorable discharge from the U.S. military, or (4) students who transfer into the college having already received credit for all other pre-engineering courses listed above. Please note that First Time in College (FTIC) students cannot use (4) to be exempt from First-Year Lab. Students who are eligible for an FYEL exemption must declare their intended engineering major during their first term at the college or they lose their eligibility for the exemption. Students should contact the Office of Student Services and Undergraduate Affairs if they feel they qualify for the exemption. Any student who transfers out of pre-engineering before completing the FYEL course and then desires to transfer back to engineering must complete the course or its equivalent.
4. Any student who needs two repeated attempts to complete the four courses may be considered for continuation in engineering if additional grade and coursework requirements are satisfied. Contact the Student Services office at the College of Engineering for details. Any student who needs three or more repeated attempts to complete the four courses listed above does not satisfy this requirement and will not be allowed to continue in the engineering program. There are NO exceptions to this requirement. Grades of "W" are not considered as repeated attempts.

Once a pre-engineering student satisfies all pre-engineering requirements, he/she may visit the Student Services office to initiate the transfer process to his/her intended engineering major prior to the beginning of the following term..

Course Grade Requirement and Practice

It is the policy of the college not to assign "plus and minus (+/–)" grades for undergraduate engineering courses.

The college requires that all engineering students earn a grade of "C" or better in all engineering courses that apply toward the degree. A course grade of "D" may be waived by the department chair or designee.

A student who is failing a course cannot receive a grade of Incomplete (I). Students who receive a grade of Incomplete should complete all course requirements during the next term of the student's enrollment

Repeated Course Attempts Policy

A student who has an excessive number of repeated engineering course attempts may be placed on probation with their major and may have a mapping hold placed on their record. The student may continue with his/her original engineering major only upon the approval of his/her academic department.

Engineering Course Prerequisite and Co-requisite Policy

It is the policy of the College of Engineering that a student must achieve a satisfactory grade ("C-" or better) in all prerequisites to an engineering course prior to enrolling in it. Concurrent registration in an engineering course and its prerequisite is not permitted unless special permission has been received from the student's academic department. All co-requisites of an engineering course must be taken concurrently or prior to enrolling in the engineering course. Students are responsible for knowing the prerequisites for each engineering course in which they are enrolled. They may request this information from the course instructor or departmental academic advisor. A student, therefore, may not use "lack of proper prerequisites" as a justification for a grade appeal or retroactive course withdrawal. Engineering academic departments reserve the right to administratively cancel the course enrollment of any student who does not meet course prerequisites at any time during the term, with no refund of tuition and fees.

Course Withdrawal/Drop Policy

The Course Withdrawal/Drop Policy at the College of Engineering is different from the policy at either university. Students who seek to withdraw from the university or drop a course should do so by the drop deadline established by the College of Engineering as outlined below:

Current Term Withdrawal/Drop. Undergraduate Engineering students may drop from any course in the current term for any reason up to and including the end of the seventh week of classes. Engineering late drop period goes into effect after the seventh week and up to the late drop deadline of each term. There may be financial aid and other implications for dropping a course, so students should always contact their academic advisor first. All pre-engineering students and students classified as Lower Division by FSU are limited to a total of two "late drops" only. Students who reach their "two late drops" limit will not be permitted another late drop until they enter their intended engineering major and leave Lower Division. Unused late drops may not be "banked." Students who are coded in a degree granting engineering major and are classified as Upper Division at FSU are permitted three "late drops" while coded as such. Students wishing to withdraw from the university by dropping all of their courses may do so up to the late drop deadline. Engineering students will not be permitted to drop or withdraw after the late drop deadline except in documented cases in which the justification for the drop/withdrawal is due to extenuating circumstances which are beyond the student's immediate control. The drop/withdrawal deadlines are posted on the College of Engineering website (https://www.eng.famu.fsu.edu) each term. Students will be responsible for the grade they receive in all enrolled courses in the term after the course drop/withdrawal deadline.

Retroactive Withdrawal/Drop. A student may apply for a retroactive withdrawal from a course in which he or she received a grade of "D" or "F" for extenuating circumstances beyond the student's control. Extenuating circumstances must fall into one of these four categories: (1) medical issues, (2) death of an immediate family member, (3) military service, or (4) other. Each application is reviewed by a committee of engineering faculty to determine the merit of the request. Applications must be submitted before the deadline set each term. This deadline will be emailed to students via their university email accounts. Additionally, applications received more than one year after the original course attempt may not be accepted. Applications and more information can be found online at https://www.eng.famu.fsu.edu/student-resources.

Transfer Students

Students who plan to enroll in another institution for the first two years and then transfer into the College of Engineering should use great care in selecting freshman and sophomore coursework. To be admitted to an engineering major, transfer students must have satisfied the same pre-engineering requirements as students who take all their coursework at FSU. Transfer students who will earn an AA degree prior to enrollment at the college must have completed at least Calculus I. Students are strongly advised to consult with the college as early as possible concerning their first two years of study. Students who transfer out of an engineering major and then desire to transfer back to the college may be subject to additional academic requirements before their request to transfer is considered. Please consult with the Student Services office for more information.

Bachelor of Science Degree Requirements

A student who has taken a college preparatory curriculum in high school including algebra, geometry, trigonometry, physics, and chemistry can complete the requirements for the Bachelor of Science degree in four years and one summer with an average load of 16 hours per term. A student with superior high school training may take advantage of opportunities for advanced placement through the university's programs for acceleration. In order to satisfy the State of Florida Division of Colleges and Universities requirement of summer attendance, it is recommended that students enroll in the summer session at the end of the first year. Students who are not prepared to begin with Calculus I (MAC 2311) may need to attend additional summer sessions.

The engineering curriculum is made up of four components: CoreFSU Curriculum, first-year engineering laboratory, required courses in the engineering major area, and technical electives.

General Education Requirement

All students must meet university requirements for baccalaureate degrees stated in the “Undergraduate Degree Requirements” chapter of this General Bulletin. Of the 36 credit hours required in general education courses, thirteen of these are automatically satisfied by the engineering required courses. The engineering student must take a total of 24 credit hours in the areas of English, ethics/social responsibility, history, humanities/cultural practices, natural sciences, and social sciences. Students unprepared to begin calculus at the university level must, of course, also complete the necessary mathematics coursework preparatory to calculus. All prospective engineering students should select humanities and social science courses to meet university requirements.

State of Florida Common Program Prerequisites

The state of Florida has identified common program prerequisites for this university degree program. Specific prerequisites are required for admission into the upper-division program and **must** be completed by the student at either a community college or a state university prior to being admitted to this program. **Students may be admitted into the university without completing the prerequisites, but may not be admitted into the program.**

At the time this document was published, some common program prerequisites were being reviewed by the state of Florida and may have been revised. Please visit https://dlss.flvc.org/admin-tools/common-prerequisites-manuals for a current list of state-approved prerequisites.

The following lists the common program prerequisites or their substitutions, necessary for admission into these upper-division degree programs:

1. MAC X311 or MAC X281
2. MAC X312 or MAC X282
3. MAC X313 or MAC X283
4. MAP X302 or MAP X305
5. CHM X045/X045L or CHM X045C or CHS X440/X440L
6. CHM X046/X046L or CHM X046C*
7. PHY X048/X048L or PHY X048C, or PHY X043 and PHY X048L
8. PHY X049/X049L or PHY X049C, or PHY X044 and PHY X049L

*Chemical and biomedical engineering majors

Engineering Major Area

Degree requirements for engineering major areas consist of additional mathematics and basic science courses, engineering science courses, and engineering design courses. Current requirements for engineering major areas are included in the advising materials in the academic departments, which include Chemical and Biomedical Engineering; Civil and Environmental Engineering; Electrical and Computer Engineering; Industrial and Manufacturing Engineering; and Mechanical Engineering. More complete information can be found at the college web site, https://www.eng.famu.fsu.edu, and in the department sections of this General Bulletin.

Combined Bachelor's/Master's Pathways

All departments at the college offer combined bachelor's/master's pathways that provide academically talented students an opportunity to complete both a bachelor's and a master's degree in engineering in a shorter time span than completing the degrees separately. Students should discuss this option with their department advisor during their junior year to ensure that appropriate courses are taken during their senior year.

Student Organizations

The College of Engineering has more than 35 student organizations at the college, representing many engineering disciplines, areas of interest, affinity groups, and honor societies. They give students extra access to industry employers and create opportunities for social activities, study groups and travel to conferences and competitions. For a current list of student organizations at the college, visit http://www.eng.famu.fsu.edu/student-organizations.

GRADUATE STUDIES

Information for Graduate Students

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Opportunities

A large number of graduate students in the College of Engineering are supported through department teaching or research assistantships. University fellowships are available for exceptionally qualified students. In addition, tuition waivers for graduate assistants and fellows are available on a competitive basis. Students should contact the department of their proposed major regarding financial support.

Master of Science (MS) Degree

The departments of Chemical and Biomedical, Electrical and Computer, Industrial and Manufacturing, and Mechanical Engineering, offer both thesis and non-thesis programs for the Master of Science degree. The Department of Civil and Environmental Engineering and the Department of Materials Science and Engineering offer a thesis program for the Master of Science degree. The Department of Industrial and Manufacturing Engineering offers specialized, non-thesis programs in engineering management and systems engineering. The thesis-based programs are designed to provide the student with advanced coursework and experience in the chosen engineering discipline. The non-thesis programs are designed to provide the student with a strong technical education with less emphasis on research. The thesis programs are appropriate for a student who plans to engage in research or to continue graduate studies for the doctoral degree. Candidates for the master's degree must satisfy all regulations and requirements of the department in which they enroll. For additional departmental requirements consult the degree requirements under each department.

Master of Engineering (MEng) Degree

The Department of Civil and Environmental Engineering offers the Master of Engineering (MEng) degree program option. This is a non-thesis, coursework-only master's degree tailored to civil engineering professionals who are working in the field as well as for recent BS in Civil Engineering or BS in Environmental Engineering graduates. The option is designed for students who wish to pursue their advanced degree either part-time or on an accelerated one-year track. Please visit the Department of Civil and Environmental Engineering website at https://eng.famu.fsu.edu/cee for more information.

Doctor of Philosophy (PhD) Degree

The Doctor of Philosophy degree is awarded after the student satisfies all requirements of the university, the college, and department. This degree is offered in aerospace; biomedical; chemical; civil; electrical; industrial; materials science and engineering; and mechanical engineering.

Graduate Certificate

The Aerodynamics/Aerospace Engineering graduate certificate program is offered by the Department of Mechanical Engineering (ME). The Engineering Data Analytics and Systems Engineering Leadership graduate certificate programs are housed in the Department of Industrial and Manufacturing Engineering (IME). The Cyber Security for Engineers Graduate Certificate is housed in the Department of Electrical and Computer Engineering. All applicants to the certificate program must be currently enrolled as a graduate student in good standing or be admitted as a graduate degree seeking student or graduate non-degree seeking student. Students must apply for the certificate program before completion of their second course. In addition to the appropriate university application and acceptance, acceptance to the certificate program by way of a supplemental departmental application is required. Additional information can be found at https://eng.famu.fsu.edu/me/aerospace-engineering-aerodynamics-certificate for ME and at https://www.eng.famu.fsu.edu/ime for IME programs and https://eng.famu.fsu.edu/ece/cyber-security-graduate-certificate for ECE.

Admission Requirements

A candidate must meet the following, minimum criteria to be considered for admission into the graduate program:

- A Bachelor of Science degree in engineering or a closely allied field from an accredited institution of higher learning or a comparable degree from and international institution.
- A grade point average (GPA) of 3.0 or better on a 4.0 scale on all work while registered as an upper-division student..
- Test scores from the Graduate Record Examinations (GRE). Applicants may be eligible for a GRE waiver. Please visit the eligibility requirements here: https://eng.famu.fsu.edu/student/gre-waiver-form.
- An international applicant whose native language is not English must have taken an English language proficiency exam within the last five years. Minimum test scores are set by individual academic departments. See the College of Engineering website at https://eng.famu.fsu.edu/prospective/graduate/admissions-requirements for more information..

For further details on graduate or research programs, contact the College of Engineering at (850) 410-6619 or by e-mail at gradstudies@eng.famu.fsu.edu. The college also maintains a website at https://eng.famu.fsu.edu with detailed information on all its graduate programs.

DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING

Undergraduate Department of Chemical & Biochemical Engineering

FAMU—FSU COLLEGE OF ENGINEERING

Website: https://www.eng.famu.fsu.edu/cbe

Chair: Bruce R. Locke; **Professors**: Grant, Kalu, Li, Locke, Ramakrishnan, Ramamoorthy, Siegrist, Yeboah; **Associate Professors**: Arnett, Chung, Guan, Hallinan, Mohammadigoushki; **Assistant Professors**: Ali, Driscoll, Liu, Mao, Mysona, Ricarte; **Teaching Faculty I**: Slauch, Thourson, Wandell; **Teaching Faculty II**: Hunter; **Teaching Faculty III**: Arce; **Professor Emeritus**: Alamo, Collier; **Affiliate Faculty**: Hsu, Sachdeva, Shanbhag, Zheng

Program Overview

The vision of the Department of Chemical and Biomedical Engineering is to be recognized as a place of excellence in fundamental and applied chemical and biomedical engineering education and life-long learning, and to be recognized as a national leader in research in modern areas of engineering. To attain this vision, the department realizes that it must continually satisfy its major stakeholders: students, industrial employers, alumni, departmental faculty, the college, the universities, the community, ABET, and other professional societies.

Chemical engineering encompasses the development, application, and operation of processes in which chemical, biological, and/or physical changes of material are involved. Chemical engineers analyze, develop, design, control, construct, and/or supervise chemical processes in research and development, pilot-scale operations, and industrial production. Chemical engineers are employed in the manufacture of inorganic chemicals (e.g., acids, alkalis, pigments, fertilizers), organic chemicals (e.g., petrochemicals, polymers, fuels, propellants, pharmaceuticals, specialty chemicals), biological products (e.g., enzymes, vaccines, biochemicals, biofuels), and other materials (e.g., ceramics, polymeric materials, paper, biomaterials). The graduate in chemical engineering is particularly versatile. Industrial work may involve production, operation, research, and development. Graduate education in business, medicine, dentistry, and law, as well as chemical engineering, biomedical engineering, and other engineering and scientific disciplines are viable alternatives for the more accomplished graduate.

The Department of Chemical and Biomedical Engineering emphasizes a biological component in its curriculum. The increasing importance of biological and medical subjects within the field of engineering cannot be underestimated. Many of the remarkable breakthroughs in medical care can be directly attributed to advances in chemicals, materials, and devices spearheaded by biochemical and biomedical engineers. Training in biological and biomedical engineering provides an excellent background for graduate and/or medical school, especially considering the increasing technological complexity of medical practice.

Biomedical engineering concerns the application of engineering and life science principles and practices to living organisms, most specifically humans. The field is based upon the fundamentals of chemical, electrical, and mechanical engineering, as well as the medical and life sciences. Biomedical engineering is carried out at universities, teaching hospitals, and private companies and focuses on developing new materials and products designed to improve or restore bodily form or function. Biomedical engineers are employed in diverse areas such as artificial limb and organ development, genetic, metabolic and cellular engineering applications, development of drug delivery systems, and cellular and tissue engineering. Many biomedical engineering professionals are engaged in medical research and to make biomedical devices (e.g., drug delivery capsules, synthetic materials, and prosthetic devices). Because of the increasing interest in biomedical sciences and biotechnology, the degree in biomedical engineering also provides an avenue for students interested in pursuing a career in medicine, biotechnological patent law, or biomedical product sales and services.

The Department currently offers two Bachelor of Science (BS) degrees. The first is in Chemical Engineering with two major options (Chemical Engineering and Chemical-Materials Engineering). The second is the Bachelor of Science (BS) degree in Biomedical Engineering with three major options (Cell and Bioprocess, Biomaterials and Biopolymers, and Imaging and Signal Processing). The BS degrees are based upon a four-year curriculum. The undergraduate curriculum emphasizes the application of experimental and computer analysis to major chemical and biomedical engineering principles. This includes laboratory instruction in modern, state-of-the-art facilities in transport phenomena, unit operations, process control, anatomy and physiology, biodynamics, tissue engineering, biomaterials, and bioinstrumentation laboratories. Students are instructed in and utilize state-of-the-art computational programs such as MATLAB, Simulink, Aspen, and COMSOL Multiphysics.

To meet newly developed interests in chemical and biomedical engineering and related fields, elective courses are available in bioengineering, polymer engineering, materials engineering, neural engineering, electrochemical engineering, and petroleum engineering. The majors build upon the core chemical and biomedical engineering principles. Consult an advisor for specific requirements for the majors.

Please contact the Department of Chemical and Biomedical Engineering at Suite A131, 2525 Pottsdamer Street, Tallahassee, FL 32310-6046; phone: (850) 410-6144 or (850) 410-6149; fax: (850) 410-6150; e-mail: chemical@eng.famu.fsu.edu; or website: https://www.eng.famu.fsu.edu/cbe.

Program Objectives and Outcomes

The Program in Chemical Engineering and the Program in Biomedical Engineering are accredited by the Engineering Accreditation Commission of ABET, found at https://www.abet.org. As part of the accreditation process, the department has developed program educational objectives and student outcomes to reflect our specific educational goals, and we continually assess and modify outcomes to meet the changing demands of the departmental stakeholders.

Program Educational Objectives

The Department of Chemical and Biomedical Engineering shall prepare its students for academic and professional work through the creation and dissemination of knowledge related to the field, as well as through the advancement of those practices, methods, and technologies that form the basis of the chemical engineering profession. Accordingly, the Department of Chemical and Biomedical Engineering has established the following educational objectives that our graduates are expected to attain within five years of graduation from our undergraduate program:

- Successfully pursue careers in a wide range of industrial, professional, and academic settings through application of their rigorous foundation in chemical engineering principles and strong communication skills.
- Successfully adapt and innovate to meet future technological challenges and evolving regulatory issues, while addressing the ethical and societal implications of their work at both the local and global level.
- Successfully function on interdisciplinary teams and assume participatory and leadership roles in professional societies, and interact with educational, community, state, and federal institutions.

Student Outcomes

These objectives are further expanded and detailed through seven student outcomes.

Student Outcome #1 – Scientific Knowledge and Problem Solving.

Outcome Definition: Students graduating from the program will have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Student Outcome #2 – Design Skills

Outcome Definition: Students graduating from the program will have the 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.

Student Outcome #3 – Effective Communication

Outcome Definition: Students graduating from the program will have the ability to communicate effectively with a range of audiences.

Student Outcome #4 – Professional and Ethical Responsibility

Outcome Definition: Students graduating from the program will have the 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.

Student Outcome #5 – Teamwork

Outcome Definition: Students graduating from the program will have the 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.

Student Outcome #6 – Experimentation

Outcome Definition: Students graduating from the program will be able to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Student Outcome #7 – Lifelong Learning

Outcome Definition: Students graduating from the program will have the ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

ABET encourages each engineering department to pursue its own unique BS degree program objectives in accordance with its own environment and stakeholder demands. ABET also stipulates that the outcomes of program implementation must be assessed and evaluated regularly, and the results of such assessments and evaluations must be utilized as needed in future program objectives and implementation.

Digital Literacy Requirement

Students must complete at least one course designated as meeting the Digital Literacy Requirement with a grade of "C–" or higher. Courses fulfilling the Digital Literacy Requirement must accomplish at least three of the following outcomes:

- Evaluate and interpret the accuracy, credibility, and relevance of digital information
- Evaluate and interpret digital data and their implications
- Discuss the ways in which society and/or culture interact with digital technology
- Discuss digital technology trends and their professional implications
- Demonstrate the ability to use digital technology effectively
- Demonstrate the knowledge to use digital technology safely and ethically

Each academic major has determined the courses that fulfill the Digital Literacy requirement for that major. Students should contact their major department(s) to determine which courses will fulfill their Digital Literacy requirement. Undergraduate majors in chemical engineering satisfy this requirement by earning a grade of "C–" or higher in ECH 3854. Undergraduate majors in biomedical engineering satisfy this requirement by earning a grade of "C–" or higher in BME 3702.

State of Florida Common Program Prerequisites for Chemical Engineering

The Florida Virtual Campus (FLVC) houses the statewide, internet-based catalog of distance learning courses, degree programs, and resources offered by Florida's public colleges and universities, and they have developed operational procedures and technical guidelines for the catalog that all institutions must follow. The statute governing this policy can be reviewed by visiting https://www.flsenate.gov/Laws/Statutes/2021/1006.73.

FLVC has identified common program prerequisites for the degree program in Chemical Engineering. To obtain the most up-to-date, state-approved prerequisites for this degree, visit: https://cpm.flvc.org/programs/338/279.

Specific prerequisites are required for admission into the upper-division program and must be completed by the student at either a community college or a state university prior to being admitted to this program. Students may be admitted into the University without completing the prerequisites but may not be admitted into the program.

Undergraduate Laboratory and Computational Facilities

Undergraduate chemical engineering teaching laboratories in measurements and transport phenomena, unit operations, and process control are designed to augment classroom instruction. Our undergraduate chemical engineering laboratory experiments feature a twenty-stage distillation column for the study of organic chemical separations, several reactor vessels for the design and analysis of batch and continuous reactor configurations, and a liquid/liquid continuous extraction process system, among others. All experiments include computer data control and data acquisition systems to provide a "real world" experience for our students. The department has biomedical engineering laboratories in the areas of bioinstrumentation, cell and tissue engineering, medical imaging, anatomy and physiology, and biodynamics and control.

The department has extensive computational and laboratory facilities in several areas. In addition to the University computing center facilities accessible by remote terminals, students have access to College of Engineering computer labs that have workstations connected to college-wide servers. Within the Department of Chemical and Biomedical Engineering, undergraduate students working on research projects utilize laboratory computer terminals connected to the college servers and workstations dedicated to research use. The department requires the use of computers for data acquisition, process control, experimental design and analysis, report writing, and homework problem calculations in the chemical engineering curriculum.

DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING

BIOMEDICAL ENGINEERING

BS Degree in Biomedical Engineering

Areas of Study (Majors)

In the Bachelor of Science degree (BS) in Biomedical Engineering, students may choose from among three diverse areas of study that reflect new directions in the broader field of biomedical engineering. These majors include cell and bioprocess, biomaterials and biopolymers, and imaging and signal processing.

Cell and Bioprocess. Biomedical engineers in this field are employed in diverse areas such as artificial limb and organ development, genetic engineering research, development of drug delivery systems, and cellular, metabolic, and tissue engineering.

Biomaterials and Biopolymers. Engineering professionals in this field are engaged in medical research to model living organisms (pharmacokinetic models), and to make biomedical devices (e.g., drug delivery capsules, synthetic materials, and prosthetic devices).

Imaging and Signal Processing. The field of signal and image processing encompasses the theory and practice of algorithms and hardware that convert signals produced by artificial or natural means into a form useful for a specific purpose. The signals might be speech, audio, images, video, sensor data, telemetry, electrocardiograms, or seismic data, among others. This major option is tailored to students interested in pursuing a career in medicine, biotechnological patent law, or biomedical product sales and services.

Requirements for a BS Degree in Biomedical Engineering

A program of study encompassing at least 128 semester hours is required for the Bachelor of Science (BS) degree in biomedical engineering. A candidate for the bachelor's degree is required to earn a “C” or higher in all engineering courses and must achieve a 2.0 grade point average (GPA) in all biomedical engineering major courses. In addition, students must achieve a grade of “C–” or higher in all courses transferred into the Department of Chemical and Biomedical Engineering. Students should contact the department for the most up-to-date information concerning the chemical engineering curriculum requirements.

There are three majors within the biomedical engineering bachelor's degree program. These include Cell and Bioprocess, Biomaterials and Biopolymers, and Imaging and Signal Processing. Most of the curriculum is common to all three majors, and includes topics in CoreFSU Curriculum, mathematics, basic science, computer science, advanced chemistry, general engineering science, and biomedical engineering science and design. History/social science/humanities electives are to be selected to satisfy the CoreFSU Curriculum requirement. Students in all three majors should successfully complete the following courses in addition to the CoreFSU Curriculum, other University, and College of Engineering requirements.

Math and Science Prerequisites

MAC 2311 Calculus with Analytic Geometry I (4)

MAC 2312 Calculus with Analytic Geometry II (4)

MAC 2313 Calculus with Analytic Geometry III (5)

ECH 3301 Process Analysis and Design (4)

BSC 2010 Biological Science I (3)

CHM 1045 General Chemistry I (3)

CHM 1045L General Chemistry I Laboratory (1)

CHM 1046 General Chemistry II (3)

CHM 1046L General Chemistry II Laboratory (1)

PHY 2048C General Physics A (combined lecture/lab) (5)

PHY 2049C General Physics B (combined lecture/lab) (5)

Advanced Chemistry

CHM 2210 Organic Chemistry I (3)

CHM 2211 Organic Chemistry II (3)

Or

CHM 3217 Organic Chemistry (3) (One Semester)

BCH 3023 Survey of Biochemistry (3)

General Engineering

EGN 1004L First Year Engineering Lab (1)

Chemical and Biomedical Engineering Science and Design

ECH 3023 Mass and Energy Balances I (3)

ECH 3024 Mass and Energy Balances II (4)

BME 3009 Introduction to Biomedical Engineering (3)

BME 3100 Biomaterials (3)

BME 3361 Biotransport Phenomena I (3)

BME 3622 Biothermodynamics (3)

BME 3702 Biocomputations (4)

BME 3723 Biostatistics (3)

BME 4211 Biomechanics (3)

BME 4744C Biodynamics and Control (4)

BME 4403C Quantitative Physiology (3)

BME 4503 Bioinstrumentation (3)

BME 4503L Bioinstrumentation Laboratory (1)

BME 4801 Biomedical Engineering Process Design I (3)

BME 4802 Biomedical Engineering Process Design II (3)

BME 4XXX Biomedical Engineering Electives (9)

Biomedical Engineering Electives

Select from three of the following choices:

BCH 4053 General Biochemistry (3)

BME 4XXX Biomedical Engineering Elective (3)

BME 4361 Neural Engineering (3)

BME 4581 Biomicroelectromechanical Systems (3)

BME 4937 Special Topics (3)

ECH 4743 Bioengineering (3)

MAP 4481 Mathematical Modeling in Biology (3)

Major Requirements

In addition to the courses listed above that are required for all majors, the following courses are specifically required for each of the three majors.

Major in Cell and Bioprocess

Biomedical Engineering Science and Design

BME 4332 Cell and Tissue Engineering (3)

BME 4332L Cell and Tissue Engineering Laboratory (1)

Chemical Engineering Science and Design

ECH 4504 Kinetics and Reactor Design (3)

Biomedical Engineering Electives

The three biomedical engineering electives (three semester hours each) are to be selected from the 4000-level elective courses offered in the Department of Chemical and Biomedical Engineering.

Note: A six credit hour sequence in the Department's Undergraduate Research Program, consisting of the course designations BME 4904 (BME - URP), or BME 4906 (BME - Honors in the Major), will substitute for six of the nine hours of the Biomedical Engineering Elective requirement.

Major in Biomaterials and Biopolymers

Biomedical Engineering Science and Design

BME 4332 Cell and Tissue Engineering (3)

BME 4332L Cell and Tissue Engineering Laboratory (1)

Chemical Engineering Science and Design

ECH 4822 Polymer Physical Science and Engineering (3)

OR

ECH 4823 Polymer Science and Engineering (3)

Biomedical Engineering Electives

The three biomedical engineering electives (three semester hours each) are to be selected from the 4000-level elective courses offered in the Department of Chemical and Biomedical Engineering.

Note: A six credit hour sequence in the Department's Undergraduate Research Program, consisting of the course designations BME 4904 (BME - URP), or BME 4906 (BME - Honors in the Major), will substitute for six of the nine hours of the Biomedical Engineering Elective requirement.

Major in Imaging and Signal Processing

Biomedical Engineering Science and Design

BME 4531 Medical Imaging (3)

BME 4531L Medical Imaging Laboratory (1)

BME 4508 Biosignals Systems (3)

Biomedical Engineering Electives

The three biomedical engineering electives (three semester hours each) are to be selected from the 4000-level elective courses offered in the Department of Chemical and Biomedical Engineering.

Note: A six credit hour sequence in the Department's Undergraduate Research Program, consisting of the course designations BME 4904 (BME - URP), or BME 4906 (BME - Honors in the Major), will substitute for six of the nine hours of the Biomedical Engineering Elective requirement.

Pre-Med Electives (recommended, consult the College of Medicine for details)

BCH 4053 General Biochemistry I (3)

BSC 2010L Biological Science I Lab (1)

BSC 2011 Biological Science II (3)

BSC 2011L Biological Science II Lab (1)

CHM 2211L Organic Chemistry II Lab (3)

PCB 3743 Vertebrate Physiology (3)

Academic Requirements and Policies

In accordance with criteria, specified by ABET, all engineering students are subject to a uniform set of academic requirements agreed upon by Florida State University and Florida A&M University. Students should consult the "FAMU-FSU College of Engineering" chapter of this General Bulletin and the Department of Chemical and Biomedical Engineering Website (https://www.eng.famu.fsu.edu/cbe) for a list of all academic requirements and policies.

Prerequisite Grade Requirements

In addition to the college course prerequisite requirements, the Department of Chemical and Biomedical Engineering requires students to have obtained a grade of at least "C–" in all courses listed as prerequisites for the department's engineering courses.

Undergraduate Research Program (URP)

The Department of Chemical and Biomedical Engineering offers an Undergraduate Research Program (URP) in chemical and biomedical engineering to encourage talented juniors and seniors to undertake independent and original research as part of the undergraduate experience. The program is two-tiered, with those students meeting a more stringent set of academic requirements being admitted to the Honors in the major (Chemical and Biomedical Engineering) program. For requirements and other information, contact the department, and see the "University Honors Office and Honor Societies" chapter of this General Bulletin.

Definition of Prefixes

BME—Biomedical Engineering

ECH—Engineering: Chemical

EGN—Engineering: General

EGS—Engineering: Support

Undergraduate Courses

BIOMEDICAL ENGINEERING

BME 3009. Introduction to Biomedical Engineering (3). Prerequisites: BSC 2010, MAC 2312, and PHY 2048C, all with a grade of "C" or higher. Corequisites: ECH 3024, ECH 3301, MAC 2313, and PHY 2049C. This course presents an introduction to the field of biomedical engineering, building on previous basic coursework in biological science, physics, and calculus. Topics in cell physiology and modeling, bioinstrumentation, biomaterials, tissue engineering, and bioimaging are covered. The course provides sophomore-level biomedical engineering students with both fundamentals and applications in contemporary biomedical science and engineering.

BME 3100 Biomaterials (3). Prerequisites: BME 3361, BME 3622, BME 3702, and BME 4403C. Corequisites: BME 4211, BME 4503, BME 4503L, and BME 4404C. This course introduces fundamental concepts of biomaterials science and engineering. The course covers the basic properties of major classes of biomaterials including natural, polymeric, metallic, ceramic, carbon-based, composite, and nano-biomaterials. It also presents critical interactions between the biomaterials and biological systems, such as biocompatibility of biomaterials and foreign body reaction of the host to biomaterials. Since characterization tools are indispensable for biomaterials science and engineering, major techniques for characterizing biomaterials are taught, with an emphasis on introducing their basic principles.

BME 3622. Biothermodynamics (3). Prerequisites: "C" grade or better in ECH 3024, ECH 3301, PHY 2049C, and BME 3009. Corequisites: BME 3361, BME 3702, and BME 4403C. This course covers the fundamental principles of thermodynamics and their application to biochemical, cellular, and physiological function. In addition, the principles of chemical kinetics of biochemical reactions and metabolic reaction networks are addressed.

BME 3631. Biotransport Phenomena (3). Prerequisites: BME 3009E, ECH 3024, ECH 3301, and PHY 2049C. Corequisites: BME 3622, BME 3702, and BME 4403C. This course presents the fundamental concepts of transport phenomena in biological systems and applies these concepts to the solutions of problems relevant to biomedical engineering.

BME 3702. Biocomputations (4). Prerequisites: BME 3009, CHM 2210, ECH 3024, ECH 3301, and PHY 2049C all with a grade of "C" or higher. Corequisites: BME 3361, BME 3622, and BME 4403C. In this course, students learn to apply computational tools to address some biomedical processes and phenomena. For those that involve concurrent cellular and molecular processes (e.g., blood clotting), computational modelling is almost the only solution thus far to glimpse what is happening at different spatiotemporal scales.

BME 3723. Statistics for Biomedical Engineers (3). Prerequisites: BME 3009 and ECH 3024 (C or better). Corequisites: BME 3100, BME 4211, BME 4503, and BME 4503L. This course serves as an introduction to statistical analysis with applications relevant to Biomedical Engineering. Students utilize software to analyze and interpret experimental data.

BME 4007. Biomedical Engineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course introduces the major principles of the life sciences (microbiology, cell biology, and genetics) that are important for biomedical engineering applications. The application of the chemical engineering principles of kinetics, mass transport, bioreactor design, and separation processes to solve the important problems in the biomedical engineering are emphasized.

BME 4082. Biomedical Engineering Ethics (3). Prerequisite: BME 4404C, ECH 3274L, ECH 3418, and ECH 4267. This course is an introduction to the key theories, concepts, principles, and methodology relevant to the development of biomedical engineering professional ethics. The student is facilitated in his/her development of a code of professional ethics through written work, class discussion, and ease analysis.

BME 4211. Biomechanics (3). Prerequisites: "C" grade or better in the following courses: BME 3361, BME 3622, and BME 3702. Corequisites: BME 3100, BME 4503, BME 4503L, and BME 4404C. The course introduces the mechanical behavior of biological tissues and living systems, the mechanical properties of biological materials and its influence on the structure and function of living systems. Methods for the analysis of both rigid body and deformational mechanics are introduced as they apply to biological tissues including bone, muscle, and connective tissues. The course also introduces the methods of continuum mechanics to biomechanical phenomena at cellular to tissue or organ level.

BME 4332. Cell and Tissue Engineering (3). Prerequisites: BME 3100 and BME 3702, and BME 4404C. Corequisite: BME 4801 and BME 4332L. This course covers the application of engineering principles, combined with cell and molecular biology, to develop a fundamental understanding of property-function relationships in cells and tissues.

BME 4332L. Cell and Tissue Engineering Lab (1). Prerequisites: BME 3100 and BME 3702. Corequisite: BME 4404C. Corequisite BME 4332. This course covers the common techniques and fundamentals of cell culture for use in Biomedical Engineering investigations. Students acquire basic skills in cell culture, quantitative cell and molecular analyses, and report writing and oral presentation.

BME 4361. Neural Engineering (3). Prerequisite: Senior undergraduate standing in Biomedical Engineering. This course addresses the application of engineering principles and techniques to the understanding and repairing of the injured, diseased, or degenerated human nervous system.

BME 4403C. Quantitative Physiology I (3). Prerequisites: ME 3009, ECH 3024, ECH 3301, and PHY 2049C. Corequisites: BME 3631, BME 3622, and BME 3702. For training the next-generation biomedical engineers, this course teaches a quantitative understanding of selected topics in human physiology. Emphasis is placed on the use of calculus-based models to simulate physiological systems based on physical, chemical and engineering principles.

BME 4404C. Quantitative Anatomy and Systems Physiology II (3). Prerequisites: BME 3661, BME 3702, BME 4403C, and ECH 3301. Corequisites: BME 4503 and BME 4503L. This is the second of a two-semester course focusing on human quantitative anatomy and systems physiology. Subject matter covers the nervous, digestive, and urinary systems from an engineering perspective and offers training on applying scientific and engineering principles to understanding biological systems and solving biomedical problems.

BME 4503. Bioinstrumentation (3). Prerequisites: BME 3702, BME 4403C. Corequisite: BME 4404C. This course is an overview of instrumentation used in clinical and biomedical research. The course reviews circuit theory and its application to systems measuring for biopotentials, stress and strain, pressure, temperature, and optical properties.

BME 4503L. Bioinstrumentation Laboratory (1). Prerequisites: BME 3702, BME 4403C. This laboratory course provides hands-on use and construction of components and instrumentation used in clinical and biomedical research. The laboratory focuses on electrical components, transducers/sensors, and control systems.

BME 4508. Biosignals and Systems (3). Prerequisites: BME 3702, BME 4503, and BME 4503L. This course introduces fundamental concepts of signal processing, particularly linear systems, and stochastic processes.

BME 4531. Medical Imaging (3). Prerequisites: BME 3702, BME 4404C, BME 4503, and BME 4503L. Corequisite: BME 4531L. This course examines the fundamentals and applications of five biomedical imaging techniques: x-ray imaging and computed tomography, nuclear medicine, magnetic resonance imaging, and ultrasound and optical imaging.

BME 4531L. Medical Imaging Lab (1). Prerequisites: BME 3702, BME 4404C, BME 4503 and BME 4503L. Corequisite: BME 4531. This laboratory provides hands-on use and construction of software, components, and instrumentation used in medical imaging.

BME 4581. BioMEMS (3). Prerequisites: BME 3100, BME 4211, and BME 4503. This course introduces students to the physical fundamentals and working principles of micro-electromechanical systems (MEMS) and how to apply them to biomedical engineering problems.

BME 4744C. Biodynamics and Systems Control (4). Prerequisites: BME 3702, BME 4211, and BME 4503. This combined lecture and lab course focuses on the dynamic analysis and measurement of the human musculoskeletal system through the development of lumped mass, planar rigid body and 3D rigid body models of human movement and the use of control systems in analyzing and responding to this movement.

BME 4801. Biomedical Engineering Process Design I (3). Prerequisites: BME 3100, BME 4211, BME 4404C, BME 4503 and BME 4503L. This course is the first of a two-semester sequence on the design of biomedical engineering processes and products. In this course, students will arrive at a technologically feasible solution to an engineering design problem using a methodological approach to gather and evaluate available information leading to a prototype product or process.

BME 4802. Biomedical Engineering Process Design II (3). Prerequisites: BME 4801 and either BME 4332 or BME 4508, depending on the major pathway. This course is the second of a two-semester sequence on the design of biomedical engineering processes and products.

BME 4904r. Undergraduate Research Project (1–3). Prerequisite: BME 3361, BME 3622, BME 3702 and BME 4403C, a 3.0 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six (6) credit hours; repeatable within the same term.

BME 4905r. Directed Individual Study (3). Prerequisite: Department chair permission. This course offers a supervised program of study approved by the department chair. May be repeated to a maximum of twelve (12) semester hours; repeatable within the same term.

BME 4906r. Honors URP in Biomedical Engineering (1–3). Prerequisite: BME 3361, BME 3622, BME 3702 and BME 4403C, a 3.2 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six semester hours. May be repeated within the same semester.

BME 4937r. Special Topics in Biomedical Engineering (3). Prerequisite: BME 3100, BME 4211, BME 4404C, and BME 4503. Corequisite: ECH 4504. This course emphasizes recent developments in the field of biomedical engineering. Selected readings are assigned by the instructor. Structure of the course varies by instructor and topic, but generally involve lectures and a final project on a topic in biomedical engineering. May be repeated to a maximum of twelve semester hours.

CHEMICAL ENGINEERING

ECH 3023. Mass and Energy Balances I (3). Prerequisites: CHM 1046 and MAC 2312. Corequisites: CHM 2210, MAC 2313, and PHY 2048C. This course covers mass and energy balances related to chemical process systems and measurements, as well as to the development of problem-solving methodologies in mass and energy balances.

ECH 3024. Mass and Energy Balances II (4). Prerequisites: CHM 2210, MAC 2313, and PHY 2048C; as well as ECH 3023 with a grade of “C” or higher. Corequisites: BSC 2010, ECH 3301, and PHY 2049C. This course introduces the general concepts of chemical engineering. In this course, the applications of mass and energy balances are extended to include reactive systems, and systems undergoing phase changes as well as transient processes. Computational tools such as Excel and MATLAB are used to demonstrate the use of a structured programming language for material and energy balances.

ECH 3101. Chemical Engineering Thermodynamics (3). Prerequisites: ECH 3023, ECH 3024, and ECH 3301, all with a grade of “C” or higher; and PHY 2049C. Corequisites: ECH 3266 and ECH 3854. In this course, students learn the basics of classical and solution thermodynamics. The course forms the link between the mass and energy balance courses, and separations.

ECH 3266. Transport Phenomena I (3). Prerequisites: ECH 3024 and ECH 3301, both with a grade of “C” or higher; and PHY 2049C. Corequisites: ECH 3101 and ECH 3854. This course examines integral balance equations for conservation of momentum, energy, and mass. Topics include the following: analysis of chemical processes involving fluid flow and heat and mass transfer, estimation of friction factors, and heat and mass transfer coefficients, pump selection and sizing, piping network analysis, and design of heat exchangers.

ECH 3274L. Transport Phenomena Laboratory (3). Prerequisites: ECH 3101, ECH 3266, and ECH 3854. Corequisites: ECH 3418 and ECH 4267. This course enables students to design and conduct experiments on fluid mechanics and heat transfer; analyze and interpret data; apply spreadsheets, statistical methods, and process models; as well as gain proficiency in operating basic chemical-engineering equipment and instruments. Emphasis is placed on safety, professionalism, teamwork, and oral/written communication.

ECH 3301. Process Analysis and Design (4). Prerequisite: MAC 2312. Corequisites: ECH 3023 and MAC 2313. This course examines the development and analysis of process models for systems that arise in chemical engineering applications.

ECH 3418. Separations Processes (3). Prerequisites: ECH 3101, ECH 3266, and ECH 3854. Corequisites: ECH 3274L and ECH 4267. This course examines the principles of equilibrium and transport-controlled separations. Topics include analysis and design of stagewise and continuous separation processes, including distillation, absorption, extraction, filtration, and membrane separations.

ECH 3844. Chemical Engineering Statistics (3). This course introduces basic statistical analysis with an emphasis on applications relevant to Chemical Engineering. Applications covered include design of experiments and analysis of experimental data and modern software tools are utilized.

ECH 3854. Chemical Engineering Computations (4). Prerequisites: ECH 3024, ECH 3301, and PHY 2049C, all with a grade of “C” or higher. Corequisites: ECH 3101, ECH 3266, and ECH 3844. This course utilizes computational modeling (using programs like MATLAB) to understand complex science/engineering problems and design solutions in a timely manner.

ECH 4267. Transport Phenomena II (3). Prerequisites: ECH 3101, ECH 3266, and ECH 3854. Corequisites: ECH 3274L and ECH 3418. This course focuses on the critical analytical and mathematical skills for analyzing fundamental concepts in transport phenomena (including fluid mechanics, heat transfer, and mass transfer) and the application of these concepts to the solution of problems relevant to chemical and biomedical engineering. The focus is on the microscopic description of momentum, energy, and mass transfer to obtain balance equations and to utilize information obtained from solutions of the balance equations to calculate engineering quantities of interest drag force, rate of heat and mass transfer in a wide variety of problems.

ECH 4323. Process Control (3). Prerequisites: ECH 4404L, ECH 4504, and ECH 4604. Corequisite: ECH 4615. This course focuses on the design and implementation of model-based control systems for chemical and biochemical systems. Topics include formulation of dynamic models, time and Laplace domain analysis of open-loop and closed-loop systems, and design of single variable and multivariable controllers. MATLAB and SIMULINK are used for dynamic process simulation and control system development. The lab is comprised of experiments designed to illustrate and apply control theory, measurement techniques, calibration, tuning of controls, characterization of sensors, and control circuits.

ECH 4323L. Process Control Lab (1). Prerequisites: ECH 4404L, ECH 4504, and ECH 4604. Corequisite: ECH 4615. This lab is comprised of experiments designed to illustrate and apply control theory, measurement techniques, calibration, tuning of controls, characterization of sensors, and control circuits.

ECH 4404L. Unit Operations Lab (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4504 and ECH 4604. This course includes activities such as designing and conducting experiments in reaction kinetics and chemical separations, analyzing and interpreting data, applying spreadsheets, statistical methods, and process models. Students gain proficiency in operating basic chemical engineering equipment and instruments. Emphasis on safety, professionalism, teamwork, and oral and written communication.

ECH 4504. Kinetics and Reactor Design (3). Prerequisites: Senior standing in Chemical Engineering and ECH 3274L, ECH 3418, and ECH 4267 or senior standing in Biomedical Engineering and BME 3100, BME 4211, and BME 4503. This course aims to give students a thorough understanding of the fundamentals of chemical reactor design. Isothermal and non-isothermal reactors as well as series and parallel configurations will be considered.

ECH 4604. Chemical Engineering Process Design I (4). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L and ECH 4504. This course is the first in a two-semester sequence on the analysis, synthesis, and design of chemical processes, preparing students for engineering practice. Students integrate knowledge from prior courses with process economics, computer-aided design, engineering standards, and realistic constraints to solve open-ended process problems.

ECH 4615. Chemical Engineering Process Design II (3). Prerequisites: ECH 4404L, ECH 4504, and ECH 4604. Corequisites: ECH 4323 and ECH 4323L. This course is the second in a two-semester sequence on the analysis, synthesis, and design of chemical processes, and prepares students for engineering practice. Students integrate knowledge from prior courses with process economics, computer-aided design, engineering standards, and realistic constraints to the design of chemical-process facilities.

ECH 4705. Electrochemical Engineering Science (3). Prerequisites: Senior standing in Chemical Engineering or instructor permission. In this course, students learn about electrochemistry and electrochemical engineering science and their applications in batteries and fuel cells. Quantitative analysis and the role of transport and kinetics are emphasized.

ECH 4743. Bioengineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course introduces chemical engineering students to the major principles of life sciences that are important for biotechnological applications, and extends and applies the students' knowledge of the chemical engineering principles of kinetics, mass transfer, separation, purification, and characterization to important problems in bioprocess engineering.

ECH 4803. Petroleum Science and Technology (3). Prerequisite: Senior standing in Chemical Engineering or instructor permission. In this course, students learn about petroleum, the most important resource of energy and materials in modern days. This course emphasizes historical developments, technologies and processes used in the petroleum industry (upstream, midstream, and downstream).

ECH 4822. Polymer Physical Science and Engineering (3). Prerequisites: PHY 2048C (or at least one semester of General Physics) or instructor permission. This course is an introduction to static and dynamic polymer physics, including models of chains and macroscopic properties.

ECH 4823. Polymer Science and Engineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course offers an introduction to different types of polymers and their physical properties. Topics include major synthetic paths and reaction kinetics, properties of macromolecules in solution, methods of molecular weight determination, and the role of phase transitions in amorphous and crystalline polymers.

ECH 4824. Chemical Engineering Materials (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course provides an introduction to engineering materials, with emphasis on understanding the relation between structure, processing, and properties.

ECH 4904r. Undergraduate Research Project in Chemical Engineering (1–3). Prerequisites: CHM 4410, ECH 3101, ECH 3266, ECH 3854, a 3.0 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six semester hours.

ECH 4905r. Directed Individual Study (1–3). Prerequisite: Permission of department chair. This is a supervised program of study. May be repeated to a maximum of twelve semester hours.

ECH 4906r. Honors URP in Chemical Engineering (1–3). Prerequisites: BME 4403C, CHM 4410, ECH 3266, ECH 3854, a 3.2 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six (6) credit hours; repeatable within the same term.

ECH 4937r. Special Topics in Chemical Engineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisite: ECH 4504. This course covers selected topics in chemical engineering with emphasis on contemporary developments in the field. May be repeated within the same term to a maximum of twelve semester hours.

ECH 4940r. Interdisciplinary Capstone Product Design (3). Prerequisites: Graduate standing in Chemical Engineering or instructor permission. In this course, students design and construct an engineering product (such as a car powered and stopped by chemical reaction other than combustion) based on technical safety, ethical, economic, environmental, and other considerations. May be repeated up to a maximum of six credit hours.

DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING

CHEMICAL ENGINEERING

BS Degree in Chemical Engineering

Areas of Study (Majors)

In the Bachelor of Science degree (BS) in Chemical Engineering, students may choose between two different areas of study that reflect new directions in the broader field of chemical engineering. These majors include chemical engineering and chemical-materials engineering.

Chemical Engineering. The most common major prepares students for employment or further study in traditional areas of chemical engineering (described above).

Chemical-Materials Engineering. Chemical engineers have extensively developed and studied the molecular structures and dynamics of materials—including solids, liquids, and gases—to develop macroscopic descriptions of the behavior of such materials. In turn, these macroscopic descriptions have allowed the construction and analysis of unit processes that facilitate desired chemical and physical changes. This constant interplay between molecular scale understanding and macroscopic descriptions is unique and central to the field of chemical engineering. The materials major provides additional elective courses in polymers and other materials as described below.

Requirements for a BS Degree in Chemical Engineering

A program of study encompassing at least 128 credit hours is required for the Bachelor of Science (BS) degree in chemical engineering. A candidate for the bachelor's degree is required to earn a "C" or higher in all engineering courses and must achieve a 2.0 grade point average (GPA) in all of the chemical engineering major courses. In addition, students must achieve a grade of "C–" or higher in all courses transferred into the Department of Chemical and Biomedical Engineering. Students should contact the department for the most up-to-date information concerning the chemical engineering curriculum requirements.

There are two majors within the chemical engineering bachelor's degree program. These include Chemical Engineering and Chemical-Materials Engineering. Most of the curriculum is common to both majors, and includes topics in CoreFSU Curriculum, mathematics, basic science, computer science, advanced chemistry, general engineering science, and chemical engineering science and design. History/social science/humanities electives are to be selected to satisfy the CoreFSU Curriculum requirement. Students in both majors should successfully complete the following courses in addition to the CoreFSU Curriculum, other University, and College of Engineering requirements:

Math and Science Prerequisites

MAC 2311 Calculus with Analytic Geometry I (4)

MAC 2312 Calculus with Analytic Geometry II (4)

MAC 2313 Calculus with Analytic Geometry III (5)

ECH 3301 Process Analysis and Design (4)

BSC 2010 Biological Science I (3)

CHM 1045 General Chemistry I (3)

CHM 1045L General Chemistry I Laboratory (1)

CHM 1046 General Chemistry II (3)

CHM 1046L General Chemistry II Laboratory (1)

PHY 2048C General Physics A (combined lecture/lab) (5)

PHY 2049C General Physics B (combined lecture/lab) (5)

Advanced Chemistry

CHM 2210 Organic Chemistry I (3)

CHM 2211 Organic Chemistry II (3)

CHM XXXX Advanced Chemistry Elective (3–4)

General Engineering

EGN 1004L First Year Engineering Lab (1)

EGM 3512 Engineering Mechanics (4)

EEL 3003 Introduction to Electrical Engineering (3)

Chemical Engineering Science and Design

ECH 3023 Mass and Energy Balances I (3)

ECH 3024 Mass and Energy Balances II (4)

ECH 3101 Chemical Engineering Thermodynamics (3)

ECH 3266 Transport Phenomena I (3)

ECH 3274L Transport Phenomena Laboratory (3)

ECH 3418 Separations Processes (3)

ECH 3844 Chemical Engineering Statistics (3)

ECH 3854 Chemical Engineering Computations (4)

ECH 4267 Transport Phenomena II (3)

ECH 4323 Process Control (3)

ECH 4323L Process Control Laboratory (1)

ECH 4404L Unit Operations Laboratory (3)

ECH 4504 Kinetics and Reactor Design (3)

ECH 4604 Chemical Engineering Process Design I (4)

ECH 4615 Chemical Engineering Process Design II (3)

ECH 4XXX Chemical Engineering Electives (6) (for Chemical Engineering and Chemical-Materials Engineering Majors)

Major Requirements

In addition to the courses listed above that are required for all majors, the following courses are specifically required for the two majors.

Major in Chemical Engineering

Advanced Chemistry Elective

The advanced chemistry elective is to be selected from the following courses offered in the Department of Chemistry and Biochemistry or selected other courses in either chemical engineering or biological sciences specifically approved by the Chair of the Department of Chemical and Biomedical Engineering.

Select from one of the following choices:

CHM 3120 Analytical Chemistry I (3)

CHM 4080 Environmental Chemistry I (3)

CHM 4081 Environmental Chemistry II (3)

CHM 4410 Physical Chemistry I (3)

CHM 4411 Physical Chemistry II (3)

CHM 2211L Organic Chemistry II Laboratory (3)

BCH 4053 General Biochemistry I (3)

ECH 4XXX Approved Advanced Chemistry Course taught in the CBE Department

Chemical Engineering Electives

The two chemical engineering electives (three credit hours each) are to be selected from the 4000-level elective courses offered in the Department of Chemical and Biomedical Engineering.

Note: A six credit-hour sequence in the Department's Undergraduate Research Program (URP), consisting of the course designations ECH 4904 (ECH URP), or ECH 4906 (ECH Honors in the Major), will substitute for this requirement.

Major in Chemical-Materials Engineering

Advanced Chemistry Elective

CHM 3120 Analytical Chemistry I (3)

ECH 4XXX Approved Advanced Chemical Engineering Course taught in the CBE Department

Chemical Engineering Electives

ECH 4705 Electrochemical Engineering Science (3)

ECH 4803 Petroleum Science and Engineering (3)

ECH 4822 Polymer Physical Science and Engineering (3)

ECH 4823 Introduction to Polymer Science and Engineering (3)

ECH 4824 Chemical Engineering Materials (3)

ECH 4825 Polymer Process Engineering (3)

ECH 4937 Special Topics in Chemical Engineering (3) or other approved elective (3)

ECH 4940 Interdisciplinary Capstone Product Design (3)

Note: A six credit hour sequence in the Department's Undergraduate Research Program, consisting of the course designations ECH 4904 (ECH - URP), ECH 4906 (ECH - Honors in the Major), will substitute for the Chemical Engineering Electives requirement.

Definition of Prefixes

BME—Biomedical Engineering

ECH—Engineering: Chemical

EGN—Engineering: General

EGS—Engineering: Support

Undergraduate Courses

BIOMEDICAL ENGINEERING

BME 3009. Introduction to Biomedical Engineering (3). Prerequisites: BSC 2010, MAC 2312, and PHY 2048C, all with a grade of “C” or higher. Corequisites: ECH 3024, ECH 3301, MAC 2313, and PHY 2049C. This course presents an introduction to the field of biomedical engineering, building on previous basic coursework in biological science, physics, and calculus. Topics in cell physiology and modeling, bioinstrumentation, biomaterials, tissue engineering, and bioimaging are covered. The course provides sophomore-level biomedical engineering students with both fundamentals and applications in contemporary biomedical science and engineering.

BME 3100 Biomaterials (3). Prerequisites: BME 3361, BME 3622, BME 3702, and BME 4403C. Corequisites: BME 4211, BME 4503, BME 4503L, and BME 4404C. This course introduces fundamental concepts of biomaterials science and engineering. The course covers the basic properties of major classes of biomaterials including natural, polymeric, metallic, ceramic, carbon-based, composite, and nano-biomaterials. It also presents critical interactions between the biomaterials and biological systems, such as biocompatibility of biomaterials and foreign body reaction of the host to biomaterials. Since characterization tools are indispensable for biomaterials science and engineering, major techniques for characterizing biomaterials are taught, with an emphasis on introducing their basic principles.

BME 3622. Biothermodynamics (3). Prerequisites: “C” grade or better in ECH 3024, ECH 3301, PHY 2049C, and BME 3009. Corequisites: BME 3361, BME 3702, and BME 4403C. This course covers the fundamental principles of thermodynamics and their application to biochemical, cellular, and physiological function. In addition, the principles of chemical kinetics of biochemical reactions and metabolic reaction networks are addressed.

BME 3631. Biotransport Phenomena (3). Prerequisites: BME 3009E, ECH 3024, ECH 3301, and PHY 2049C. Corequisites: BME 3622, BME 3702, and BME 4403C. This course presents the fundamental concepts of transport phenomena in biological systems and applies these concepts to the solutions of problems relevant to biomedical engineering.

BME 3702. Biocomputations (4). Prerequisites: BME 3009, CHM 2210, ECH 3024, ECH 3301, and PHY 2049C all with a grade of “C” or higher. Corequisites: BME 3361, BME 3622, and BME 4403C. In this course, students learn to apply computational tools to address some biomedical processes and phenomena. For those that involve concurrent cellular and molecular processes (e.g., blood clotting), computational modelling is almost the only solution thus far to glimpse what is happening at different spatiotemporal scales.

BME 3723. Statistics for Biomedical Engineers (3). Prerequisites: BME 3009 and ECH 3024 (C or better). Corequisites: BME 3100, BME 4211, BME 4503, and BME 4503L. This course serves as an introduction to statistical analysis with applications relevant to Biomedical Engineering. Students utilize software to analyze and interpret experimental data.

BME 4007. Biomedical Engineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course introduces the major principles of the life sciences (microbiology, cell biology, and genetics) that are important for biomedical engineering applications. The application of the chemical engineering principles of kinetics, mass transport, bioreactor design, and separation processes to solve the important problems in the biomedical engineering are emphasized.

BME 4082. Biomedical Engineering Ethics (3). Prerequisite: BME 4404C, ECH 3274L, ECH 3418, and ECH 4267. This course is an introduction to the key theories, concepts, principles, and methodology relevant to the development of biomedical engineering professional ethics. The student is facilitated in his/her development of a code of professional ethics through written work, class discussion, and ease analysis.

BME 4211. Biomechanics (3). Prerequisites: “C” grade or better in the following courses: BME 3361, BME 3622, and BME 3702. Corequisites: BME 3100, BME 4503, BME 4503L, and BME 4404C. The course introduces the mechanical behavior of biological tissues and living systems, the mechanical properties of biological materials and its influence on the structure and function of living systems. Methods for the analysis of both rigid body and deformational mechanics are introduced as they apply to biological tissues including bone, muscle, and connective tissues. The course also introduces the methods of continuum mechanics to biomechanical phenomena at cellular to tissue or organ level.

BME 4332. Cell and Tissue Engineering (3). Prerequisites: BME 3100 and BME 3702, and BME 4404C. Corequisite: BME 4801 and BME 4332L. This course covers the application of engineering principles, combined with cell and molecular biology, to develop a fundamental understanding of property-function relationships in cells and tissues.

BME 4332L. Cell and Tissue Engineering Lab (1). Prerequisites: BME 3100 and BME 3702. Corequisite: BME 4404C. Corequisite BME 4332. This course covers the common techniques and fundamentals of cell culture for use in Biomedical Engineering investigations. Students acquire basic skills in cell culture, quantitative cell and molecular analyses, and report writing and oral presentation.

BME 4361. Neural Engineering (3). Prerequisite: Senior undergraduate standing in Biomedical Engineering. This course addresses the application of engineering principles and techniques to the understanding and repairing of the injured, diseased, or degenerated human nervous system.

BME 4403C. Quantitative Physiology I (3). Prerequisites: ME 3009, ECH 3024, ECH 3301, and PHY 2049C. Corequisites: BME 3631, BME 3622, and BME 3702. For training the next-generation biomedical engineers, this course teaches a quantitative understanding of selected topics in human physiology. Emphasis is placed on the use of calculus-based models to simulate physiological systems based on physical, chemical and engineering principles.

BME 4404C. Quantitative Anatomy and Systems Physiology II (3). Prerequisites: BME 3661, BME 3702, BME 4403C, and ECH 3301. Corequisites: BME 4503 and BME 4503L. This is the second of a two-semester course focusing on human quantitative anatomy and systems physiology. Subject matter covers the nervous, digestive, and urinary systems from an engineering perspective and offers training on applying scientific and engineering principles to understanding biological systems and solving biomedical problems.

BME 4503. Bioinstrumentation (3). Prerequisites: BME 3702, BME 4403C. Corequisite: BME 4404C. This course is an overview of instrumentation used in clinical and biomedical research. The course reviews circuit theory and its application to systems measuring for biopotentials, stress and strain, pressure, temperature, and optical properties.

BME 4503L. Bioinstrumentation Laboratory (1). Prerequisites: BME 3702, BME 4403C. This laboratory course provides hands-on use and construction of components and instrumentation used in clinical and biomedical research. The laboratory focuses on electrical components, transducers/sensors, and control systems.

BME 4508. Biosignals and Systems (3). Prerequisites: BME 3702, BME 4503, and BME 4503L. This course introduces fundamental concepts of signal processing, particularly linear systems, and stochastic processes.

BME 4531. Medical Imaging (3). Prerequisites: BME 3702, BME 4404C, BME 4503, and BME 4503L. Corequisite: BME 4531L. This course examines the fundamentals and applications of five biomedical imaging techniques: x-ray imaging and computed tomography, nuclear medicine, magnetic resonance imaging, and ultrasound and optical imaging.

BME 4531L. Medical Imaging Lab (1). Prerequisites: BME 3702, BME 4404C, BME 4503 and BME 4503L. Corequisite: BME 4531. This laboratory provides hands-on use and construction of software, components, and instrumentation used in medical imaging.

BME 4581. BioMEMS (3). Prerequisites: BME 3100, BME 4211, and BME 4503. This course introduces students to the physical fundamentals and working principles of micro-electromechanical systems (MEMS) and how to apply them to biomedical engineering problems.

BME 4744C. Biodynamics and Systems Control (4). Prerequisites: BME 3702, BME 4211, and BME 4503. This combined lecture and lab course focuses on the dynamic analysis and measurement of the human musculoskeletal system through the development of lumped mass, planar rigid body and 3D rigid body models of human movement and the use of control systems in analyzing and responding to this movement.

BME 4801. Biomedical Engineering Process Design I (3). Prerequisites: BME 3100, BME 4211, BME 4404C, BME 4503 and BME 4503L. This course is the first of a two-semester sequence on the design of biomedical engineering processes and products. In this course, students will arrive at a technologically feasible solution to an engineering design problem using a methodological approach to gather and evaluate available information leading to a prototype product or process.

BME 4802. Biomedical Engineering Process Design II (3). Prerequisites: BME 4801 and either BME 4332 or BME 4508, depending on the major pathway. This course is the second of a two-semester sequence on the design of biomedical engineering processes and products.

BME 4904r. Undergraduate Research Project (1–3). Prerequisite: BME 3361, BME 3622, BME 3702 and BME 4403C, a 3.0 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six (6) credit hours; repeatable within the same term.

BME 4905r. Directed Individual Study (3). Prerequisite: Department chair permission. This course offers a supervised program of study approved by the department chair. May be repeated to a maximum of twelve (12) semester hours; repeatable within the same term.

BME 4906r. Honors URP in Biomedical Engineering (1–3). Prerequisite: BME 3361, BME 3622, BME 3702 and BME 4403C, a 3.2 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six semester hours. May be repeated within the same semester.

BME 4937r. Special Topics in Biomedical Engineering (3). Prerequisite: BME 3100, BME 4211, BME 4404C, and BME 4503. Corequisite: ECH 4504. This course emphasizes recent developments in the field of biomedical engineering. Selected readings are assigned by the instructor. Structure of the course varies by instructor and topic, but generally involve lectures and a final project on a topic in biomedical engineering. May be repeated to a maximum of twelve semester hours.

CHEMICAL ENGINEERING

ECH 3023. Mass and Energy Balances I (3). Prerequisites: CHM 1046 and MAC 2312. Corequisites: CHM 2210, MAC 2313, and PHY 2048C. This course covers mass and energy balances related to chemical process systems and measurements, as well as to the development of problem-solving methodologies in mass and energy balances.

ECH 3024. Mass and Energy Balances II (4). Prerequisites: CHM 2210, MAC 2313, and PHY 2048C; as well as ECH 3023 with a grade of "C" or higher. Corequisites: BSC 2010, ECH 3301, and PHY 2049C. This course introduces the general concepts of chemical engineering. In this course, the applications of mass and energy balances are extended to include reactive systems, and systems undergoing phase changes as well as transient processes. Computational tools such as Excel and MATLAB are used to demonstrate the use of a structured programming language for material and energy balances.

ECH 3101. Chemical Engineering Thermodynamics (3). Prerequisites: ECH 3023, ECH 3024, and ECH 3301, all with a grade of "C" or higher; and PHY 2049C. Corequisites: ECH 3266 and ECH 3854. In this course, students learn the basics of classical and solution thermodynamics. The course forms the link between the mass and energy balance courses, and separations.

ECH 3266. Transport Phenomena I (3). Prerequisites: ECH 3024 and ECH 3301, both with a grade of "C" or higher; and PHY 2049C. Corequisites: ECH 3101 and ECH 3854. This course examines integral balance equations for conservation of momentum, energy, and mass. Topics include the following: analysis of chemical processes involving fluid flow and heat and mass transfer, estimation of friction factors, and heat and mass transfer coefficients, pump selection and sizing, piping network analysis, and design of heat exchangers.

ECH 3274L. Transport Phenomena Laboratory (3). Prerequisites: ECH 3101, ECH 3266, and ECH 3854. Corequisites: ECH 3418 and ECH 4267. This course enables students to design and conduct experiments on fluid mechanics and heat transfer; analyze and interpret data; apply spreadsheets, statistical methods, and process models; as well as gain proficiency in operating basic chemical-engineering equipment and instruments. Emphasis is placed on safety, professionalism, teamwork, and oral/written communication.

ECH 3301. Process Analysis and Design (4). Prerequisite: MAC 2312. Corequisites: ECH 3023 and MAC 2313. This course examines the development and analysis of process models for systems that arise in chemical engineering applications.

ECH 3418. Separations Processes (3). Prerequisites: ECH 3101, ECH 3266, and ECH 3854. Corequisites: ECH 3274L and ECH 4267. This course examines the principles of equilibrium and transport-controlled separations. Topics include analysis and design of stagewise and continuous separation processes, including distillation, absorption, extraction, filtration, and membrane separations.

ECH 3844. Chemical Engineering Statistics (3). This course introduces basic statistical analysis with an emphasis on applications relevant to Chemical Engineering. Applications covered include design of experiments and analysis of experimental data and modern software tools are utilized.

ECH 3854. Chemical Engineering Computations (4). Prerequisites: ECH 3024, ECH 3301, and PHY 2049C, all with a grade of "C" or higher. Corequisites: ECH 3101, ECH 3266, and ECH 3844. This course utilizes computational modeling (using programs like MATLAB) to understand complex science/engineering problems and design solutions in a timely manner.

ECH 4267. Transport Phenomena II (3). Prerequisites: ECH 3101, ECH 3266, and ECH 3854. Corequisites: ECH 3274L and ECH 3418. This course focuses on the critical analytical and mathematical skills for analyzing fundamental concepts in transport phenomena (including fluid mechanics, heat transfer, and mass transfer) and the application of these concepts to the solution of problems relevant to chemical and biomedical engineering. The focus is on the microscopic description of momentum, energy, and mass transfer to obtain balance equations and to utilize information obtained from solutions of the balance equations to calculate engineering quantities of interest drag force, rate of heat and mass transfer in a wide variety of problems.

ECH 4323. Process Control (3). Prerequisites: ECH 4404L, ECH 4504, and ECH 4604. Corequisite: ECH 4615. This course focuses on the design and implementation of model-based control systems for chemical and biochemical systems. Topics include formulation of dynamic models, time and Laplace domain analysis of open-loop and closed-loop systems, and design of single variable and multivariable controllers. MATLAB and SIMULINK are used for dynamic process simulation and control system development. The lab is comprised of experiments designed to illustrate and apply control theory, measurement techniques, calibration, tuning of controls, characterization of sensors, and control circuits.

ECH 4323L. Process Control Lab (1). Prerequisites: ECH 4404L, ECH 4504, and ECH 4604. Corequisite: ECH 4615. This lab is comprised of experiments designed to illustrate and apply control theory, measurement techniques, calibration, tuning of controls, characterization of sensors, and control circuits.

ECH 4404L. Unit Operations Lab (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4504 and ECH 4604. This course includes activities such as designing and conducting experiments in reaction kinetics and chemical separations, analyzing and interpreting data, applying spreadsheets, statistical methods, and process models. Students gain proficiency in operating basic chemical engineering equipment and instruments. Emphasis on safety, professionalism, teamwork, and oral and written communication.

ECH 4504. Kinetics and Reactor Design (3). Prerequisites: Senior standing in Chemical Engineering and ECH 3274L, ECH 3418, and ECH 4267 or senior standing in Biomedical Engineering and BME 3100, BME 4211, and BME 4503. This course aims to give students a thorough understanding of the fundamentals of chemical reactor design. Isothermal and non-isothermal reactors as well as series and parallel configurations will be considered.

ECH 4604. Chemical Engineering Process Design I (4). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L and ECH 4504. This course is the first in a two-semester sequence on the analysis, synthesis, and design of chemical processes, preparing students for engineering practice. Students integrate knowledge from prior courses with process economics, computer-aided design, engineering standards, and realistic constraints to solve open-ended process problems.

ECH 4615. Chemical Engineering Process Design II (3). Prerequisites: ECH 4404L, ECH 4504, and ECH 4604. Corequisites: ECH 4323 and ECH 4323L. This course is the second in a two-semester sequence on the analysis, synthesis, and design of chemical processes, and prepares students for engineering practice. Students integrate knowledge from prior courses with process economics, computer-aided design, engineering standards, and realistic constraints to the design of chemical-process facilities.

ECH 4705. Electrochemical Engineering Science (3). Prerequisites: Senior standing in Chemical Engineering or instructor permission. In this course, students learn about electrochemistry and electrochemical engineering science and their applications in batteries and fuel cells. Quantitative analysis and the role of transport and kinetics are emphasized.

ECH 4743. Bioengineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course introduces chemical engineering students to the major principles of life sciences that are important for biotechnological applications, and extends and applies the students' knowledge of the chemical engineering principles of kinetics, mass transfer, separation, purification, and characterization to important problems in bioprocess engineering.

ECH 4803. Petroleum Science and Technology (3). Prerequisite: Senior standing in Chemical Engineering or instructor permission. In this course, students learn about petroleum, the most important resource of energy and materials in modern days. This course emphasizes historical developments, technologies and processes used in the petroleum industry (upstream, midstream, and downstream).

ECH 4822. Polymer Physical Science and Engineering (3). Prerequisites: PHY 2048C (or at least one semester of General Physics) or instructor permission. This course is an introduction to static and dynamic polymer physics, including models of chains and macroscopic properties.

ECH 4823. Polymer Science and Engineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course offers an introduction to different types of polymers and their physical properties. Topics include major synthetic paths and reaction kinetics, properties of macromolecules in solution, methods of molecular weight determination, and the role of phase transitions in amorphous and crystalline polymers.

ECH 4824. Chemical Engineering Materials (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisites: ECH 4404L, ECH 4504, and ECH 4604. This course provides an introduction to engineering materials, with emphasis on understanding the relation between structure, processing, and properties.

ECH 4904r. Undergraduate Research Project in Chemical Engineering (1–3). Prerequisites: CHM 4410, ECH 3101, ECH 3266, ECH 3854, a 3.0 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six semester hours.

ECH 4905r. Directed Individual Study (1–3). Prerequisite: Permission of department chair. This is a supervised program of study. May be repeated to a maximum of twelve semester hours.

ECH 4906r. Honors URP in Chemical Engineering (1–3). Prerequisites: BME 4403C, CHM 4410, ECH 3266, ECH 3854, a 3.2 GPA, and instructor permission. Corequisites: ECH 3274L, ECH 3418, and ECH 4267. This course involves the completion of an Honors Undergraduate Research Program (URP) for six hours with a minimum grade of "C". This program requires independent student research on a topic relevant to biomedical engineering and may be used to satisfy the Chemical Engineering Elective requirement. May be repeated to a maximum of six (6) credit hours; repeatable within the same term.

ECH 4937r. Special Topics in Chemical Engineering (3). Prerequisites: ECH 3274L, ECH 3418, and ECH 4267. Corequisite: ECH 4504. This course covers selected topics in chemical engineering with emphasis on contemporary developments in the field. May be repeated within the same term to a maximum of twelve semester hours.

ECH 4940r. Interdisciplinary Capstone Product Design (3). Prerequisites: Graduate standing in Chemical Engineering or instructor permission. In this course, students design and construct an engineering product (such as a car powered and stopped by chemical reaction other than combustion) based on technical safety, ethical, economic, environmental, and other considerations. May be repeated up to a maximum of six credit hours.

DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING

GRADUATE STUDIES

Information for Graduate Students

FAMU—FSU COLLEGE OF ENGINEERING

Website: https://eng.famu.fsu.edu/cbe

Chair: Bruce R. Locke; **Professors**: Grant, Hallinan, Kalu, Li, Locke, Ramakrishnan, Ramamoorthy, Siegrist, Yeboah; **Associate Professors**: Arnett, Chung, Guan, Mohammadigoushki; **Assistant Professors**: Ali, Driscoll, Liu, Mao, Mysona, Ricarte; **Teaching *Faculty I***: Slauch, Thourson, Wandell; **Teaching Faculty II**: Hunter; **Teaching Faculty III**: Arce; **Professor Emeritus**: Alamo, Collier; **Affiliate Faculty**: Hsu, Sachdeva, Shanbhag, Zheng

Program Overview

The Department of Chemical and Biomedical Engineering at the FAMU-FSU College of Engineering offers the degrees of Doctor of Philosophy (PhD) and Master of Science (MS) in both biomedical and chemical engineering, as well as the Bachelor of Science (BS) degrees in biomedical and chemical engineering. The Department is strongly committed to building a graduate research program of national reputation in both applied and fundamental areas. The faculty believes that graduate programs must be diverse, interdisciplinary, and flexible to prepare biomedical and chemical engineers who can handle the challenging applications in modern research, industry, and society. Major research areas include:

Advanced Materials

Investigate relationships among material structure, processing and performance to develop next-generation technologies addressing critical societal challenges.

Energy, Environment and Sustainability

Develop innovative materials and technologies for energy sustainability, efficient chemical synthesis and waste processing to tackle global challenges.

Life and Health

Use molecular and cellular engineering innovations to enhance drug delivery, tissue engineering, and bioimaging, revolutionizing healthcare through targeted therapies and regenerative medicine.

Theory, Computation and Artificial Intelligence

Apply AI and simulation tools to predict processes, optimize conditions, and transform fields like sustainable materials, pharmaceuticals, and healthcare.

Many of these efforts are conducted in close cooperation with the High Performance Materials Institute (HPMI); Aero-Propulsion, Mechatronics, and Energy (AME) Center; the Institute of Molecular Biophysics (IMB); the FSU Departments of Biological Sciences, Chemistry and Biochemistry, Physics, and Scientific Computing; the National High Magnetic Field Laboratory (NHMFL); the FSU College of Medicine and Department of Biomedical Sciences; the Florida A&M University School of Pharmacy and Pharmaceutical Sciences; as well as with the Departments of Mechanical, Industrial and Manufacturing, and Electrical and Computer Engineering in the College of Engineering.

Please contact the Department of Chemical and Biomedical Engineering at Suite A131, 2525 Pottsdamer Street, Tallahassee, FL, 32310–6046; phone: (850) 410-6149 or (850) 410-6151; fax: (850) 410-6150; e-mail: chemical@eng.famu.fsu.edu; or website: https://eng.famu.fsu.edu/cbe.

Research Facilities

The Department of Chemical and Biomedical Engineering has extensive graduate research laboratory facilities located in the College of Engineering buildings and the university campus. Six undergraduate teaching laboratories, a design classroom, and 15 graduate research laboratories comprise the current physical resources. All laboratories are well equipped with modern experimental apparatus. These facilities include laboratories dedicated to polymer science and engineering; electrochemical engineering; plasma reaction engineering; nuclear magnetic resonance; and cell and tissue engineering.

Research facilities include extensive cell and tissue growth facilities; rheological apparatus; state-of-the-art 3D printers; pulsed and DC power supplies; analytical instruments (GC, UV-IR, spectrophotometers, FTIR, etc.); and analytical microscopes. Process equipment includes various types of gas- and liquid-phase chemical reactors; controlled temperature fermenters; and polymer production reactors also are in these laboratories. Infrastructure includes autoclaves; controlled environment incubators; water polishing systems; refrigerated/heating circulating baths; isotherm ovens; high-purity gas production and mixing systems; refrigerated centrifuges; and additional support equipment.

Faculty and students have access to the FSU Research Computing Center's computing facilities including access to the High-Performance Computing (HPC) cluster. Many faculty are closely affiliated with the world-class National High Magnetic Field Laboratory (https://nationalmaglab.org) and make extensive use of NHMFL resources and instrumentation. Additionally, faculty are affiliated with and maintain laboratories at the Aero-Propulsion, Mechatronics, and Energy Design Center (https://ame.fsu.edu/); the High Performance Materials Institute (https://hpmi.research.fsu.edu/); and the NSF CREST Center for Complex Materials for Multidimensional Additive Processing (CoManD Center, (https://web1.eng.famu.fsu.edu/nsfscholars//crest.html).

Academic Regulations and Procedures for Graduate Students

Selection of Course Plan

Selection of courses for the first term should be done in consultation with the departmental Graduate Committee chair. All students must also register for the departmental seminar listed as a repeatable course BME/ECH 5935 Biomedical/Chemical Engineering Seminar every fall and spring terms. After the first term in the graduate program, the supervising faculty advisor will develop a course plan for MS-thesis and PhD candidates. For course-based MS students, the departmental Graduate Committee chair will assist in developing the course plan, acting as the faculty advisor.

Selection of Faculty Advisor

All full-time graduate students following the MS thesis or PhD options are required to select a research topic and faculty advisor by the end of the first term in which they enter the Department. A form for this purpose is available in Canvas. The completed form should be submitted to the departmental Graduate Coordinator.

The faculty advisor is responsible for directing the student's research and progress toward a degree. Once a faculty advisor has been approved, a supervisory committee should be established, and a program of study prepared in consultation with the faculty professor before the end of the second fall term of enrollment in the graduate program.

Supervisory Committee

The supervisory committee for a master's thesis degree candidate must consist of a minimum of three faculty members with graduate faculty status. The faculty advisor is the chair of the supervisory committee and must be a faculty member from the Department of Chemical and Biomedical Engineering. At least one other member of the committee must be from the Department of Chemical and Biomedical Engineering; the third member of the committee can be from outside the department. Additional members may be appointed to the committee if deemed desirable by the faculty advisor.

The supervisory committee for a doctoral candidate must have at least four members (including faculty advisor) with graduate faculty status. The faculty advisor is the chair of the supervisory committee and must be a faculty member from the Department of Chemical and Biomedical Engineering. Two of the remaining members of the committee must be from the Department of Chemical and Biomedical Engineering, and the fourth member must be from outside the Department and eligible to serve as the University Representative (i.e., tenured faculty with graduate faculty status). Additional members may be appointed if deemed desirable. Members of the supervisory committee must be approved by the committee chair.

PhD Preliminary Examination and Prospectus

All students admitted to the PhD program will be required to take the PhD Preliminary Examination in the first spring term. A research topic will be assigned by the graduate preliminary examination committee. The student must write a research proposal and defend it orally in front of the graduate preliminary-examination committee by the end of the first Spring term, unless otherwise approved by the Graduate Committee. This examination must be passed within two consecutive attempts, or the individual will not be allowed to continue as a doctoral student. For additional details, see PhD Preliminary Examination Requirements on the departmental website.

Upon successful completion of the preliminary examination, the student may continue work toward the PhD degree. Within six terms of admission to the graduate program (within the fourth terms following the PhD preliminary examination), students are expected to present a prospectus detailing their program of study for PhD dissertation work by the end of the third spring term of PhD studies. If this timeframe cannot be met, the student must petition the graduate committee chair for special dispensation, stating specific reasons for the delay. The PhD prospectus will consist of a written plan of research that must be orally defended in a formal presentation before the student's faculty professor and supervisory committee.

The outcome of the prospectus can only be reported as "passed" or "failed." If the student does not pass the PhD prospectus, that student will have one more attempt to pass the PhD prospectus, and normally, the re-examination will require revision to the written document with a repeat of the oral presentation, although individual committees may require only one of the above as deemed appropriate.

In the term after the prospectus completion, the student will receive an increase in stipend and should complete all dissertation work within the following two academic years.

The doctoral committee should provide continual feedback to the PhD candidate throughout the progression of the student's research. As such, it is important to maintain regular and at minimum annual meetings of the student and doctoral committee so that updates on research can be presented and feedback can be received by the student. For additional details, see Academic Regulations and Procedures for Graduate Students at https://eng.famu.fsu.edu/cbe/graduate-resources.

Maintenance of Good Standing

To maintain good standing in the department, the student must maintain an overall GPA of at least 3.0, with no more than two grades in the "C" range. No more than one course with a grade of "C" will be counted toward fulfilling the degree requirements. No grades below "C" will be counted toward degree requirements.

Thesis master's and doctoral degree students must submit a brief written annual report on research progress, goals, and completed courses during each spring term for evaluation by the graduate and supervisory committees. A form for this purpose is available on the departmental Canvas site. An assessment of the progress of the student in research and courses by the student's supervisory committee will be placed in the student's permanent file. Continuance of assistantships and/or tuition waivers is contingent upon satisfactory evaluations.

Time to Degree Completion

Students with undergraduate degrees in biomedical or chemical engineering normally complete the thesis-type master's program in four to five terms, including one summer term. Although the availability of departmental support ultimately is subject to budgetary constraints, the Graduate Committee will not normally recommend continuation of assistantships and tuition waivers beyond a period of two years after the student's admission to the master's program. Students without an undergraduate degree in biomedical or chemical engineering will be given one additional year for completion. However, these students are normally not supported financially during their first year, when they are primarily taking preparatory undergraduate chemical/biomedical engineering courses. In some cases, students without appropriate undergraduate background will take undergraduate classes prior to admission into the graduate program, and once admitted, will follow the same rules as first year graduate students

Students with undergraduate degrees in biomedical or chemical engineering normally complete the doctoral program within five years of their admission to graduate school, with reduced time expected if the student enters the program with a master's degree. Although the availability of departmental support ultimately is subject to budgetary constraints, departmental/college commitments, and research grant availability, doctoral candidates will be recommended for departmental support only for a period of four years after being admitted initially to candidacy for the doctoral program following the successful completion of the PhD Preliminary Examination. PhD students should submit and defend a prospectus on the dissertation topic to the supervisory committee within no later than six terms from admission to the graduate program.

Assistantship Duties

Graduate student support is generally in the form of research or teaching assistantships (Graduate Research Assistant, Graduate Teaching Assistant, Graduate Assistant in Teaching) https://hr.fsu.edu/sections/employee-data-management/ops-appointments/graduate-assistants-modifiers-and-class-codes). University and College fellowships are also available on a highly competitive basis. Graduate Research Assistantships supported by contracts and grants focus mainly on the performance of research leading to their degree. However, graduate research assistants who receive departmental support for tuition waivers may be required to grade or run recitation sections for lecture courses in addition to research responsibilities. Doctoral candidates will also need to satisfy the teaching requirements of the degree by performing teaching assistantship duties for one laboratory course. The duties of graduate assistants in teaching include grading homework and projects, conducting problem-solving recitation sections, and having office hours for answering student questions in support of a faculty member responsible for the class. There may be opportunities for graduate students to be Graduate Teaching Assistants where they have instructor of record responsibilities for an entire class, and these are restricted to eligible graduate students who have completed the necessary number of graduate level courses.estricted to eligible graduate students who have completed the necessary number of graduate level courses.

DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING

GRAD BME PROGRAM

Information for Graduate Students in Biomedical Engineering

FAMU—FSU COLLEGE OF ENGINEERING

Dramatic advances in health care and medical technology made possible by the merger of engineering and medicine have prompted the development of new graduate degree programs in biomedical engineering at many of the top institutions in the United States. The overall goal of this program is to implement education and research in biomedical engineering that will prepare graduates for industrial, governmental, and academic careers in clinical research, bioengineering, biotechnology, and related professions. Biomedical engineers analyze and design solutions to problems in medicine and biology, with the goal of improving the quality and effectiveness of patient care.

The graduate program in biomedical engineering (BME) provides special emphasis in bioimaging, biomaterials, and cell and tissue engineering. Advanced engineering, medicine, chemistry, physics, and biology students will gain the necessary knowledge and skills that will allow them to contribute to improved technology in health and medical care and to solve real-world engineering problems in biology and medicine, both in research and industrial settings.

The thesis and non-thesis MS degrees require 30 credit hours for completion, while the PhD requires a total of 57 credit hours.

Master of Science (MS)

Admission Requirements

Admission to the MS program requires:

- A baccalaureate degree in chemical/biomedical engineering or an allied field from an accredited college or university. Depending on the student's academic background, certain undergraduate classes might have to be taken to prepare for the chemical/biomedical engineering graduate curriculum.
- An undergraduate upper-division GPA or graduate GPA of 3.0 (on a 4.0 scale) or higher
- CV/Resume-Information should be current.
- Statement of Purpose – Outlining your research and career goals. We want to know how your background and prior training make you the right candidate and why FAMU-FSU College of Engineering is a good fit for you.
- Two Letters of Recommendation – Academics or professionals who can comment on the academic and research potential of the applicant

Credit Requirements

International Credit Requirements — International applicants or degrees earned from international institutions must submit official transcripts through a NACES approved evaluator. We recommend using SpanTran for your course-by-course evaluation. We are unable to review applications with unofficial transcripts from international institutions. The University will not waive this requirement. For more information visit FSU Graduate School or FAMU Graduate School.

US Credit Requirements — Credits earned from US institutions can be reviewed with unofficial transcripts.

The GRE requirement has been waived (and extended) for all engineering master's applicants through Fall 2026.

For international students, an English Proficiency Score Report is required if:

- The applicant's country's official language is NOT English or
- The applicant did NOT graduate from an accredited US institution with either a bachelor's or master's degree

The following are the minimum scores required for admission to the University:

- Internet based TOEFL (IBTOEFL): 80
- Paper based TOEFL (TOEFL): 550
- International English Language Testing System (Academic IELTS): 6.5
- Pearson Test of English (PTE): 55
- Duolingo: 120
- Cambridge C1 Advanced Level: 180
- Michigan Language Assessment: 55

Students who do not have a bachelor's degree in biomedical engineering may be required to complete a department-designated sequence of undergraduate courses with grade of “B” or higher in each course. Additionally, depending upon the courses taken for the biomedical engineering undergraduate degree, students with undergraduate degrees in biomedical engineering may need to take such undergraduate courses as biotransport phenomena. The department will evaluate the undergraduate transcript and make appropriate recommendations. In all cases, an applicant must have taken a course in differential equations and have completed sequences in basic sciences (biology, chemistry, and physics) prior to their matriculation. Typical undergraduate course sequences (in preparation for graduate courses) may include, but are not limited to, the following courses:

BME 3100 Biomaterials (3)

BME 3266 Biotransport Phenomena (3)

BME 3622 Biothermodynamics (3)

BME 4226 Biomechanics (3)

BME 4403C Quantitative Physiology (3)

BME 4503 Bioinstrumentation (3)

ECH 4504 Kinetics and Reactor Design (3)

If necessary, sophomore pre-requisite classes ECH 3023 (Mass and Energy Balances I), ECH 3024 (Mass and Energy Balances II), and ECH 3301 (Process Analysis and Design) may be required prior to taking the above-listed classes.

In addition, students also should have taken Biological Sciences I (if not included in their degree program). Additional courses in subjects including mathematics, chemistry, physics, and general engineering may also be required. Departmental financial support may not be available for graduate students taking undergraduate courses. Transfer credit from another institution is limited to six credit hours with departmental approval provided that those courses were not already counted towards another degree. Acceptance of equivalent courses is evaluated on a case-by-case basis, following petition to Graduate Committee.

Application Terms and Deadline

Biomedical Engineering-MS (Non-Thesis)	
Term	*Final Deadline*
Spring	1 November
Summer	1 March
Fall	1 July

Biomedical Engineering-MS (Thesis)	
Term	*Final Deadline*
Fall	1 July

Degree Requirements

The Department of Chemical and Biomedical Engineering offers both thesis-type and course-type (non-thesis) options leading to the Master of Science degree, and both master types are required students to complete the total 30 credit hours of coursework. Also, each fall and spring term, all graduate students are required to enroll in and attend BME 5935 Biomedical Engineering Seminar. In addition, all students are required to take required safety training courses and annual refreshers. To prepare for teaching assistant (TA) duties, graduate students are required to attend either the FSU TA training Program, “Essential Policies & Practices for TAs” by the Center for the Advancement of Teaching (CAT) or the College of Engineering Alternate TA training. This requirement is mandatory regardless of the student's classification as a teaching assistant or research assistant. For international graduate students, the SPEAK (Speaking Proficiency English Assessment Kit) is a test for evaluating the English-speaking ability of non-native speakers of English. At FSU, the SPEAK test is administered by the Center for Intensive English Studies to international students who have been appointed or will be appointed as teaching assistants in an academic department at Florida State University. The SPEAK exam requirement must be cleared (scores greater than 45 or 50 for graders or TAs, respectively) before students can serve as teaching assistants.

I. Thesis Option (30 Credit Hours)

This master's degree is awarded upon successful completion of the following requirements:

- Fifteen credit hours of biomedical engineering core courses (see below).
- Nine credit hours of approved electives.
- Six credit hours of the repeatable course listed as BME 5971r Thesis Research.
- Oral defense of the master's thesis, BME 8976 Thesis Defense.
- Registration and attendance at all departmental seminars, listed as the repeatable course BME 5935 Biomedical Engineering Seminar.
- No course with a grade below “C” will be counted toward fulfillment of degree requirements. No more than one course with a grade of “C” will be counted toward fulfillment of degree requirements. The candidate also must complete and defend an original thesis (BME 8976, Thesis Defense).

All BME graduate students must attend either the FSU TA training Program, “Essential Policies & Practices for TAs” by the Center for the Advancement of Teaching (CAT) or the College of Engineering Alternate TA training. This requirement is mandatory regardless of the student's classification as a teaching assistant or research assistant. In addition, all students are required to take the required safety training courses as necessary.

Transfer credit from another institution is limited to six credit hours toward the MS degree and only with departmental approval.

Required Core Courses (15 Credit Hours)

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5261 Advanced Transport Phenomena I (3)

ECH 5840 Advanced Chemical Engineering Mathematics I (3)

ECH 5852 Advanced Chemical Engineering Computations (3)

XXX XXXX Approved course in physiology or cell biology (3)

- An approved course in Physiology or Cell Biology is required for completion of the graduate BME degree. Approved courses include: BME 5XXX Fundamentals of Cell Bioeng., PCB 5137 Advanced Cell Biology; PCB 5204C Cell Physiology (FAMU); PCB 5525 Molecular Biology; PCB 5595 Advanced Molecular Biology; PCB 5795 Sensory Physiology; PCB 5845 Cell and Molecular Neuroscience; and BCH 5405 Molecular Biology. Additional courses may satisfy the physiology/biology requirement but require a petition to the Graduate Committee for approval as a core substitute.

Elective Courses (Nine Credit Hours)

Minimum six credit hours are required to be on the biomedical engineering elective courses' list (BME prefixed courses). Students should consult with their faculty advisor to determine the elective courses offered by the department.

Typical biomedical engineering elective courses:

BME 5314 Bioengineering (3)

BME 5XXX Advanced Biomaterials (3)

BME 5362 Neural Engineering (3)

BME 5937r Special Topics in Biomedical Engineering (3)

BME 6530 NMR and MRI Methods in Biology and Medicine (3)

NOTE: Other elective courses may be found on the department website.

Thesis Hours (6 Credit Hours)

BME 5971 Thesis Research (1- 12) (S/U grade only)

Thesis Defense (0 Credit Hours)

BME 8976 Thesis Defense (0) (P/F grade only)

In addition to the 30 credit hours of coursework and thesis, an oral examination in defense of the thesis (BME 8976) is required for the MS in the biomedical engineering thesis option. At least two hours of thesis research (BME 5971) must be completed during the term of the thesis defense (BME 8976).

II. Non-Thesis (Course) Option (30 Credit Hours)

The non-thesis master's degree is awarded upon successful completion of the following requirements:

- Fifteen credit hours of biomedical engineering core courses (see below).
- Fifteen credit hours of approved electives.
- Registration and attendance at all departmental seminars listed under the repeatable course BME 5935 Biomedical Engineering Seminar.
- No course with a grade below “C” will be counted toward fulfillment of degree requirements. No more than one course with a grade in the “C” range will be counted toward fulfillment of degree requirements.

Transfer credit from another institution is limited to six credit hours toward the MS degree and only with departmental approval.

NOTE: Departmental support is generally not available for students pursuing a non-thesis master's degree.

Required Core Courses (15 Credit Hours)

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5261 Advanced Transport Phenomena I (3)

ECH 5840 Advanced Chemical Engineering Mathematics I (3)

ECH 5852 Advanced Chemical Engineering Computations (3)

XXX XXXX Approved course in physiology or cell biology (3)

- An approved course in Physiology or Cell Biology is required for completion of the graduate BME degree. Approved courses include: BME 5XXX Fundamentals of Cell Bioeng., PCB 5137 Advanced Cell Biology; PCB 5204C Cell Physiology (FAMU); PCB 5525 Molecular Biology; PCB 5595 Advanced Molecular Biology; PCB 5795 Sensory Physiology; PCB 5845 Cell and Molecular Neuroscience; and BCH 5405 Molecular Biology. Additional courses may satisfy the physiology/biology requirement but require a petition to the Graduate Committee for approval as a core substitute.

Elective Courses (15 Credit Hours)

Minimum six credit hours are required to be in biomedical engineering elective courses' list (BME prefixed courses). Students should consult with graduate committee chair to determine the elective courses offered by the department.

Typical biomedical engineering elective courses:

BME 5314 Bioengineering (3)

BME 5XXX Advanced Biomaterials (3)

BME 5362 Neural Engineering (3)

BME 5937r Special Topics in Biomedical Engineering (3)

BME 6530 NMR and MRI Methods in Biology and Medicine (3)

NOTE: Other elective courses may be found on the departmental website.

Doctor of Philosophy (PhD)

Admission Requirements

Admission to the PhD program requires:

A baccalaureate degree in chemical/biomedical engineering or an allied field from an accredited college or university. Depending on the students' academic background certain undergraduate classes might have to be taken to prepare for the chemical/biomedical engineering graduate curriculum.

- An undergraduate upper-division GPA or graduate GPA of 3.0 (on a 4.0 scale) or higher.
- A recommended Graduate Record Examination General Test (GRE) score of a minimum GRE percentile of at least 48% on the verbal portion and 75% on the quantitative portion of the test. However, the decision to admit will be based on a prospective student's entire application package. NOTE: The GRE percentiles of funded graduate students on assistantship are typically higher than these minima. Students can submit the GRE waiver request form if they would like to waive the GRE requirement.
- The CV/Resume-Information should be current.
- A statement of purpose outlining your research and career goals. We want to know how your background and prior training make you the right candidate and why FAMU-FSU College of Engineering is a good fit for you.
- Two letters of recommendation from academics or professionals who can comment on the academic and research potential of the applicant.

Credit Requirements

International Credit Requirements — International applicants or degrees earned from international institutions must submit official transcripts through a NACES approved evaluator. We recommend using SpanTran for your course-by-course evaluation. We are unable to review applications with unofficial transcripts from international institutions. The University will not waive this requirement. For more information visit FSU Graduate School or FAMU Graduate School.

US Credit Requirements — Credits earned from US institutions can be reviewed with unofficial transcripts.

For International students, an English Proficiency Score Report is required if:

- The applicant's country's official language is NOT English or
- The applicant did NOT graduate from an accredited US institution with either a bachelor's or master's degree.

The following are the minimum scores required for admission to the University:

- Internet based TOEFL (IBTOEFL): 80
- Paper based TOEFL (TOEFL): 550
- International English Language Testing System (Academic IELTS): 6.5
- Pearson Test of English (PTE): 55
- Duolingo: 120
- Cambridge C1 Advanced Level: 180
- Michigan Language Assessment: 55

Students who do not have a bachelor's degree in biomedical engineering may be required to complete a department-designated sequence of undergraduate courses with grade of “B” or higher in each course. Additionally, depending upon the courses taken for the biomedical engineering undergraduate degree, students with undergraduate degrees in biomedical engineering may need to take such undergraduate courses as biotransport phenomena. The department will evaluate the undergraduate transcript and make appropriate recommendations. In all cases, an applicant must have taken a course in differential equations and have completed sequences in basic sciences (biology, chemistry, and physics) prior to their matriculation. Typical undergraduate course sequences (in preparation for graduate courses) may include, but are not limited to, the following courses:

BME 3100 Biomaterials (3)

BME 3266 Biotransport Phenomena (3)

BME 3622 Biothermodynamics (3)

BME 4226 Biomechanics (3)

BME 4403C Quantitative Physiology (3)

BME 4503 Bioinstrumentation (3)

ECH 3266 Transport Phenomena (3)

ECH 4504 Kinetics and Reactor Design (3)

If necessary, sophomore pre-requisite classes ECH 3023 (Mass and Energy Balances I), ECH 3024 (Mass and Energy Balances II), and ECH 3301 (Process Analysis and Design) may be required prior to taking the above-listed classes.

In addition, students also should have taken Biological Sciences I (if not included in their degree program). Additional courses in subjects including mathematics, chemistry, physics, and general engineering may also be required. Departmental financial support may not be available for graduate students taking undergraduate courses. Transfer credit from another institution is limited to six credit hours with departmental approval provided that those courses were not already counted towards another degree. Acceptance of equivalent courses is evaluated on a case-by-case basis, following petition to Graduate Committee.

Application Term and Deadline

Biomedical Engineering-PhD		
Term	*Decision Type*	*Final Deadline*
Fall	Early Admissions	12 December
	Full Funding Consideration/Admissions	15 January
	Regular Domestic (USA) Student Admissions	1 May

NOTE: International Applicants living outside of the United States are highly encouraged to apply by January 15 for the Fall semester.

Degree Requirements

Students are required to complete total 57 credit hours in coursework and dissertation research hours. Each fall and spring term, all graduate students are required to enroll in and attend the departmental seminar listed as repeatable course BME 5935 Biomedical Engineering Seminar. In addition, all students are required to take required safety training courses. All graduate students are required to attend either the FSU TA training Program, “Essential Policies & Practices for TAs” by the Center for the Advancement of Teaching (CAT) or the College of Engineering Alternate TA training to prepare for teaching assistant (TA) duties. This requirement is mandatory regardless of the student's classification as a teaching assistant or research assistant. For international graduate students, the SPEAK (Speaking Proficiency English Assessment Kit) is a test for evaluating the English-speaking ability of non-native speakers of English. At FSU, the SPEAK test is administered by the Center for Intensive English Studies to international students who have been appointed or will be appointed as teaching assistants in an academic department at Florida State University. The SPEAK exam requirement must be cleared (scores greater than 45 or 50 for graders or TAs, respectively) before students can serve as teaching assistants or progress to full PhD candidate status by completing the PhD qualifying examination and PhD prospectus.

Required Core Courses (15 Credit Hours)

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5261 Advanced Transport Phenomena I (3)

ECH 5840 Advanced Chemical Engineering Mathematics I (3)

ECH 5852 Advanced Chemical Engineering Computations (3)

XXX XXXX Approved course in physiology or cell biology (3)

- An approved course in Physiology or Cell Biology is required for completion of the graduate BME degree. Approved courses include: BME 5XXX Fundamentals of Cell Bioeng., PCB 5137 Advanced Cell Biology; PCB 5204C - Cell Physiology (FAMU);PCB 5525 Molecular Biology; PCB 5595 - Advanced Molecular Biology; PCB 5795 - Sensory Physiology; PCB 5845 Cell and Molecular Neuroscience; and BCH 5405 Molecular Biology. Additional courses may satisfy the physiology/biology requirement but require a petition to the Graduate Committee for approval as a core substitute.

Elective Courses (15 Credit Hours)

Minimum six credit hours are required to be in biomedical engineering elective courses' list (BME Prefix courses). Students should consult with their faculty advisor to determine the elective courses offered by the department.

Typical biomedical engineering elective courses:

BME 5314 Bioengineering (3)

BME 5XXX Advanced Biomaterials (3)

BME 5362 Neural Engineering (3)

BME 5937r Special Topics in Biomedical Engineering (3)

BME 6530 NMR and MRI Methods in Biology and Medicine (3)

NOTE: Other elective courses may be found on the department website.

Dissertation Hours (27 Credit Hours)

BME 6980 Dissertation (1- 9) (S/U grade only)

Dissertation Defense (0 Credit Hours)

BME 8985 Dissertation Defense (0) (P/F grade only)

In addition to the 30 credit hours of coursework and 27 dissertation hours, an oral examination in defense of the dissertation (BME 8985) is required for the biomedical engineering PhD students. At least two hours of dissertation research (BME 5980) must be completed during the term of the dissertation defense.

Fifty-seven credit hours and the following requirements must be completed successfully for the PhD degree in Biomedical Engineering to be awarded:

- Pass BME 8965: BME Doctoral Preliminary Examination within two consecutive exam attempts (see PhD preliminary examination requirements below for more details). The first attempt would be in the spring term of the first year of PhD studies.
- Successfully complete Responsible Conduct of Research (RCR) training as part of the degree requirements by the end of the first fall term.
- Register and attend at all departmental seminars listed as the repeatable course BME 5935 Biomedical Engineering Seminar every fall and spring term.
- Select a research topic and faculty advisor(s) by the end of first fall term.
- Form a supervisory committee in consultation with the faculty advisor(s) by the end of second fall term.
- Submit and defend a prospectus on the dissertation topic to the supervisory committee no later than the end of the third year of the PhD studies.
- Complete a one-term teaching assistantship (lab TA) in an approved undergraduate laboratory.
- Present a research topic at one local, regional, national, or international professional meeting.
- Submit or publish a minimum of one scholarly article in peer-reviewed journal(s) based on original dissertation research.
- Pass BME 8985 Dissertation Defense. At least two hours of dissertation (BME 6980r) must be completed during the term of the dissertation defense (BME 8985).

No course with a grade below “C” will be counted toward fulfillment of degree requirements. No more than one course with a grade of “C” will be counted toward fulfillment of degree requirements.

Graduate Courses

BIOMEDICAL ENGINEERING

BME 5362. Neural Engineering (3). This course addresses the application of engineering principles and techniques to the understanding and repairing of the injured, diseased, or degenerated human nervous system.

BME 5905r. Directed Individual Study (1–3). Prerequisite: Instructor permission. This course allows students to do a detailed examination of some topic in biomedical engineering. Conducted on a personal basis with the instructor. A maximum of only three (3) credit hours can be used toward the MS or PhD. May be repeated to a maximum of 12 credit hours as topics change; may be repeated within the same term.

BME 5910r. Supervised Research (1-6). (S/U grade only). Prerequisites: Graduate standing in Biomedical Engineering and instructor permission. In this course, students perform a research project required for graduate students. May be repeated up to a maximum of six credit hours.

BME 5935. Biomedical Engineering Seminar (0). (S/U grade only). Prerequisite: Graduate standing in Biomedical Engineering. This seminar consists of presentations by faculty, students, and visiting scientists. Full-time graduate students must enroll each term.

BME 5937r. Special Topics in Biomedical Engineering (3). Prerequisite: Instructor permission. This course is a detailed study of some topic of special interest to biomedical engineers. May be repeated to a maximum of six (6) credit hours; may be repeated within the same semester.

BME 5971r. Master's Thesis Research (1–12). (S/U grade only). This course provides a means of registering for thesis research work and recording progress towards its completion. Student must consult with the academic department for appropriate registration of course credit hours. May be repeated to a maximum of forty-five credit hours; may be repeated within the same term.

BME 6530. NMR and MRI Methods in Biology and Medicine (3). Prerequisite: Doctoral candidate status in Biomedical Engineering. This course investigates MR imaging methods, spin echo methods, Bloch equations, proton diffusion, imaging, and microimaging NMR spectrometers in research.

BME 6980r. Dissertation (1–9). Prerequisite: Admission to doctoral candidacy. This course consists of research on the dissertation topic. May be repeated as often as approved by the supervisory committee to a maximum of twenty-four semester hours; may be repeated within the same semester.

BME 8965r. Doctoral Preliminary Exam (0). (P/F grade only.) Prerequisite: Doctoral candidate status in Biomedical Engineering. All doctoral students must enroll in this course the semester they intend to take the qualifying exam. May be repeated within the same term.

BME 8976. Thesis Defense (0). (P/F grade only.) Prerequisite: Instructor permission. All students must register for this course for the term during which they intend to defend their thesis.

BME 8985. Dissertation Defense (0). (P/F grade only.) Prerequisites: Doctoral candidate status in Biomedical Engineering and instructor permission. This course must be included in the final semester schedule for all doctoral students.

CHEMICAL ENGINEERING

ECH 5000. Graduate Transition for Non-Majors (3). This course provides fundamental connect for student from majors outside of biomedical or chemical engineering prior to enrollment in graduate core courses. The course introduces concepts in mass and energy balances, transport and thermodynamics, with application to relevant problems, to provide this background.

ECH 5052. Research Methods in Chemical Engineering (3). This course for first-term graduate students includes instruction in the performance of scientific research, including problem definition, literature review, project proposal development, laboratory and computational research, oral presentations, technical report writing, and professional conduct.

ECH 5126. Advanced Chemical Engineering Thermodynamics I (3). Prerequisite: ECH 3101 or equivalent. This course presents the fundamental aspects of classical thermodynamics, and its application to multicomponent, multiphase, and chemically reacting systems. Introduction to the thermodynamics of irreversible processes and statistical mechanics.

ECH 5261. Advanced Transport Phenomena I (3). Prerequisite: ECH 5842 or instructor permission. This course examines the development of the fundamental aspects of continuum mechanics in order to describe the transport of momentum, energy, and mass. The basic equations of fluid mechanics are developed, and a number of applications to chemical engineering problems are considered. Also emphasizes boundary conditions at phase interfaces, and derivation of the point and macroscopic balance equations for these transport processes.

ECH 5262. Advanced Transport Phenomena II (3). Prerequisite: ECH 5261. This course is a rigorous analysis of transport phenomena at the micro- and macroscopic scales in systems with mixtures of several components and featuring more than one phase. Boundary layer flows, mixing effects, transport in porous and structured media, transport processes at interfaces.

ECH 5526. Advanced Reactor Design (3). Prerequisite: ECH 4504. This course is a study of catalytic and noncatalytic reactor design for homogeneous and heterogeneous systems. Includes non-ideal flow and mixing, including distribution functions and modeling.

ECH 5706. Electrochemical Engineering Science (3). Prerequisite: Instructor permission. In this course, students learn about electrochemistry and electrochemical engineering science and their applications in batteries and fuel cells. Quantitative analysis and the role of transport and kinetics are emphasized.

ECH 5806. Petroleum Science and Technology (3). Prerequisites: Senior standing in Chemical Engineering or instructor permission. In this course, students learn about petroleum, the most important resource of energy and materials in modern days. This course emphasizes historical developments, technologies and processes used in the petroleum industry (upstream, midstream and downstream).

ECH 5820. Advanced Polymer Physical Science and Engineering (3). Prerequisites: PHY 2048C, and at least one semester of a general physics course or instructor permission. This course is a graduate introduction to static and dynamic polymer physics, including models of chains and macroscopic properties.

ECH 5828. Introduction to Polymer Science and Engineering (3). Prerequisites: Graduate standing and instructor permission. This course explores the classification and characterization of polymeric systems. Topics include the introduction to the physical chemistry, synthesis and reaction kinetics, reaction engineering, characterization, and the processing and properties of polymeric systems.

ECH 5834. Chemical Engineering Materials (3). Prerequisite: Instructor permission. This course introduces engineering materials with emphasis on understanding the relation between structure, processing, and properties.

ECH 5838. X-Ray Structural Characterization of Materials (3). Prerequisite: ECH 4824 or equivalent. This course is an introduction to the structural characterization of materials using X-ray diffraction techniques. It covers crystallographic concepts to describe structures (symmetry, CIF) and discuss diffraction using the reciprocal lattice. It provides hands-on activities in powder and single-crystal X-ray diffraction techniques. Open-source programs are used to analyze the data.

ECH 5840. Advanced Chemical Engineering Mathematics I (3). Prerequisite: ECH 4403 and MAP 3305. This course is an introduction at the graduate level to the mathematical formulation and solution of chemical engineering problems involving transport phenomena and reaction. Course includes dimensional analysis and scaling, linear algebraic, ordinary, and partial differential equations, vector and tensor analysis, Fourier series, Integral (Fourier and Laplace) transforms, boundary value problems.

ECH 5841. Advanced Chemical Engineering Mathematics II (3). Prerequisite: ECH 5840. This course presents advanced mathematical techniques for chemical engineering applications within a unified framework of operator-theoretic methods. Green's functions solution of partial differential equations, regular and singular perturbation techniques, boundary value problems, and boundary-element and finite-element techniques.

ECH 5852. Advanced Chemical Engineering Computations (3). Prerequisites: ECH 5841. This course presents the central concepts of practical numerical analysis techniques and their application to chemical engineering problems. The course includes interpolation and approximation theory, solution of linear and nonlinear systems, solution of ordinary differential and partial differential equations, single step and multi-step methods, stiff systems, and two-point boundary problems.

ECH 5905r. Directed Individual Study (1–3). Prerequisite: Instructor permission. This course is a detailed examination of some topic in chemical engineering. Conducted on a personal basis with the instructor. May be repeated with different topics. Only three semester hours may be used toward the MS degree. May be repeated within the same semester.

ECH 5910. Supervised Research (1–6). (S/U grade only). In this course, students perform a research project required for the non-thesis MS degree.

ECH 5934r. Special Topics in Chemical Engineering (3). Prerequisite: Instructor permission. This course is a detailed study of some topic of special interest to chemical engineers. Typical topics might include: aerosol mechanics, polymer processing, combustion, bioseparations, fluidization. May be repeated to a maximum of six semester hours with different topics. May be repeated in the same semester.

ECH 5935r. Chemical Engineering Seminar (0). (S/U grade only). This seminar consists of presentations by faculty, students, and visiting scientists. Full-time graduate students must enroll each term.

ECH 5971r. Master's Thesis Research (1–12). This course provides a means of registering for thesis research work and recording progress towards its completion. Students must consult with the academic department for appropriate registration of course credit hours. May be repeated to a maximum of forty-five (45) credit hours; repeatable within the same term.

ECH 6980r. Dissertation (1–24). (S/U grade only). Prerequisite: Admission to doctoral candidacy. This course is for research on the dissertation topic. May be repeated as often as approved by the supervisory committee. A maximum of 24 hours can be applied to the doctoral degree. May be repeated within the same semester.

ECH 8965r. Doctoral Preliminary Exam (0). (P/F grade only.) Prerequisite: Doctoral candidate status in Biomedical Engineering. All doctoral students must enroll in this course the semester they intend to take the qualifying exam. May be repeated within the same term.

ECH 8976. Thesis Defense (0). (P/F grade only.) Prerequisites: ECH 5126, ECH 5261, and ECH 5842. Corequisite: ECH 5971r. All students must register for this course for the term in which they intend to defend their thesis.

ECH 8985. Dissertation Defense (0). (P/F grade only.) Corequisite: ECH 6980r. Must be included in the final semester schedule for all doctoral students.

DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING

GRAD CE PROGRAM

Graduate Program in Chemical Engineering

Chemical engineering (ChE) encompasses the development, application, and operation of the processes in which chemical and/or physical changes of material are involved. The work of a chemical engineer is to analyze, develop, design, control, construct, and/or supervise chemical processes in research and development, pilot-scale operations, and industrial production. Chemical engineers are employed in the manufacture of inorganic chemicals (i.e., acids, alkalis, pigments, and fertilizers); organic chemicals (i.e., petrochemicals, polymers, fuels, propellants, pharmaceuticals, and specialty chemicals); biological products (i.e., enzymes, vaccines, biochemicals, biofuels, etc.); foods; semiconductors; and paper.

Chemical engineers with graduate degrees work in a wide range of organizations where their technical skills are needed. These organizations may include local, state, and federal governments; private and public corporations; and education. Chemical engineers are involved in process and plant operation, technical services groups; research and development laboratories; plant design groups; occupational and safety programs; technical sales; technical training; and technical management. Graduate education can lead to careers in the medical sciences, chemical engineering, and other engineering and scientific disciplines, as well as business and law.

The thesis and non-thesis MS degrees require 30 credit hours for completion, while the PhD requires a total of 57 credit hours.

Master of Science (MS)

Admission Requirements

Admission to the Master of Science program requires:

- A baccalaureate degree in chemical/biomedical engineering or an allied field from an accredited college or university. Depending on the student's academic background, certain undergraduate classes might have to be taken to prepare for the chemical/biomedical engineering graduate curriculum.
- An undergraduate upper-division GPA or graduate GPA of 3.0 (on a 4.0 scale) or higher.
- CV/Resume-Information should be current.
- Statement of Purpose – Outlining your research and career goals. We want to know how your background and prior training make you the right candidate and why FAMU-FSU College of Engineering is a good fit for you.
- Two Letters of Recommendation – Academics or professionals who can comment on the academic and research potential of the applicant.

Credit Requirements

International Credit Requirements—International applicants or degrees earned from international institutions must submit official transcripts through a NACES approved evaluator. We recommend using SpanTran for your course-by-course evaluation. We are un-able to review applications with unofficial transcripts from international institutions. The University will not waive this requirement. For more information visit FSU Graduate School or FAMU Graduate School.

US Credit Requirements—Credits earned from US institutions can be reviewed with unofficial transcripts.

The GRE requirement has been waived (and extended) for all engineering master's applicants through Fall 2026.

For international students, an English Proficiency Score Report is required if:

- The applicant's country's official language is NOT English or
- The applicant did NOT graduate from an accredited US institution with either a bachelor's or master's degree.

The following are the minimum scores required for admission to the University:

- Internet based TOEFL (IBTOEFL): 80
- Paper based TOEFL (TOEFL): 550
- International English Language Testing System (Academic IELTS): 6.5
- Pearson Test of English (PTE): 55
- Duolingo: 120
- Cambridge C1 Advanced Level: 180
- Michigan Language Assessment: 55

Students who do not have a bachelor's degree in chemical engineering may be required to complete a department-designated sequence of undergraduate courses with grade of “B” or higher in each course. In all cases, an applicant must have taken a course in differential equations prior to their matriculation and have completed sequences in basic sciences (biology, chemistry, and physics). Typical preparatory undergraduate course-sequences for graduate courses may include, but are not limited to, the following courses:

ECH 3101 Chemical Engineering Thermodynamics (3)

ECH 3266 Transport Phenomena I (3)

ECH 3418 Separations Processes (3)

ECH 3854 Chemical Engineering Computations (3)

ECH 4267 Transport Phenomena II (3)

ECH 4504 Kinetics and Reactor Design (3)

If necessary, sophomore pre-requisite classes ECH 3023 (Mass and Energy Balances I), ECH 3024 (Mass and Energy Balances II), and ECH 3301 (Process Analysis and Design) may be required prior to taking the above listed classes.

Additional courses in subjects including mathematics, chemistry, physics, and general engineering may also be required. Departmental financial support may not be available for graduate students taking undergraduate courses. Transfer credit from another institution is limited to six credit hours with departmental approval provided that those courses were not already counted towards another degree. Acceptance of equivalent courses is evaluated on a case-by-case basis, following petition to the Graduate Committee.

Application Term and Deadline

Chemical Engineering-MS (Non-Thesis)	
Term	*Final Deadline*
Spring	1 November
Summer	1 March
Fall	1 July

Chemical Engineering-MS (Thesis)	
Term	*Final Deadline*
Fall	1 July

Degree Requirements

The Department of Chemical and Biomedical Engineering offers both thesis-type and course-type (non-thesis) options leading to the Master of Science (MS) degree. Each term, all graduate students are required to enroll in and attend ECH 5935 Chemical Engineering Seminar. In addition, all students are required to take safety training courses and annual refreshers. To prepare for any teaching assistant (TA) duties, graduate students are required to attend either the FSU TA training program, “Essential Policies & Practices for TAs” by the Center for the Advancement of Teaching (CAT) or the College of Engineering Alternate TA training. For international graduate students, the SPEAK (Speaking Proficiency English Assessment Kit) is a test for evaluating the English-speaking ability of non-native speakers of English. At FSU, the SPEAK test is administered by the Center for Intensive English Studies to international students who have been appointed or will be appointed as teaching assistants in an academic department at Florida State University. The SPEAK exam requirement must be cleared (scores greater than 45 or 50 for graders or TAs, respectively) before students can serve as teaching assistants.

I. Thesis Option (30 Credit Hours)

The thesis-type master's degree is awarded upon successful completion of the following requirements:

- Fifteen credit hours of chemical engineering core courses (see below)
- Nine credit hours of approved electives
- Six credit hours of the repeatable course listed as ECH 5971 Thesis Research
- Registration and attendance at all departmental seminars, listed under the repeatable course ECH 5935 Chemical Engineering Seminar every fall and spring term
- Oral defense of the master's thesis listed as ECH 8976 Thesis Defense.
- No course with a grade below “C” will be counted toward fulfillment of degree requirements. No more than one course with a grade in the “C” range will be counted toward fulfillment of degree requirements.

Required Core Courses (15 Credit Hours)

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5126 Advanced Chemical Engineering Thermodynamics I (3)

ECH 5261 Advanced Transport Phenomena I (3)

ECH 5840 Advanced Chemical Engineering Mathematics I (3)

ECH 5852 Advanced Chemical Engineering Computations (3)

Elective Courses (Nine Credit Hours)

Minimum six credit hours are required to be in chemical engineering elective courses' list (ECH prefixed courses). Students should consult with the faculty advisor to determine the elective courses offered by the department.

Typical chemical engineering elective courses:

ECH 5262 Advanced Transport Phenomena II (3)

ECH 5526 Advanced Reactor Design (3)

ECH 5706 Electrochemical Engineering Science (3)

ECH 5806 Petroleum Science and Technology (3)

ECH 5820 Polymer Physical Science and Engineering (3)

ECH 5828 Introduction to Polymer Science and Engineering (3)

ECH 5834 Chemical Engineering Materials (3)

ECH 5838 X-Ray Structural Characterization of Materials (3)

ECH 5834 Chemical Engineering Materials (3)

ECH 5841 Advanced Chemical Engineering Mathematics II (3)

ECH 5934r Special Topics in Chemical Engineering (3)

Other elective courses may be found on the department's website.

Thesis Hours (6 Credit Hours)

ECH 5971 Thesis Research (1-12) (S/U grade only)

Thesis Defense (0 Credit Hours)

ECH 8976 Thesis Defense (0) (P/F grade only)

In addition to the 30 credit hours of coursework and thesis, an oral examination in defense of the thesis defense (ECH 8976) is required for the MS in the chemical engineering thesis option. At least two hours of thesis research, listed as repeatable course (ECH 5971) must be registered for concurrently during the term of the thesis defense.

II. Non-Thesis (Course) Option (30 Credit Hours)

The non-thesis master's degree is awarded upon successful completion of the following requirements:

- Fifteen credit hours of chemical engineering core courses (see below),
- Fifteen credit hours of approved electives, and
- Registration and attendance at all departmental seminars, listed under the repeatable course ECH 5935 Chemical Engineering Seminar every fall and spring term
- No course with a grade below “C” will be counted toward fulfillment of degree requirements. No more than one course with a grade in the “C” range will be counted toward fulfillment of degree requirements.

NOTE: Departmental support is generally not available for students pursuing a non-thesis master's degree.

Required Core Courses (15 Credit Hours)

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5126 Advanced Chemical Engineering Thermodynamics I (3)

ECH 5261 Advanced Transport Phenomena I (3)

ECH 5840 Advanced Chemical Engineering Mathematics I (3)

ECH 5852 Advanced Chemical Engineering Computations (3)

Elective Courses (15Credit Hours)

Minimum six credit hours are required to be in chemical engineering elective courses' list (ECH Prefix courses). Students should consult with the graduate committee chair to determine the elective courses offered by the department.

Typical chemical engineering elective courses:

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5262 Advanced Transport Phenomena II (3)

ECH 5526 Advanced Reactor Design (3)

ECH 5706 Electrochemical Engineering Science (3)

ECH 5806 Petroleum Science and Technology (3)

ECH 5820 Polymer Physical Science and Engineering (3)

ECH 5828 Introduction to Polymer Science and Engineering (3)

ECH 5834 Chemical Engineering Materials (3)

ECH 5838 X-Ray Structural Characterization of Materials (3)

ECH 5841 Advanced Chemical Engineering Mathematics II (3)

ECH 5934r Special Topics in Chemical Engineering (3)

Other elective courses may be found on the department's website.

Doctor of Philosophy (PhD)

Admission Requirements

Admission to the PhD program requires:

- A baccalaureate degree in chemical/biomedical engineering or an allied field from an accredited college or university. Depending on the students' academic background certain undergraduate classes might have to be taken to prepare for the chemical/biomedical engineering graduate curriculum.
- An undergraduate upper-division GPA or graduate GPA of 3.0 (on a 4.0 scale) or higher.
- A recommended Graduate Record Examination General Test (GRE) score of a minimum GRE percentile of at least 48% on the verbal portion and 75% on the quantitative portion of the test. However, the decision to admit will be based on a prospective student's entire application package. **NOTE**: The GRE percentiles of funded graduate students on assistantship are typically higher than these minima. Students could submit the GRE waiver request form if they would like to waive the GRE requirement.
- CV/Resume - Information should be current.
- Statement of Purpose – Outlining your research and career goals. We want to know how your background and prior training make you the right candidate and why FAMU-FSU College of Engineering is a good fit for you.
- Two Letters of Recommendation – Two signed letters of recommendation on official letterheads, from academic or professionals who can comment on the academic and research potential of the applicant.

Credit Requirements

International Credit Requirements—International applicants or degrees earned from international institutions must submit official transcripts through a NACES approved evaluator. We recommend using SpanTran for your course-by-course evaluation. We are unable to review applications with unofficial transcripts from international institutions. The University will not waive this requirement. For more information visit FSU Graduate School or FAMU Graduate School.

US Credit Requirements—Credits earned from US institutions can be reviewed with unofficial transcripts.

For International students, an English Proficiency Score Report is required if:

- The applicant's country's official language is NOT English or
- The applicant did NOT graduate from an accredited US institution with either a bachelor's or master's degree.

The following are the minimum scores required for admission to the University:

- Internet based TOEFL (IBTOEFL): 80
- Paper based TOEFL (TOEFL): 550
- International English Language Testing System (Academic IELTS): 6.5
- Pearson Test of English (PTE): 55
- Duolingo: 120
- Cambridge C1 Advanced Level: 180
- Michigan Language Assessment: 55

Students who do not have a bachelor's degree in chemical engineering may be required to complete a department-designated sequence of undergraduate courses with grade of “B” or higher in each course. In all cases, an applicant must have taken a course in differential equations prior to their matriculation and have completed sequences in basic sciences (biology, chemistry, and physics). Typical preparatory undergraduate course-sequences for graduate courses may include, but are not limited to, the following courses:

ECH 3101 Chemical Engineering Thermodynamics (3)

ECH 3266 Transport Phenomena I (3)

ECH 3418 Separations Processes (3)

ECH 3854 Chemical Engineering Computations (3)

ECH 4267 Transport Phenomena II (3)

ECH 4504 Kinetics and Reactor Design (3)

If necessary, sophomore pre-requisite classes ECH 3023 (Mass and Energy Balances I), ECH 3024 (Mass and Energy Balances II), and ECH 3301 (Process Analysis and Design) may be required prior to taking the above-listed classes.

Additional courses in subjects including mathematics, chemistry, physics, and general engineering may also be required. Departmental financial support may not be available for graduate students taking undergraduate courses. Transfer credit from another institution is limited to six credit hours with departmental approval provided that those courses were not already counted towards another degree. Acceptance of equivalent courses is evaluated on a case-by-case basis, following petition to the Graduate Committee.

Application Term and Deadline

Chemical Engineering-PhD		
Term	*Decision Type*	*Final Deadline*
Fall	Early Admissions	12 December
	Full Funding Consideration/Admissions	15 January
	Regular Domestic (USA) Student Admissions	1 May

NOTE: International Applicants living outside of the United States are highly encouraged to apply by January 15 for the Fall semester.

Degree Requirements

Required Core Courses (15 Credit Hours)

ECH 5052 Research Methods in Chemical Engineering (3)

ECH 5126 Advanced Chemical Engineering Thermodynamics I (3)

ECH 5261 Advanced Transport Phenomena I (3)

ECH 5840 Advanced Chemical Engineering Mathematics I (3)

ECH 5852 Advanced Chemical Engineering Computations (3)

Elective Courses (15 Credit Hours)

A minimum of six credit hours are required to be in chemical engineering elective courses' list (ECH prefixed courses). Students should consult with their faculty advisor to determine the elective courses offered by the department.

Typical chemical engineering elective courses

ECH 5262 Advanced Transport Phenomena II (3)

ECH 5526 Advanced Reactor Design (3)

ECH 5706 Electrochemical Engineering Science (3)

ECH 5806 Petroleum Science and Technology (3)

ECH 5820 Polymer Physical Science and Engineering (3)

ECH 5828 Introduction to Polymer Science and Engineering (3)

ECH 5834 Chemical Engineering Materials (3)

ECH 5838 X-Ray Structural Characterization of Materials (3)

ECH 5841 Advanced Chemical Engineering Mathematics II (3)

ECH 5934r Special Topics in Chemical Engineering (3)

Other elective courses may be found on department website.

Dissertation Hours (27 Credit Hours)

ECH 6980 Dissertation (1-24) (S/U grade only)

Dissertation Defense (0 credit hours)

ECH 8985 Dissertation Defense (0) (P/F grade only)

In addition to the 30 credit hours of coursework and 27 dissertation hours, an oral examination in defense of the dissertation (ECH 8985) is required for the chemical engineering PhD students. At least two hours of dissertation research (ECH 6980) must be completed during the term of the dissertation defense.

Fifty-seven credit hours and the following requirements must be completed successfully for the award of the PhD degree in Chemical Engineering:

- Pass ECH 8965 Doctoral Preliminary Examination within two consecutive exam attempts (see PhD Preliminary Examination requirements below for more details). The first attempt would be in the spring term of the first year of PhD studies.
- Successfully complete responsible conduct of research (RCR) training as part of the degree requirements by the end of the first fall term.
- Register and attend at all departmental seminars listed under repeatable course ECH 5935 Chemical Engineering Seminar every fall and spring term
- Select a research topic and faculty advisor(s) by the end of the first fall term
- Form a supervisory committee in consultation with the faculty advisor(s) by the end of second fall term
- Submit and defend of a PhD prospectus on the dissertation topic to the supervisory committee no later than the end of the third year of the PhD studies
- One term teaching assistantship (lab TA) in an approved undergraduate laboratory
- Presentation of a research topic at one local, regional, national, or international professional meeting.
- Submit or publish a minimum of one scholarly article in peer-reviewed journal(s) based on original dissertation research.
- Pass ECH 8985 Dissertation Defense. At least two hours of dissertation (ECH 6980) must be completed during the term of the dissertation defense (ECH 8985).

NOTE: No course with a grade below “C” will be counted toward fulfillment of degree requirements. No more than one course with a grade in the “C” range will be counted toward fulfillment of degree requirements.

Definition of Prefixes

BME—Biomedical Engineering

ECH—Engineering: Chemical

Graduate Courses

BIOMEDICAL ENGINEERING

BME 5362. Neural Engineering (3). This course addresses the application of engineering principles and techniques to the understanding and repairing of the injured, diseased, or degenerated human nervous system.

BME 5905r. Directed Individual Study (1–3). Prerequisite: Instructor permission. This course allows students to do a detailed examination of some topic in biomedical engineering. Conducted on a personal basis with the instructor. A maximum of only three (3) credit hours can be used toward the MS or PhD. May be repeated to a maximum of 12 credit hours as topics change; may be repeated within the same term.

BME 5910r. Supervised Research (1-6). (S/U grade only). Prerequisites: Graduate standing in Biomedical Engineering and instructor permission. In this course, students perform a research project required for graduate students. May be repeated up to a maximum of six credit hours.

BME 5935. Biomedical Engineering Seminar (0). (S/U grade only). Prerequisite: Graduate standing in Biomedical Engineering. This seminar consists of presentations by faculty, students, and visiting scientists. Full-time graduate students must enroll each term.

BME 5937r. Special Topics in Biomedical Engineering (3). Prerequisite: Instructor permission. This course is a detailed study of some topic of special interest to biomedical engineers. May be repeated to a maximum of six (6) credit hours; may be repeated within the same semester.

BME 5971r. Master's Thesis Research (1–12). (S/U grade only). This course provides a means of registering for thesis research work and recording progress towards its completion. Student must consult with the academic department for appropriate registration of course credit hours. May be repeated to a maximum of forty-five credit hours; may be repeated within the same term.

BME 6530. NMR and MRI Methods in Biology and Medicine (3). Prerequisite: Doctoral candidate status in Biomedical Engineering. This course investigates MR imaging methods, spin echo methods, Bloch equations, proton diffusion, imaging, and microimaging NMR spectrometers in research.

BME 6980r. Dissertation (1–9). Prerequisite: Admission to doctoral candidacy. This course consists of research on the dissertation topic. May be repeated as often as approved by the supervisory committee to a maximum of twenty-four semester hours; may be repeated within the same semester.

BME 8965r. Doctoral Preliminary Exam (0). (P/F grade only.) Prerequisite: Doctoral candidate status in Biomedical Engineering. All doctoral students must enroll in this course the semester they intend to take the qualifying exam. May be repeated within the same term.

BME 8976. Thesis Defense (0). (P/F grade only.) Prerequisite: Instructor permission. All students must register for this course for the term during which they intend to defend their thesis.

BME 8985. Dissertation Defense (0). (P/F grade only.) Prerequisites: Doctoral candidate status in Biomedical Engineering and instructor permission. This course must be included in the final semester schedule for all doctoral students.

CHEMICAL ENGINEERING

ECH 5000. Graduate Transition for Non-Majors (3). This course provides fundamental connect for student from majors outside of biomedical or chemical engineering prior to enrollment in graduate core courses. The course introduces concepts in mass and energy balances, transport and thermodynamics, with application to relevant problems, to provide this background.

ECH 5052. Research Methods in Chemical Engineering (3). This course for first-term graduate students includes instruction in the performance of scientific research, including problem definition, literature review, project proposal development, laboratory and computational research, oral presentations, technical report writing, and professional conduct.

ECH 5126. Advanced Chemical Engineering Thermodynamics I (3). Prerequisite: ECH 3101 or equivalent. This course presents the fundamental aspects of classical thermodynamics, and its application to multicomponent, multiphase, and chemically reacting systems. Introduction to the thermodynamics of irreversible processes and statistical mechanics.

ECH 5261. Advanced Transport Phenomena I (3). Prerequisite: ECH 5842 or instructor permission. This course examines the development of the fundamental aspects of continuum mechanics in order to describe the transport of momentum, energy, and mass. The basic equations of fluid mechanics are developed, and a number of applications to chemical engineering problems are considered. Also emphasizes boundary conditions at phase interfaces, and derivation of the point and macroscopic balance equations for these transport processes.

ECH 5262. Advanced Transport Phenomena II (3). Prerequisite: ECH 5261. This course is a rigorous analysis of transport phenomena at the micro- and macroscopic scales in systems with mixtures of several components and featuring more than one phase. Boundary layer flows, mixing effects, transport in porous and structured media, transport processes at interfaces.

ECH 5526. Advanced Reactor Design (3). Prerequisite: ECH 4504. This course is a study of catalytic and noncatalytic reactor design for homogeneous and heterogeneous systems. Includes non-ideal flow and mixing, including distribution functions and modeling.

ECH 5706. Electrochemical Engineering Science (3). Prerequisite: Instructor permission. In this course, students learn about electrochemistry and electrochemical engineering science and their applications in batteries and fuel cells. Quantitative analysis and the role of transport and kinetics are emphasized.

ECH 5806. Petroleum Science and Technology (3). Prerequisites: Senior standing in Chemical Engineering or instructor permission. In this course, students learn about petroleum, the most important resource of energy and materials in modern days. This course emphasizes historical developments, technologies and processes used in the petroleum industry (upstream, midstream and downstream).

ECH 5820. Advanced Polymer Physical Science and Engineering (3). Prerequisites: PHY 2048C, and at least one semester of a general physics course or instructor permission. This course is a graduate introduction to static and dynamic polymer physics, including models of chains and macroscopic properties.

ECH 5828. Introduction to Polymer Science and Engineering (3). Prerequisites: Graduate standing and instructor permission. This course explores the classification and characterization of polymeric systems. Topics include the introduction to the physical chemistry, synthesis and reaction kinetics, reaction engineering, characterization, and the processing and properties of polymeric systems.

ECH 5834. Chemical Engineering Materials (3). Prerequisite: Instructor permission. This course introduces engineering materials with emphasis on understanding the relation between structure, processing, and properties.

ECH 5838. X-Ray Structural Characterization of Materials (3). Prerequisite: ECH 4824 or equivalent. This course is an introduction to the structural characterization of materials using X-ray diffraction techniques. It covers crystallographic concepts to describe structures (symmetry, CIF) and discuss diffraction using the reciprocal lattice. It provides hands-on activities in powder and single-crystal X-ray diffraction techniques. Open-source programs are used to analyze the data.

ECH 5840. Advanced Chemical Engineering Mathematics I (3). Prerequisite: ECH 4403 and MAP 3305. This course is an introduction at the graduate level to the mathematical formulation and solution of chemical engineering problems involving transport phenomena and reaction. Course includes dimensional analysis and scaling, linear algebraic, ordinary, and partial differential equations, vector and tensor analysis, Fourier series, Integral (Fourier and Laplace) transforms, boundary value problems.

ECH 5841. Advanced Chemical Engineering Mathematics II (3). Prerequisite: ECH 5840. This course presents advanced mathematical techniques for chemical engineering applications within a unified framework of operator-theoretic methods. Green's functions solution of partial differential equations, regular and singular perturbation techniques, boundary value problems, and boundary-element and finite-element techniques.

ECH 5852. Advanced Chemical Engineering Computations (3). Prerequisites: ECH 5841. This course presents the central concepts of practical numerical analysis techniques and their application to chemical engineering problems. The course includes interpolation and approximation theory, solution of linear and nonlinear systems, solution of ordinary differential and partial differential equations, single step and multi-step methods, stiff systems, and two-point boundary problems.

ECH 5905r. Directed Individual Study (1–3). Prerequisite: Instructor permission. This course is a detailed examination of some topic in chemical engineering. Conducted on a personal basis with the instructor. May be repeated with different topics. Only three semester hours may be used toward the MS degree. May be repeated within the same semester.

ECH 5910. Supervised Research (1–6). (S/U grade only). In this course, students perform a research project required for the non-thesis MS degree.

ECH 5934r. Special Topics in Chemical Engineering (3). Prerequisite: Instructor permission. This course is a detailed study of some topic of special interest to chemical engineers. Typical topics might include: aerosol mechanics, polymer processing, combustion, bioseparations, fluidization. May be repeated to a maximum of six semester hours with different topics. May be repeated in the same semester.

ECH 5935r. Chemical Engineering Seminar (0). (S/U grade only). This seminar consists of presentations by faculty, students, and visiting scientists. Full-time graduate students must enroll each term.

ECH 5971r. Master's Thesis Research (1–12). This course provides a means of registering for thesis research work and recording progress towards its completion. Students must consult with the academic department for appropriate registration of course credit hours. May be repeated to a maximum of forty-five (45) credit hours; repeatable within the same term.

ECH 6980r. Dissertation (1–24). (S/U grade only). Prerequisite: Admission to doctoral candidacy. This course is for research on the dissertation topic. May be repeated as often as approved by the supervisory committee. A maximum of 24 hours can be applied to the doctoral degree. May be repeated within the same semester.

ECH 8965r. Doctoral Preliminary Exam (0). (P/F grade only.) Prerequisite: Doctoral candidate status in Biomedical Engineering. All doctoral students must enroll in this course the semester they intend to take the qualifying exam. May be repeated within the same term.

ECH 8976. Thesis Defense (0). (P/F grade only.) Prerequisites: ECH 5126, ECH 5261, and ECH 5842. Corequisite: ECH 5971r. All students must register for this course for the term in which they intend to defend their thesis.

ECH 8985. Dissertation Defense (0). (P/F grade only.) Corequisite: ECH 6980r. Must be included in the final semester schedule for all doctoral students.

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

UNDERGRADUATE DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://www.eng.famu.fsu.edu/cee

Chair: Lisa Spainhour; **Professors**: AbdelRazig, Abichou, Chen, Huang, Jung, Moses, Mtenga, Rambo-Roddenberry, Sobanjo, Spainhour, Tawfiq; **Associate Professors**: Choi, Dulebenets, Ozguven, Tang; **Assistant Professors**: Alamdari, Elwardany, Farner, Fernández-Cabán, Guo, Sharma, Wasman, Zhang; **Teaching Faculty III**: Adalier, Ahmad, Pamuk; **Teaching Faculty II**: Nnaji; **Teaching Faculty I**: Park; **Professor of Practice**: Martin; **Professors Emeriti**: Dzurik, Ping, Wekezer

Mission

The mission of the Department of Civil and Environmental Engineering is to teach the fundamentals of civil engineering science, analysis, design, and management in order to empower students to assume careers as professional engineers; to conduct basic and applied research in order to improve the state of knowledge of civil engineering; to serve as a source of information and advice to the community on engineering matters; and to assist in the continuing education of professional engineers and other interested individuals. The department has a special mission to provide an opportunity for a civil engineering education for under-represented groups in the profession.

Programs Offered

The department offers a program of study for the Bachelor of Science (BS) in civil engineering, which is accredited by ABET, Inc, 111 Market Place, Suite 1050, Baltimore, MD, 21202-4012, phone (410) 347-7700. The civil engineering major is broad-based, emphasizing all aspects of civil engineering practice, including structural geotechnical, construction, transportation, hydraulics, water resources, and environmental engineering. Within the civil engineering program, the environmental engineering major is a course of study that focuses primarily on environmental engineering, hydraulics, hydrology, water resources, and water quality.

Regardless of focus, all students learn to apply state-of-the-art technologies to solve problems in these areas.

The department offers graduate programs leading to Master's and Doctor of Philosophy (PhD) degrees in civil engineering. In addition to the thesis-based Master of Science (MS) degree, a courses-only Master of Engineering (MEng) option is available. These programs provide areas of concentration in structural, geotechnical, environmental/ water resources, construction/infrastructure, and transportation engineering.

Admission to graduate programs requires a 3.0 grade point average (GPA) in the last two years of undergraduate school and an acceptable score on the graduate record exam (GRE). For the MEng option, evidence of passing the NCEES Fundamentals of Engineering (FE) or Principles and Practice of Engineering (PE) exam or holding PE licensure may be used in lieu of the GRE. For more details, refer to the Graduate Bulletin or the department website at https://www.eng.famu.fsu.edu/cee.

Opportunities and Facilities

Many opportunities exist in the field of civil engineering that encompass planning, designing, and managing a variety of projects. Your work could be on site at a project or at a computer workstation. Civil and environmental engineers often find themselves involved in many of the public work projects funded by federal, state, and municipal governments, as well as those projects undertaken by the private sector. As a structural engineer, you might analyze and design structures out of steel, concrete, aluminum, timber, plastic, and other new materials that are able to support required loads and withstand natural disasters. An environmental engineer, with a background in either physical, chemical, or biological science, helps to prevent and solve environmental problems. Engineers in the geotechnical area apply technology, field test information, and laboratory analyses related to mechanics and mathematics to create the infrastructure facilities within and on top of the earth. The structure and stability of soils determine how and where to construct tunnels, pipelines, and deep foundations as well as highways and other buildings. In hydraulic and water resources engineering, you might design, construct, or maintain facilities related to the quality and quantity of water, flood prevention, wastewater treatment, and waterfront erosion protection. As a professional in transportation engineering, your purpose is to move people and things in a safe and efficient manner locally and through mass transportation systems. Transportation facilities include highways, airfields, railroads, and seaports. Several courses are also offered in construction engineering.

Instructional equipment includes the MTS structures and material testing systems with computer control for data acquisition and analysis, equipment for in situ and laboratory measurements of engineering properties of soils and rocks, including triaxial, bearing, and shear testing equipment and seismographs; and a self-contained glass-sided tilting flume for investigations of flow phenomena and sediment transport. A complete stand-alone automated data acquisition and analysis system is available for undergraduate student laboratory work and research. A fully equipped water quality testing lab as well as portable field testing kits are used both for classroom teaching as well as for student research and design projects.

Students have access to a large number and variety of computer systems. A network of nearly 700 computing devices is available for the academic and research efforts of the college.

The college computers are connected to a high-speed, switched, fiber-optic LAN and to the Internet via the Florida State University connection to the NSF v BNS network.

Additional information about the department can be obtained from the college home page: https://eng.famu.fsu.edu.

B.S. Master's Pathway

This pathway provides academically talented undergraduate students an opportunity to complete both a bachelor's and a master's degree in five years. Upon approval, this pathway allows 6 graduate hours to be counted toward both undergraduate and graduate degree programs. The student will earn the Bachelor of Science (BS) degree upon completion of the undergraduate program and the master's degree upon completion of the graduate program.

The program requirements for the graduate portion of this pathway are identical to the M.Eng. or M.S. program requirements. The only difference is that the pathway students take 24 hours of coursework instead of 30 hours, because six graduate hours were already taken while completing the undergraduate degree.

To apply, students in term five or six of their undergraduate program (the Junior year) according to the CEE Undergraduate Academic Map should submit an on-line application to the combined degree pathway. An overall GPA of 3.2 as well as area-specific requirements must be met.

During the last year as an undergraduate, the student applies to the master's program. The admission requirements for this step are identical to the master's admission requirements.

Additional information and the online application are available at https://eng.famu.fsu.edu/cee/bs-meng-pathway.

Program Educational Objectives

Consistent with the mission and goals of the FAMU-FSU College of Engineering, and based upon the input and needs of its constituents, the Civil Engineering program will produce graduates who achieve the following program educational objectives (PEOs) several years after graduation:

- Progress in successful professional careers in civil and environmental engineering or related fields, and/or enroll in studies at the graduate level;
- Apply engineering principles to address the needs of society, including sustainability, and practice effective management, communication, and leadership skills;
- Respond to the rapid pace of change in civil and environmental engineering by becoming professionally licensed, engaging in ongoing continuing education, and participating in professional society activities; and
- Contribute to workforce diversity as members and leaders of multi-disciplinary teams.

Student Learning Outcomes

By the time students graduate from the Civil Engineering program, they will attain the following outcomes and attributes:

- An ability to identify, formulate, and solve civil engineering problems by applying principles of engineering, science, and mathematics;
- An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs;
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
- An ability to communicate effectively with a range of audiences;
- 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;
- An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately;
- An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.

Engineering Design

Following engineering design criteria established by ABET, the civil engineering curricula provide excellent design experiences for students. The faculty of the Department of Civil and Environmental Engineering has carefully integrated design components into the curriculum with increased complexity as students progress toward graduation. These design components offer opportunities for students to work individually and in teams on meaningful engineering design experiences building upon the fundamental concepts of mathematics, basic sciences, humanities, social sciences, engineering topics, and oral and written communication skills. Design components in engineering coursework help students develop an appreciation for and apply the knowledge of the wide variety of courses they have studied. Consequently, they participate in meaningful solutions and effective design development for practical engineering problems.

The majority of the design experiences are integrated into junior and senior level courses.

In both majors, CGN 4800, Senior Design I, and CGN 4802, Senior Design II, provide significant, culminating design experiences in which students working in interdisciplinary teams apply realistic constraints to an actual engineering scenario.

Additional information about design credits may be obtained from departmental brochures and by contacting faculty advisors at the Department of Civil and Environmental Engineering.

State of Florida Common Program Prerequisites in Civil Engineering

The Florida Virtual Campus (FLVC) houses the statewide, internet-based catalog of distance learning courses, degree programs, and resources offered by Florida's public colleges and universities, and they have developed operational procedures and technical guidelines for the catalog that all institutions must follow. The statute governing this policy can be reviewed by visiting https://www.flsenate.gov/Laws/Statutes/2021/1006.73.

FLVC has identified common program prerequisites for the degree program in Civil Engineering. To obtain the most up-to-date, state-approved prerequisites for this degree, visit: https://cpm.flvc.org/programs/337/278.

Specific prerequisites are required for admission into the upper-division program and must be completed by the student at either a community college or a state university prior to being admitted to this program. Students may be admitted into the University without completing the prerequisites but may not be admitted into the program.

Digital Literacy Requirement

Students must complete at least one course designated as meeting the Digital Literacy Requirement with a grade of "C–" or higher. Courses fulfilling the Digital Literacy Requirement must accomplish at least three of the following outcomes:

- Evaluate and interpret the accuracy, credibility, and relevance of digital information
- Evaluate and interpret digital data and their implications
- Discuss the ways in which society and/or culture interact with digital technology
- Discuss digital technology trends and their professional implications
- Demonstrate the ability to use digital technology effectively
- Demonstrate the knowledge to use digital technology safely and ethically

Each academic major has determined the courses that fulfill the Digital Literacy requirement for that major. Students should contact their major department(s) to determine which courses will fulfill their Digital Literacy requirement. Undergraduate majors in civil and environmental engineering satisfy this requirement by earning a grade of "C" or higher in CGN 3326, Civil Engineering Graphics & Design Tools.

Oral Communication Competency

If a grade of "C" or better is earned in the following two courses, the Oral Communication Competency requirement as defined in the "Undergraduate Degree Requirements" section of this General Bulletin will be satisfied. If the oral communication competency requirement of either course is not met, the student will not earn an overall grade of "C" or better in the course, regardless of how well the student performs in the remaining portions of the course.

CGN 4800 Senior Design I (3)

CGN 4802 Senior Design II (3)

Upper Division Writing

The Upper Division Writing (UDW) requirement at FSU is met by CGN 4800 Senior Design I, which is a required course for Civil Engineering and Environmental Engineering majors. To fulfill FSU's Upper-Division Writing requirement, the student must earn a "C" or higher in the course and earn at least a "C" average on the required writing assignments. If the student does not earn a "C-" or higher in the required writing assignments, the student will not earn an overall grade of "C" or higher in the course, no matter how well the student performs in the remaining portion of the course. Note that the UDW requirement is not the same as the State-Mandated Writing requirement, and that students must meet both requirements.

Scholarship in Practice/Formative Experience

CGN 4800 Senior Design 1, which is a required course for Civil and Environmental Engineering majors, has been approved as meeting the Scholarship-in-Practice requirement, and thus is designed to help the student become a critical thinker, a creative user of knowledge, and an independent learner. To fulfill FSU's Scholarship-in-Practice requirement, the student must earn a "C" or higher in the course.

CGN 4802 Senior Design II, which is a required course for Civil Engineering and Environmental Engineering majors, has been approved to meet CoreFSU Curriculum Formative Experience requirement and develops the student's ability to develop and use knowledge by engaging in a hands-on experience outside of the classroom. To fulfill FSU's FE requirement, the student must earn a "C" or higher in the course.

Requirements for the Bachelor of Science in Civil Engineering: Civil Engineering Major

In addition to college requirements, a candidate for the BS degree in civil engineering will be expected to successfully complete the following requirements:

Mathematics and Basic Engineering Sciences

CEG 2202 Introduction to Geomatics Engineering (3)

CEG 2202L Introduction to Geomatics Engineering Lab (1)

EGM 3512 Engineering Mechanics (4)

EGN 1004L First Year Engineering Lab (1)

EGN 3331 Strength of Materials (3)

EGN 3613 Principles of Engineering Economy (2)

EEL 3003 Introduction to Electrical Engineering (3)

OR

EML 3100 Thermodynamics (2)

STA 2023 Fundamental Business Statistics (3)

OR

STA 2122 Introduction to Applied Statistics (3)

OR

STA 3032 Applied Statistics for Engineers and Scientists (3)

Note: The 128 credit hours required for CEE degrees is calculated using EEL 3003. Students who take EML 3100 should see their advisor or academic coordinator to ensure that their degree will be a minimum of 128 credit hours total.

Group A Science Elective: An additional three-credit hour science elective course is required to allow students to develop increased breadth in the basic sciences, while completing existing curricular requirements. Students should select one course from the following group.

BSC 1005 General Biology for Nonmajors (3)

BSC 2010 Biological Science (3)

GLY 1030 Environmental Issues in Geology (3)

GLY 2010C Physical Geology (4)

MET 2700 General Meteorology (3)

PCB 3043 General Ecology (3)

OCE 4008 Principles of Oceanography (3)

Additional options may be available. See department for a list of approved Group A electives.

Civil Engineering Core Courses

CCE 3101 Construction Materials (3)

CEG 3011 Soil Mechanics (3)

CES 3100 Structural Analysis (4)

CGN 3326 CE Graphics & Design Tools (3)

CGN 3508L Civil Engineering Materials Laboratory (1)

CWR 3200L Environmental and Hydraulic Engineering Laboratory (1)

CWR 3201 Hydraulics (3)

EES 3040 Introduction to Environmental Engineering (3)

TTE 3004 Transportation Engineering (3)

Civil Engineering Design and Professional Courses

Students must take the courses in the following areas plus four additional electives* for a total of 24 hours credit. To meet the requirement, students may select elective courses (as indicated below) to specialize their degree program to suit their individual objectives.

Structures

CES 4605 Steel Design (3)

OR

CES 4702 Concrete Design (3)

Geotechnical

CEG 4801 Geotechnical Design (3)

Construction/Transportation

CCE 4XXX Construction elective (3)

OR

TTE 4XXX Transportation elective (3)

Environmental/Water Resources

ENV 4XXX Environmental Engineering (3)

OR

CWR 4XXX Hydraulics, Hydrology, or Water Resources elective (3)

Additional Electives

Group B Electives (9 credits total)

Engineering/Math/Science Elective: Any three 4000-level courses (CCE 4XXX, CEG 4XXX, CES 4XXX, approved or selected CGN 4930 courses, CWR 4XXX, ENV 4XXX, TTE 4XXX) offered by the Department of Civil and Environmental Engineering that are not being used to meet another requirement. Specified 3000- or 4000-level courses selected from engineering, math, or science departments may be used for one Group B elective. See department for a list of approved Group B electives.

Group C Elective (3 credits)

Professional/Technical Elective: A course outside of the CEE department emphasizing professional development, computing, and other professional/technical skills. See department for a current list of approved Group C electives.

Major Design Experience

CGN 4800 Senior Design Project I (3)

CGN 4802 Senior Design Project II (3)

Requirements for the Bachelor of Science in Civil Engineering: Environmental Engineering Major

In addition to college requirements, a candidate for the Bachelor of Science (BS) degree in civil engineering with a major in environmental engineering will be expected to successfully complete the following course requirements.

Mathematics and Basic Engineering Sciences

CEG 2202 Introduction to Geomatics Engineering (3)

CEG 2202L Introduction to Geomatics Engineering Lab (1)

CHM 1046/L General Chemistry II and Laboratory (4)

OR

MCB 2004 Microbiology for Health Services and Laboratory (4)

EGM 3512 Engineering Mechanics (4)

EGN 1004L First Year Engineering Lab (1)

EGN 3331 Strength of Materials (3)

EGN 3613 Principles of Engineering Economy (2)

EML 3100 Thermodynamics (2)

OR

EEL 3003 Introduction to Electrical Engineering (3)

STA 2023 Fundamental Business Statistics (3)

OR

STA 2122 Introduction to Applied Statistics (3)

OR

STA 3023 Applied Statistics for Engineers and Scientists (3)

Note: The 128 credit hours required for CEE degrees is calculated using EEL 3003. Students who take EML 3100 should see their advisor or academic coordinator to ensure that their degree will be a minimum of 128 credit hours total.

Group A Science Elective: An additional three-credit hour science elective course is required to allow students to develop increased breadth in the basic sciences, while completing existing curricular requirements. Students should select one course from the following group.

BSC 1006 General Biology for Nonmajors (3)

BSC 2010 Biological Science (3)

GLY 1030 Environmental Issues in Geology (3)

GLY 2010C Physical Geology (4)

MET 2700 General Meteorology (3)

PCB 3043 General Ecology (3)

OCE 4008 Principles of Oceanography (3)

Additional elective options may be available. See department for a list of approved Group A electives.

Environmental Engineering Core Courses

CCE 3101 Construction Materials (3)

CEG 3011 Soil Mechanics (3)

CGN 3326 CE Graphics & Design Tools (3)

CGN 3508L Civil Engineering Materials Laboratory (1)

CWR 3200L Environmental and Hydraulic Engineering Laboratory (1)

CWR 3201 Hydraulics (3)

EES 3040 Introduction to Environmental Engineering (3)

TTE 3004 Transportation Engineering (3)

Environmental Engineering Design and Professional Courses

Students are required to take courses in the following areas plus four additional electives for a total of 24 credit hours. To meet the requirement, students may select elective courses (as indicated below) to specialize their degree program to suit their individual objectives.

Environmental

ENV 4001 Environmental Engineering (3)

OR

ENV 4500 Environmental Unit Processes and Operations (3)

Water Resources

CWR 4XXX Water Resources, Hydraulics or Hydrology elective (3)

Geotechnical

CEG 4801 Geotechnical Design (3)

Construction /Transportation:

TTE 4XXX Transportation elective (3)

OR

CCE 4XXX Construction elective (3)

Additional Electives

Group B Electives (9 credits total)

Engineering/Math/Science Elective: Any three 4000-level courses (CCE 4XXX, CEG 4XXX, CES 4XXX, approved or selected CGN 4930 courses, CWR 4XXX, ENV 4XXX, TTE 4XXX) offered by the Department of Civil and Environmental Engineering that are not being used to meet another requirement. Specified 3000- or 4000-level courses selected from engineering, math, or science departments may be used for one Group B elective. See department for a list of approved Group B electives.

Group C Elective (3 credits)

Professional/Technical Elective: A course outside of the CEE department emphasizing professional development, computing, and other professional/technical skills. See department for a current list of approved Group C electives.

Major Design Experience

CGN 4800 Senior Design Project I (3)

CGN 4802 Senior Design Project II (3)

Department Policies

Pre-Engineering students must adhere to the policies set by the College of Engineering, including standards on declaring Civil Engineering as a major. Students must achieve a grade of "C–" or better in all transfer courses and in all courses that are prerequisites to any required or elective engineering course. In addition, students are required to earn a "C–" or better in all engineering courses that apply toward the degree. In extenuating circumstances, a maximum of one "D" may be waived. The waiver shall not be applied to Senior Design, nor to a course that is a prerequisite for a subsequent course in the student's degree program.

Pre/Corequisite Course Policy

It is the policy of Department of Civil and Environmental Engineering that a student must receive grades of "C–" or better in all prerequisite courses prior to enrolling in a CEE course. Concurrent registration in a course and its prerequisites is not allowed. All prerequisites of the prerequisite course must be completed. Failure to abide by this policy can result in the cancellation of your enrollment in any course at any time during the term and with no refund of fees. Corequisite courses must be taken concurrently or prior to enrolling in the course. Registering for and remaining in a course without having completed all pre- and corequisite courses as well as all their prerequisites can result in the Department or the College of Engineering administratively canceling your course enrollment at any time during the term and with no refund of fees. Changes to prerequisites will be accompanied by a phase-in period: in such cases the CEE undergraduate committee shall serve as the authority regarding the implementation of such changes.

Course Repeat Policy

Criteria

A student in the Department of Civil and Environmental Engineering will be placed on probationary status if the student falls into any of the following situations:

- Accrued two grades below "C–" in a single engineering course that is required under his/her curriculum, or in MAC 2313, MAP 3305/2302, or PHY 2049C, or CHM 1045/1046, or in any Group A, B, C, D Electives.
- Accrued a total of three grades below "C–" in all engineering courses that are required under his/her curriculum, MAC 2313, MAP 3305/2302, and PHY 2049C, or CHM 1045/1046, or in any Group A, B, C, D Electives.
- Has an overall GPA below 2.0

Consequences

A student who meets the above criteria will be placed on academic probation during the subsequent term and will be required to sign an academic probation/readmit contract with the department. A student may not graduate while on probation.

Reinstatement

To be reinstated, the following conditions must be met:

- The student will have one term (the probationary term) to raise his/her GPA above 2.0
- The student must retake all courses that were the cause for probation according to an agreed upon schedule (during the probationary term, if available) and achieve a grade of "C–" or better.

Dismissal

A student on probation will be permanently dismissed from the CEE program and will not be eligible for further reinstatement upon the following conditions:

- If a student who is on probation does not raise his/her GPA above 2.0 and/or achieve a grade of "C–" or better in all courses taken during the probationary term.
- If a student who has been reinstated to the program subsequently falls below an overall GPA of 2.0 and/or fails to achieve a grade of "C–" or better in any math, science, or engineering course.
- A student who has already reached or exceeded the course repeat limits stated above prior to declaring the civil or environmental major is considered on reinstatement and must achieve a grade of "C–" or better in all subsequent courses to avoid permanent dismissal.

Fundamentals of Engineering Exam

All undergraduate students are strongly encouraged to take the Fundamentals of Engineering (FE) exam in the civil engineering discipline during their senior year.

Honors in the Major

The Department of Civil and Environmental Engineering offers Honors in the Major to encourage students to undertake independent and original research to enhance their undergraduate experience. For requirements and more information, see the "University Honors Office and Honor Societies" chapter of this General Bulletin.

Requirements for Optional Minor in Environmental Engineering Science

An optional minor in environmental engineering science requires a minimum of 12 credit hours of coursework in environmental engineering, including EES 3040 and ENV 4001 plus six additional hours in courses with prefixes EES or ENV at the 3000 level or above, with no more than one of the following courses counting towards the minor: ENV 4341, ENV 4611. Students must consult with the department and obtain written approval before taking courses towards the minor. Students also must satisfy prerequisites before enrolling in any environmental engineering course. Grades of "C–" or better must be earned in each course accepted for minor credit. If an environmental engineering science minor is combined with a civil engineering major, EES 3040, and one other course, up to six credits total may count toward both the major and the minor.

Definition of Prefixes

CCE—Civil Construction Engineering

CEG—Civil Geotechnical Engineering

CES—Civil Engineering Structures

CGN—Civil Engineering

CWR—Civil Water Resources

EES—Environmental Engineering Science

EGM—Engineering Science

EGN—Engineering: General

EGS—Engineering: Support

ENV—Engineering: Environmental

TTE—Transportation Engineering

Undergraduate Courses

CCE 3101. Construction Materials (3). Prerequisite: EGN 3331 (C- or better). This course covers properties and characteristics of construction materials for civil and highway engineering, metals, aggregates, cements, timber, concrete, and asphalt.

CCE 4004. Construction Engineering (3). Prerequisites: CCE 3101 and EGN 3613. This course covers theories, principles, and applications of construction engineering professionalism and ethics. Emphasis is placed on construction pre-design, planning, scheduling, contracts and specification, construction methods, and equipment and safety.

CCE 4014. Construction Cost Estimating (3). Prerequisites: CCE 3101 and EGN 3613. This course covers construction contracts, organization, and cost accounting systems; preliminary cost estimation, and cost indices; estimating material, labor, and equipment costs; construction bidding practices, and bid proposals; and project budgeting and cost systems.

CCE 4031. Construction Planning and Scheduling (3). Prerequisite: CCE 3101. This course includes topics such as: planning, basic arrow diagramming, basic precedence diagramming, establishing activity duration, scheduling computations, bar charts, project controls, overlapping networks, resource leveling, and program evaluation review technique (PERT).

CEG 2202. Introduction to Geomatics Engineering (3). Prerequisite: MAC 2311. Corequisite: CEG 2202L. This course explores methods and procedures of surface mapping and subsurface sectioning including distance measurements, traverse computations and topographic mapping, and Global Positioning Systems. Students use field equipment and procedures to measure distances, elevations, angles, and perform complete surveys.

CEG 2202L. Introduction to Geomatics Engineering Lab (1). Prerequisite: MAC 2311. Corequisite: CEG 2202. This course explores methods and procedures of surface mapping including distance measurements, elevation measurements, traverse computations, and topographic mapping. Students use field equipment and procedures to measure distances, elevations, and angles necessary for performing basic surveys. Computer Aided Design (CAD) Laboratory is used for performing basic engineering drafting.

CEG 3011. Soil Mechanics (3). Pre- or corequisite: EGN 3331 (C- or better). This course covers physical, index, hydraulic and mechanical properties of soils. Topics include classification, compaction, stress distribution, permeability and seepage, consolidation settlement, and shear strength of soil.

CEG 4801. Geotechnical Design (3). Prerequisite: CEG 3011. Pre- or corequisite: CGN 3508L.This course covers geotechnical investigation, analysis, and design of different geotechnical structures, including earth retaining structures, slopes and embankments, earthwork with geosynthetics, as well as shallow foundations.

CES 3100. Structural Analysis (4). Prerequisite: EGM 3512. Corequisites: EGN 3331 and either MAP 2302 or MAP 3305. This course covers loads, load paths, as well as advanced topics on shear and bending moment, including frames and superposition. Additional topics include influence lines, deflection of determinate structures, as well as indeterminate analysis methods including flexibility, slope-deflection, moment distribution, and stiffness methods.

CES 4605. Steel Design (3). Prerequisites: CES 3100 and EGN 3331. Pre- or corequisite: CGN 3508L. This course covers the design of tension, compression, and flexural steel members. The course also covers the design of bolted and welded connections for steel members, according to AISC specifications.

CES 4702. Concrete Design (3). Prerequisites: CES 3100 and EGN 3331. Pre- or corequisite: CGN 3508L. This course covers the design of reinforced concrete structures using current ACI specifications and building codes. Topics include flexural design of reinforced concrete beams, flanged beams, and one-way slabs. The course also presents column design, shear reinforcement design, bond and anchorage, and control of deflections and cracks.

CES 4800. Timber Design (3). Prerequisites: CES 3100 and EGN 3331. Pre- or corequisite: CGN 3508L. This course covers the design of basic timber structures including beams, columns, walls, and diaphragms – all using NDS specifications.

CES 4830. Masonry Design (3). Prerequisites: CES 3100 and EGN 3331. Pre- or corequisite: CGN 3508L. This course covers the design of basic reinforced masonry structures including walls, columns, and foundations. SBC and code applications are used.

CGN 3145. Blending STEM and Public Policy (3). This course is thematically driven with respect to the intersection of STEM and social sciences pertaining to sustainability within the themes of: (1) food, (2) water, (3) energy, and (4) climate change. Within each area, students are introduced to core theoretical concepts, historical and contemporary issues, public policy examples, institutions, personalities, geographies, governmental and non-governmental actors, and communities.

CGN 3326. CE Graphics & Design Tools (3). Prerequisites: CEG 2202 & Lab. This course covers intermediate level computer-aided drafting and design (CADD) methods, rapid sketching, and civil engineering-specific mathematical skills and computational tools.

CGN 3508L. Civil Engineering Materials Laboratory (1). Prerequisite: EGN 3331. Pre- or corequisite: CEG 3011 or CCE 3101. This course is a study of the principal construction materials used in civil engineering practice (soils, concrete, timber, steel, etc.) with special attention to measuring mechanical properties through laboratory testing according to ASTM standards. Hands-on experience in conducting tests, including preparation and instrumentation of test specimens, test execution, data acquisition, and interpretation of test results using statistical analysis.

CGN 4800. Senior Design I (3). Prerequisite: Senior standing. Pre- or corequisite: CGN 3326. This course covers issues relevant to the design and construction of engineering projects; professional ethics; project planning and scheduling; sustainable design under engineering and societal constraints; importance of licensure and continuing education; as well as oral and written communication issues. Inter- or multidisciplinary teams prepare formal proposals in this two-part course.

CGN 4802. Senior Design II (3). Prerequisites: CGN 4800 and in last full semester of CEE program. This course is a capstone senior-level design course integrating the knowledge and skills gained in undergraduate studies in civil and environmental engineering. The course involves the completion of a team-based interdisciplinary design project started in Senior Design I. This project includes industry and professional participation.

CGN 4906r. Honors Work in Civil and Environmental Engineering (1–6). Prerequisite: Admission to the honors program. This course is for faculty-directed independent research conducted by students in the honors program. Research is conducted on a topic agreed upon by the student and a faculty mentor and relevant to civil and/or environmental engineering. Variable credit is given consistent with the nature and scope of the research project to be conducted. May be repeated to a maximum of nine (9) credit hours.

CGN 4930r. Special Topics (1–3). Prerequisites vary. This course covers topics in civil and environmental engineering, with an emphasis on recent developments. Topics and credit may vary. May be repeated to a maximum of twelve semester hours. May be repeated within the same term.

CWR 3200L. Environmental and Hydraulic Engineering Laboratory (1). Pre- or corequisite: EES 3040 or CWR 3201. This course is a hands-on introduction to environmental and hydraulic engineering topics. Physical experiments that demonstrate fundamental concepts such as hydrostatics, pipe flow, open channel flow, water quality, and water treatment processes are performed.

CWR 3201. Hydraulics (3). Prerequisite: EGM 3512 (C- or better). This course covers fundamental concepts of fluid properties, hydrostatics, kinematics, ideal flow viscous effects, transport phenomena; drag, laminar, and turbulent flow in pipes and channels; and dimensional analysis.

CWR 4101. Engineering Hydrology (3). Prerequisites: CWR 3201 and CWR 3200L. This course covers the processes of the hydrologic cycle, hydrologic analyses for the planning and design of water management systems, and the use of application program packages.

CWR 4120. Groundwater Hydrology (3). Prerequisites: CWR 3201 and EES 3040. This course examines the fundamentals of groundwater flow and contaminant transport. Topics include: Darcy's law, flow nets, mass conservation, heterogeneity and anisotropy, storage properties, 3-D equation of groundwater flow, regional circulation, unsaturated flow, recharge, stream-aquifer interaction, well hydraulics, slug test analyses, and contaminant transport processes.

CWR 4202. Hydraulic Engineering I (3). Prerequisites: CWR 3201 and CWR 3200L. This course covers principles of hydrology and hydraulics as they apply to the design of water supply, urban drainage, flood control, and hydraulic energy-conversion systems. Students use computer-aided design to devise hydraulics systems.

CWR 4540. Water Resources Engineering (3). Prerequisite: CWR 3201. This course offers a systems approach to complex water resources problems as well as a systems analysis of water resources operations, design, and planning.

EES 3040. Introduction to Environmental Engineering (3). Prerequisites: CHM 1045, CHM 1045L, MAC 2311, and PHY 2048C. This course is a broad introduction to environmental engineering topics. Includes fundamental concepts in mass balance, water quality, water and wastewater treatment, air quality, and solid/hazardous waste management, with considerations to environmental and societal impacts, as well as technical limitations. This course serves as the foundation for all other environmental engineering courses.

EGM 3512. Engineering Mechanics (4). Prerequisites: MAC 2312 and PHY 2048. Corequisite: MAC 2313. This course covers statics and dynamics of particles and rigid bodies. Topics include free-body diagrams, couples, resultants, equilibrium of particles and rigid bodies in two and three dimensions, and forces in trusses, frames, and machines. Other topics include centroids, centers of mass, internal shear forces and bending moments in beams, shear and moment diagrams, friction, area moments of inertia, parallel axis theorem, work/energy, as well as impulse and momentum methods.

EGN 3331. Strength of Materials (3). Prerequisite: EGM 3512 (C- or better). This course covers axial, torsional, and flexural stresses and strains, as well as normal and shear stress. Topics include Mohr's circle, transformation of stress, safety factors, and engineering applications.

EGN 4460. Applied Simulation Modeling of Transportation Systems (3). This course is an overview of simulation as a modeling approach, analysis of complex transportation systems using simulation, evaluation of distribution/transportation processes, discrete/continuous/hybrid simulation, disruptive simulation, development of custom simulation logics, programming within simulation, scenario analysis automation.

EGN 4906r. Directed Individual Study (1–3). Prerequisites: EES 3040 and EES 3040L. Corequisite: CWR 4202. This course is directed special project/research in an area of civil engineering science or design not covered in the curriculum. May be repeated to a maximum of three semester hours.

EGS 3045. Interdisciplinary Perspectives on the Global Grand Challenges of Engineering (3). Prerequisite: Instructor permission. This course delves into the engineering challenges of the 21st Century and considers how these challenges can be overcome at the global scale.

ENV 4001. Environmental Engineering (3). Prerequisites: CHM 1045C, CWR 3200L, CRW 3201, and EES 3040. This course covers the design of water and wastewater treatment plants, wastewater collection systems, air and water pollution control, as well as solid waste management and contemporary environmental issues.

ENV 4022. Remediation Engineering (3). Prerequisite: ENV 4001. This course reviews various innovative remediation technologies used for cleanup of contaminated soil and groundwater at a site such as air sparging, soil vapor extraction, reactive walls, reactive zones, stabilization technologies, as well as hydraulic and pneumatic fracturing pump-and-treat systems.

ENV 4031. Applied Environmental Engineering Microbiology (3). Prerequisite: ENV 4001. This course surveys environmentally important microbes and their roles in the environmental restoration processes. Major topics include basics of microbiology, stoichiometry and bacterial energetics; bioremediation and other environmental microbiology applications; as well as detoxification of hazardous chemicals.

ENV 4341. Solid and Hazardous Waste Engineering (3). Prerequisites: CWR 3200L and EES 3040. This course covers definitions and characteristics of solid and hazardous wastes. Topics include history, growth, and magnitude of the problem; legislative, regulatory, and technical aspects of waste generation, storage, collection, transportation, processing, transformation, and disposal; design of waste minimization and recycling programs; and case studies of waste management.

ENV 4405. Water Reuse Engineering (3). Prerequisites: CWR 3200L and EES 3040. This course covers sources of water for reuse, treatment processes and systems, monitoring and control instrumentation, health and social aspects, and design of facilities/systems.

ENV 4417. Applied Environmental Engineering Chemistry (3). Pre- or corequisite: ENV 4001. This course covers applications of fundamental principles from general, organic and biological chemistry, to major environmental engineering processes. Emphasis is placed on the chemistry of water treatment.

ENV 4500. Environmental Unit Processes and Operations (3). Pre- or corequisite: EES 3040. This course covers the operational and design features of the physical, chemical, thermal, and biological treatments used in engineering for water and wastewater treatment and the management of solid and hazardous waste.

ENV 4561. Design of Water Quality Management Facilities (3). Prerequisite: ENV 4001. This course covers analysis of operations, processes, and systems used in the design of facilities for maintaining water supply quality, wastewater control, and aquatic pollution control. Design of small and decentralized wastewater management systems.

TTE 3004. Transportation Engineering (3). Prerequisites: CEG 2202, CEG 2202L, and STA 2122 or equivalent. This course is an introductory study of transportation engineering in the United States with special emphasis on highway and traffic engineering, planning and design, construction, operation, management, and safety.

TTE 4201. Traffic Engineering (3). Prerequisite: TTE 3004. This course covers nature, characteristics, and theories of traffic problems. Topics include traffic survey procedures, origin-destination studies, as well as an introduction to theory and design of automatic control of traffic systems.

TTE 4250. Traffic Operations (3). Prerequisite: TTE 3004. This course covers operation of transportation systems, monitoring, regulation, and control traffic.

TTE 4774. Freight Terminals and Distribution Facilities (3). Prerequisite: Instructor permission. This course covers a general overview of passenger and freight transport, an overview of operations within different types of freight transportation terminals: marine terminals (container, dry bulk, liquid bulk), cross-docking facilities, warehouses, rail terminals, freight airport terminals, and other freight transportation facilities. The course analyzes decision problems within freight terminals, operations optimization, maximization of the terminal throughput and associated monetary benefits. Students discuss future needs of freight transportation.

TTE 4804. Highway Geometric Design (3). Prerequisite: TTE 3004. This course covers principles and procedures for the geometric design of highways and streets, consideration of traffic, land use, and aesthetic factors.

TTE 4830. Hot Mix Asphalt Mixture Design (3). Prerequisite: CCE 3101. Pre- or corequisite: CGN 3508L. This course covers aggregate properties and tests, tests of asphalt and asphalt concrete mixes, fundamental engineering characteristics of hot-mix asphalt concrete, mix design methods for asphalt concrete, as well as Superpave-mix design methodology and production and placement of hot-mix asphalt.

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

GRADUATE STUDIES

Information for Graduate Students in Civil & Environmental Engineering

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://eng.famu.fsu.edu/cee

Chair: Lisa Spainhour; **Professors**: AbdelRazig, Abichou, Chen, Huang, Jung, Moses, Mtenga, Rambo-Roddenberry, Sobanjo, Spainhour, Tawfiq; **Associate Professors**: Choi, Dulebenets, Ozguven, Tang; **Assistant Professors**: Ahmadisharaf, Alamdari, Elwardany, Farner, Fernádez-Cabán, Guo, Sharma, Wasman, Zhang; **Teaching Faculty**: Adalier, Ahmad, Nnaji, Pamuk, Park; **Professor of Practice**: Martin; **Professors Emeriti**: Dzurik, Ping, Wekezer

The department offers a Doctor of Philosophy (PhD), Master of Science (MS) and non-thesis Master of Engineering (MEng) degree programs with concentrations in structural, geotechnical, transportation, construction, water resources, and environmental engineering. Special areas of emphasis in civil engineering are bridge design, bridge management systems, cementitious materials, construction management, and wind engineering; geo-environment and pavements; transportation networks and multimodal systems; disaster resilience; and computer-aided design and decision support systems as well as the integration of physical and numerical models of civil engineering systems. In water resources, the focus is on hydraulics, hydrology, hydrodynamics, groundwater, and the modeling of watersheds and coastal areas. Emphasis within environmental engineering includes water quality, drinking water and wastewater treatment, remediation, hazardous waste management, environmental systems analysis, and environmental sustainability.

Centers and Laboratories

The college has many instructional and research laboratories. Specific laboratories for the Department of Civil and Environmental Engineering are geotechnical, environmental, hydraulic, pavement, construction materials, structures, and the transportation-engineering laboratory.

Geotechnical laboratory facilities include equipment for soil classification, compaction, hydraulic conductivity, slurry evaluation, shear strength, and compressibility of soils. Electronic data acquisition systems, personal computers, sampling devices, and a machine shop are also available for student use.

The environmental engineering laboratories include both an undergraduate teaching lab and a graduate research lab. The facilities include equipment and instrumentation needed for physical, chemical, and microbiological analysis of water quality, sampling and filtering devices, and space for bench scale experiments.

The hydraulic laboratory is used by students to reinforce the basic concepts of hydraulics and become familiar with hydraulic equipment and instrumentation, and to learn procedures of data collection and analysis. Students can perform experiments of hydrostatic pressure, hydrostatic forces on submerged bodies, flow measurement, friction in pipe flow, pump power, open channel flow, hydraulic jump, and wave mechanics.

The high-bay materials and structures laboratory includes equipment for preparing and testing concrete and other civil engineering materials. Available equipment includes compression strength testing machines, L.A. abrasion test machine, MTS test system, and electronic data acquisition systems. The lab has a three-foot reinforced concrete reaction slab with 100-kip anchorage pods spaced at four-foot intervals. This facility provides undergraduate and graduate students with applied instruction on specialized testing of materials and structures, and support for high quality research in developing and testing innovative structural materials and systems for bridges, buildings, etc.

The multi-usage laboratory supports preparation of specimens for other laboratories. It also has an open-circuit wind tunnel with a twenty-four-inch square cross section, and a robotic arm capable of supporting a variety of domains, including 3D concrete printing and demolition operations.

The department houses two Tier I University Transportation Centers (UTCs) funded by the United States Department of Transportation (USDOT): the Center for Accessibility and Safety for an Aging Population (ASAP) and the Rural Equitable and Accessible Transportation (REAT) Center. ASAP concentrates its efforts on the State of Florida with a significant percentage of older adults, but the Center's research is valuable in addressing transportation issues for an aging population nationwide. The Center addresses two of USDOT's strategic goals: improving highway safety and strengthening transportation planning. Providing seniors with safe and convenient access to the goods and services they need to participate fully in society is a key issue explored by ASAP personnel. The Center also focuses on transportation issues of rural and minority segments within the elderly population. The Center captures four interdisciplinary areas: (1) Accessibility and community connectivity among older adults; (2) Human factors affecting the older population, especially regarding acceptance of emerging technologies; (3) Geometric design research, especially regarding elder crash mitigation; and (4) Health, wellness, and safety of seniors as it relates to multimodal transportation and emergency operations. The REAT Center focuses on core issues of mobility challenges for people in rural communities, which are increasingly marked by growing diversity and expanding inequities within and across regions. The REAT Center aims to assess how effective solutions for transportation-related challenges, which have been widely applied in urban and suburban areas, could be potentially implemented in rural areas to address the needs of diverse rural populations in Florida and nationwide. ASAP and REAT support educational and outreach activities, including an annual Transportation Day, brown bag lunches, student research seed grants and dissertation fellowships, and annual student research colloquia.

The department also houses the Resilient Infrastructure and Disaster Response (RIDER) Center. RIDER is a multi-disciplinary research center established with the mission of achieving adaptive capacity and resilience for the communities affected by natural disasters such as hurricanes and pandemics such as COVID-19. RIDER unites engineers, social scientists, social workers, health, public policy, communication, and information specialists synergistically towards developing emergency plans that can fit the distinct needs of both urban and rural communities to solve the real-world problem of "resilience divide." RIDER specifically focuses on understanding the factors that foster and support the efficacy of disaster resilience in varying population settings; extending our knowledge of community-scale infrastructure limitations in planning for natural disasters; and developing long-term strategic adaptation and implementation plans to reduce community vulnerability, needed desperately by the underserved areas of the state and the country affected by natural disasters to sustain their communities. RIDER currently hosts four multi-disciplinary laboratories: (1) Resilient Materials and Structures (ReMS) Lab; (2) Water Sustainability and Coastal Hazard (WaSCH) Lab; (3) Laboratory of Advanced Operations Research and Resilience Applications (LAORA); and (4) Sustainable Infrastructure Management (SIM) Lab.

Additionally, the department also houses the Center for Transportation and Public Safety (CTPS), which develops software and provides training and support for law enforcement agencies in the State of Florida. Software products are based on the TraCS Florida platform and include ELVIS (Electronic License and Vehicle Information System). The center provides Florida law enforcement agencies with cost-effective tools to collect and transmit electronic crash and citation data to various statewide repositories. This data feeds into numerous traffic safety and operations research studies and is the basis for many roadway engineering and enforcement decisions state-wide.

Computer and Other Resources

Students have access to a large number and variety of computer systems. A network of nearly 700 computing devices is available for the academic and research efforts of the college.

The college computers are connected to a high-speed, switched, fiber-optic LAN and to the Internet via the Florida State University connection to the NSF v BNS network. Other computation resources include the Department of Scientific Computing, FSU Academic Computing and Network Services (ACNS), and FAMU Computing Services.

A small collection of reference works and heavily used books and journals is located in the College of Engineering Reading Room/Library Services. Additional resources are available electronically through database services at both parent institutions.

Students may also participate in engineering clubs such as the National Society of Black Engineers (NSBE); Society of Women Engineers (SWE); American Society of Civil Engineers (ASCE); Institute of Transportation Engineers (ITE); Engineering Honor Society, Tau Beta Pi; Engineers Without Borders (EWB); and the Society of Hispanic Professional Engineers (SHPE).

Master's Admission Requirements

Admission requirements for the Master of Science (MS) program, which includes the MS thesis and Master of Engineering (MEng) options, include the following:

- A baccalaureate degree in civil engineering, or an allied academic discipline, from an accredited college or university. International students must have a Bachelor of Science (BS) degree in civil engineering from a recognized academic institution.
- Good standing in the academic institution last attended;
- A grade point average (GPA) of 3.0 on a 4.0 scale, on all work attempted while registered as an upper division student (beyond 60 credit hours of undergraduate work);
- A minimum graduate record examination (GRE) percentile rank of 25% on the verbal reasoning section and 65% on the quantitative section. For the MEng option, evidence of passing the NCEES Fundamentals of Engineering (FE) or Principles and Practice of Engineering (PE) exam or holding PE licensure in any state may be used in lieu of the GRE;
- A minimum score of 550 (paper-based), 213 (computer-based), or 80 (Internet-based) on the Test of English as a Foreign Language (TOEFL) for all international applicants whose native language is not English;
- Three letters of recommendation (two for MEng option); and
- A statement of purpose outlining the goals and reasons for pursuing the master's degree.

Doctoral Admission Requirements

Admission requirements for the Doctor of Philosophy (PhD) degree include the following:

- A Bachelor of Science (BS) or Master of Science (MS) degree in civil or environmental engineering or a closely related field;
- A grade point average (GPA) or 3.0 on a 4.0 scale for all undergraduate and graduate work;
- A minimum graduate record examination (GRE) percentile rank of 35 percent on the verbal reasoning section and 70 percent on the quantitative section;
- A minimum score of 550 (paper-based), 213 (computer-based), or 80 (Internet-based) on the Test of English as a Foreign Language (TOEFL) for all international applicants whose native language is not English;
- Three letters of recommendation;
- A statement of purpose outlining the goals and reasons for pursuing the PhD degree; and
- If requested, an interview by the Graduate Committee or its representatives.

Master's Degree Requirements

The MS thesis option requires 24 credit hours of coursework and six credit hours of thesis work. The MS thesis option requires a final oral examination in which the student defends a thesis. For the MS thesis option, the general course requirements include 12 to 15 hours in the depth area, six to nine hours in supplementary electives, and three hours of advanced mathematics or statistics. Students also must register in a non-credit graduate seminar course each term, except summer term. The MEng option requires 30 credit hours of coursework, consisting of 15 hours in the specialty area, 12 hours in supplementary electives, and three hours of advanced mathematics, statistics, or computation.

For both the MS thesis and MEng options, a maximum of six credit hours of graduate coursework, in which the student earned a grade of "B" or better, may be transferred from another program. Each individual program is designed with the approval of a major advisor and, for the MS thesis option, a supervisory committee. The general course requirements for the MS thesis and MEng options are given below.

Course Distribution	MS	M.Eng
Specialty (Depth) area	12–15	15
Supplemental electives	6–9	12
Advanced mathematics	3	3
Thesis with oral defense	6	N/A
Graduate seminar	0	N/A
Total credit hours required for the master's degree	30	30

Graduation requirements include a cumulative grade point average of 3.0 or better and the successful defense of a thesis (MS) for the thesis option. All the above requirements must be met within seven calendar years.

Bachelor's – Master's Pathway

This pathway provides academically talented undergraduate students at FAMU-FSU an opportunity to complete both a bachelor's and a master's degree in five years. Upon approval, this pathway allows six graduate hours to be double counted toward the student's undergraduate degree program. The student will earn the Bachelor of Science (BS) degree upon completion of the undergraduate program and the master's degree upon completion of the graduate program. The master's degree can be either the MS (courses and thesis) or MEng (courses only).

The program requirements for the graduate portion of this pathway are identical to the master's program requirements shown above. The only difference is that the pathway students take 24 hours of coursework instead of 30 hours, because six graduate hours were already taken while completing the undergraduate degree at the FAMU-FSU College of Engineering.

The admission for the Bachelor's—Master's Pathway has two parts:

When the student is in the undergraduate program, the student submits an online application to the combined degree pathway. Overall GPA of 3.2 as well as area-specific requirements must be met. To ensure smooth transition to the graduate program, it is recommended that the students apply during Terms 5 or 6 (the Junior year) according to the CEE Undergraduate Academic Map. Additional information and the online application are available at https://eng.famu.fsu.edu/cee/bs-meng-pathway.

During the last year as an undergraduate, the student applies to the master's program. The admission requirements for this step are identical to the master's admission requirements shown earlier.

Doctoral Degree Requirements

The program of study for the PhD degree is flexible and depends on the individual student's background and objectives. The CEE department has two tracks for the PhD program. The typical track is the MS-PhD track where the applicants already have an MS degree. An alternative is the BS-PhD track where exceptionally qualified applicants who are well prepared may enter the PhD program with only a BS degree. A student may specialize in any of the several areas that are offered in the department. Each student's specific program of study is uniquely tailored through consultation with an advisory committee that the student selects. The objectives of course selection is to develop a broad-based understanding of engineering and science, and to gain fundamental contemporary capabilities in an area of concentration necessary to conduct significant and original scholarly research.

A student must choose a major professor by the second term of enrollment in the PhD program. If a student has not chosen a major professor by this time, a professor approved by the graduate committee chair will act as the student's academic advisor. The major professor is formally appointed by the department chair and will serve as chair of the supervisory committee. The supervisory committee is formally appointed by the department chair at the request of the major professor. There must be a minimum of four committee members, including the major professor. One member must be from outside the department (i.e., the university representative). The committee supervises the student's work until all degree requirements are completed and is responsible for an annual written assessment of the student's progress. This assessment shall be made available to the student, the coordinator of graduate studies, and the department chair.

The student will prepare, with the approval of the doctoral supervisory committee, a complete plan of study to be submitted to the graduate committee within the first year of the program and to be retained on file in the department. The plan should identify the courses necessary to meet the following credit hours of course requirements and a time schedule for taking them. Degree requirements for PhD students are outlined below.

The PhD course requirements include 15 hours in a student's depth area, 12 credit hours beyond the master's degree in supplementary electives, and 24 credit hours of original dissertation work. Students also must register for a noncredit graduate seminar course each term, except summer.

Students Admitted with:	MS Degree	BS Degree
Articulation/other requirements	0–22	6–22
Depth area	15	21
Supplementary electives	12	18
Dissertation	24	24
Graduate seminar	0	0
Total credit hours for the doctoral degree	51	69

Following completion of a major portion of the coursework defined in an approved plan of study, the doctoral supervisory committee must issue certification that the student has: maintained a minimum of 3.0 GPA; demonstrated sufficient progress toward mastery of a sub-discipline; and developed a command of requisite research tools to begin independent research in the area of the proposed dissertation. Once certified, students will be permitted to take a doctoral preliminary examination.

The preliminary examination will be a written and oral exam prepared by the student's supervisory committee. The exam will be administered by the committee near the end of or after completion of the student's coursework and will comply with the requirements of the college and the university in which the student is registered. The examination committee shall report the outcome to designated college and university authorities as: “passed,” “failed,” “additional work to be completed,” or “to be reexamined.” Students are admitted to candidacy for the PhD degree only after passing this examination. If any student requires re-examination, the outcome can only be reported pass or fail. Any student who fails re-examination is dismissed from the program. Upon successful completion of the second trial the student may continue to register for dissertation hours.

The most important element of the doctoral program is original and fundamental research resulting in a doctoral dissertation. The research subject is selected by the student in consultation with the major professor and the student's doctoral supervisory committee. The dissertation must be completed on a topic approved by the committee. To be acceptable, it must comprise original research constituting a significant contribution to knowledge and represent a substantial scholarly effort on the part of the student. The defense of the dissertation will be oral. The doctoral supervisory committee and other members of the faculty as appointed by the academic dean or specified by the university regulations will conduct the examination. Publication of the dissertation shall conform to the regulations of the university through which the student is registered.

Applicants holding degrees in areas other than civil engineering, or closely allied fields, may be required to take coursework beyond the minimum requirements for the master's degree (i.e., articulation courses). Graduation requirements include a cumulative grade point average of 3.0 or better and the successful defense of a thesis or project report for the master's degree, and a grade point average (GPA) of 3.0 or better and the successful defense of dissertation for the PhD degree. All the above requirements must be met within seven calendar years.

Assistantships & Financial Aid

Students may be supported through research or teaching assistantships on a competitive basis. Most graduate students currently hold half-time assistantships equivalent to 20 hours per week. Graduate assistants also receive tuition waivers from the universities on a competitive basis. Inquiries about research assistantships should be made to the professor directing an individual research project of interest to the student. Please visit the department website to learn more about individual faculty research. Teaching assistantships are generally provided through the supporting faculty member as well based on the existing departmental policies. To access the status of your financial aid information, please contact FSU at (850) 644-0539 or on the web at https://financialaid.fsu.edu.

Contact the admissions office for application materials. For information on financial assistance contact the Department of Civil and Environmental Engineering, FAMU-FSU College of Engineering, 2525 Pottsdamer Street Rm A129, Tallahassee, FL 32310-6046, phone: (850) 410-6136.

Graduate Courses

Construction Engineering

CCE 5020. Infrastructure Resilience (3). This course provides a comprehensive overview of the basic principles of infrastructure resilience. It provides detailed background about interdependence, risk analysis, and advanced tools related to infrastructure resilience.

CCE 5035. Construction Planning and Scheduling (3). Prerequisite: CCE 4004. This course covers topics such as planning, basic arrow diagramming, basic precedence diagramming, establishing activity duration, scheduling computations, bar charts, project controls, overlapping networks, resource leveling, and program evaluation review technique (PERT).

CCE 5036. Project Controls in Construction (3). Prerequisite: Instructor permission. This course includes topics such as construction cost estimation, work breakdown structure, and cost control; critical path method (CPM) scheduling, resource-constrained scheduling, and integrated scheduling-cost control; probabilistic scheduling techniques and linear scheduling techniques; modeling and analysis of construction operations.

CCE 5212. Sustainable and Green Construction (3). This course provides a comprehensive overview of the basic principles of sustainability and green construction. The course provides detailed background about the green building (LEED) certification, as well as energy calculations and cost-benefit analysis.

CCE 5510. Computer Applications in Construction (3). Prerequisite: CCE 4004. This course provides a comprehensive review and application of basic and advanced pertinent computer software for construction engineering and management. The course emphasizes practical applications for construction project management.

Geotechnical Engineering

CEG 5015. Advanced Soil Mechanics (3). Prerequisite: CEG 3011. This course explores the mechanical behavior, internal stresses, and stability analysis of noncohesive soils, compressibility, consolidation, and settlement of cohesive soils, analytical techniques for predicting earth movement.

CEG 5115. Foundation Engineering (3). Prerequisite: CEG 4801. This course covers topics such as the design of spread footings, pile and caisson foundations, retaining structures, and waterfront structures. The course also investigates slope stability and appropriate selection of alternative design methods of foundation.

CEG 5127. Highway and Airport Pavement Design (3). Prerequisite: CEG 4801. This course focuses on the analysis of materials used for highway and runway pavements; design of rigid and flexible pavements and sub-bases for highways and airports; geotechnical considerations.

CEG 5515. Earth Retaining Systems and Slope Design (3). Prerequisite: CEG 4801 or instructor permission. This course covers the design of systems such as sheet pile walls, segmental walls, and dewatering systems. Students have a choice between alternative design methods, including software applications.

CEG 5705. Environmental Geotechnics (3). Prerequisite: CEG 3011. This course focuses on the geotechnical aspects of waste containment and storage. Aspects of design, construction, and performance of earthen structures for storing or disposing waste or remediating contaminated sites.

CEG 5865. Geotechnical and Structural Design Practices (3). Prerequisites: CEG 4801 and CES 3100. This course focuses on geotechnical and structural analysis and design of main systems and components including structural foundations, retaining structures, slabs, piles, wind-loading on structures, field preconsolidation, and solving problems related to the PE exams.

Structural Engineering

CES 5105. Advanced Mechanics of Materials (3). Prerequisites: CES 3100 and EGN 3331. This course offers an analysis and design of load-carrying members, shear center, unsymmetrical bending, curved beams, beams on elastic foundations, energy methods, theories of failure, thick-walled cylinders, as well as stress concentrations.

CES 5106. Advanced Structural Analysis (3). Prerequisites: CES 3100 and EGN 3331. This course covers matrix algebra review, direct stiffness method for truss analysis, computer applications, statically indeterminate structures, slope-deflection and moment distribution methods, as well as computer modeling and analysis of structures using commercial FE codes.

CES 5144. Matrix Methods for Structural Analysis (3). Prerequisites: CES 4101 and MAP 3305 or MAP 2302. This course covers selected fundamental techniques, including energy methods, for the formulation of the stiffness method for structural analysis. Topics include the formation of element matrices, transformed element matrices, structure stiffness matrices, and equations of equilibrium. Selected computer solution techniques are also covered.

CES 5209. Structural Dynamics (3). Prerequisites: CES 4101 and MAP 3305 or MAP 2302. This course covers analysis and design of single- and multi-degree-of-freedom structures subjected to various types of excitations and initial conditions. Topics include computational aspects of dynamic analysis, including approximate methods of analysis, and introduction to earthquake loading and design.

CES 5325. Bridge Engineering (3). Prerequisites: CES 4605 and CES 4702. This course is an introduction to design of modern steel and concrete highway bridges. Topics include materials and properties, loads on bridges, and substructure design. AASHTO LRFD specifications are used.

CES 5585. Wind Engineering (3). Prerequisites: CWR 3201, EGN 2212, and EGN 3331. This course covers statics and dynamics of wind-induced loads and structural responses. Topics include wind damage, extreme wind probability, wind characteristics, wind pressure and forces, basics of single DOF structural dynamics, and overview of wind dynamics. State-of-the-art research in wind engineering is also introduced.

CES 5606. Advanced Steel Design (3). Prerequisites: CES 4101 and CES 4605. This course explores the behavior of complex steel elements and structures. Topics include analysis and design of columns and beams under combined effects of flexure, shear and torsion. Other topics include lateral torsional buckling, plastic analysis, design of plate girders, and design of frames.

CES 5706. Advanced Reinforced Concrete Design (3). Prerequisites: CES 4101 and CES 4702. This course explores the behavior of advanced reinforced concrete structures. Topics include analysis and design for torsion, biaxial columns, slender columns, two-way slabs, retaining walls, shear walls, deep beams, the art of detailing, and the strut-and-tie method.

CES 5715. Prestressed Concrete (3). Prerequisites: CES 3100 and EGN 3331. This course covers the behavior and design of prestressed concrete structures. Topics include the design of prestressed concrete beams for flexure and shear, design of slabs, prestressing losses, serviceability of prestressed concrete members, and precast members.

CES 5801. Structural Design of Wood Structures (3). Prerequisite: CES 3100 or instructor permission. This course includes analysis and design of beams, columns, connections, diaphragm and shear walls using sawn timber, laminated timber, and structural panels such as plywood and sheathing panels.

CES 5835. Design of Masonry Structures (3). Prerequisites: CES 3100 and CES 4702. This course covers properties, specifications, and construction requirements for clay and concrete masonry structures; and, analysis and design of masonry structures including a comprehensive diaphragm / shearwall masonry structure design project.

CES 5845. Composites in Civil Engineering (3). Prerequisites: CCE 3101, CES 3100, and EGN 3331. This course covers fundamental theories of composite materials. Topics include forms of composites and their reinforcements; physical, chemical, and mechanical properties; design and testing methods; and civil engineering applications of composite materials.

CES 6116. Finite Elements Methods (3). Prerequisites: CES 4101 and MAP 3305 or MAP 2302. This course covers the formulation and analysis of finite element equations using the direct method, the variational method, and the weighted-residual method. The course also examines the computational aspects of the finite element method, including convergence and accuracy, and provides a hands-on experience with a finite element analysis program.

Hydraulic/Water Resources Engineering

CWR 5125. Groundwater Hydrology (3). Prerequisites: CWR 3201 and EES 3040. This course examines the fundamentals of groundwater flow and contaminant transport. Topics include: Darcy's law, flow nets, mass conservation, heterogeneity and anisotropy, storage properties, 3-D equation of groundwater flow, regional recirculation, unsaturated flow, recharge, stream-aquifer interaction, well hydraulics, slug test analyses and contaminant transport processes.

CWR 5205. Hydraulic Engineering II (3). Prerequisites: CWR 4202 and MAP 3305 or MAP 2302. This course presents advanced hydraulic concepts and their incorporation into the design process. Methods of solving such problems are also presented.

CWR 5635. Water Resources Planning and Management (3). Prerequisites: CWR 4101 and CWR 4202. This course examines the quantity and quality planning of water resources systems. Economic considerations.

CWR 5824. Coastal and Estuarine Hydraulics (3). Prerequisites: CWR 3201 and MAC 2313. This course examines numerous topics including coastal hydraulic principles and waves in estuaries and coastal oceans, wave properties and wave forces on coastal structures, tidal motions, mixing and transport in estuaries, and coastal engineering analysis.

Environmental Engineering

ENV 5030. Applied Environmental Engineering Microbiology (3). Prerequisite: ENV 4001 or equivalent. This course focuses on the survey of environmentally important microbes and the roles they play in environmental restoration processes. Major topics include basics of microbiology, stoichiometry and bacterial energetics, bioremediation and other environmental microbiology applications, and detoxification of hazardous chemicals.

ENV 5055. Chemical Fate and Transport in the Environment (3). Prerequisites: CWR 3201, EES 3040, and either MAP 2302 or MAP 3305. Equivalent courses are also accepted. This course focuses on the study of the processes of pollutant chemicals transformation in and transport between air, water, and soil or sediments. Use and development of predictive mathematical models for the remediation of existing contaminated sites or prevention of future contamination from new sources.

ENV 5076. Environmental Law for Engineers and Scientists (3). This course is an introduction to environmental law and policy suitable for students pursuing engineering and science majors. The course addresses major federal environmental laws and environmental permitting and develops critical thinking skills through the exploration of contemporary and sometimes controversial issues such as climate change, environmental justice, hydraulic fracturing, trade, and the environment, and international environmental law.

ENV 5105. Air Pollution Control (3). Prerequisite: ENV 4001. This course investigates analytical concepts for determination of sources, amounts, and transport of air pollutants; health and environmental effects; design of control devices and management programs.

ENV 5419. Applied Environmental Engineering Chemistry (3). This course covers applications of fundamental principles from general, organic, and biological chemistry to major environmental engineering processes. Emphasis is placed on the chemistry of water treatment.

ENV 5504. Environmental Engineering Processes and Operations (3). Prerequisite: ENV 4001 or instructor permission. This course focuses on the operational and design features of the physical, chemical, thermal, and biological treatments used in engineering for the management of solid and hazardous wastes.

ENV 5565. Design of Water Quality Management Facilities (3). Prerequisites: CWR 3200L, CWR 3201, and EES 3040. This course is an analysis of operations, processes, and systems used in the design of facilities for maintaining water supply quality, wastewater control, and aquatic pollution control. Design of wastewater collection systems, water and wastewater treatment plants, and systems for disposal for residuals from such facilities.

ENV 5617. Environmental Engineering Sustainability (3). This course explores theory in the field of environmental sustainability and green engineering: material also covers sustainability in relation to other disciplines, but focuses on environmental and engineering concepts.

Transportation and Traffic Engineering

TTE 5074. Freight Terminals and Distribution Facilities (3). Prerequisite: Instructor permission. This course covers a general overview of passenger and freight transport, detailed overview of operations within different types of freight transportation terminals; decision problems within freight terminals, operations optimization, maximization of the terminal throughput and associated monetary benefits; and discussion of future needs of freight transportation.

TTE 5205. Traffic Engineering (3). Prerequisite: TTE 3004 or equivalent. This course focuses on the nature, characteristics, and theories of traffic flow. The course also discusses street and highway traffic problems, traffic survey procedures, origin-destination studies, theory and design of automatic control of traffic systems, and transit systems.

TTE 5206. Advanced Traffic Flow Analysis (3). Prerequisite: TTE 3004. This course covers microscopic and macroscopic characteristics, traffic stream models, demand-supply analysis, shockwave analysis, queuing analysis, computer simulation models, and intelligent transportation systems.

TTE 5256. Traffic Operations (3). Prerequisite: TTE 3004. This course covers principles of capacity, freeways, rural highways, urban streets, transportation systems, and computer simulation.

TTE 5270. Intelligent Transportation Systems (3). Prerequisite: TTE 3004. This course covers advanced traffic management systems (ATMS), advanced traveler information systems (ATIS), advanced vehicle control systems, commercial vehicle operations, rural ITS human factors, institutional issues, architecture and standards, simulation, and modeling.

TTE 5305. Transportation Systems Analysis (3). Prerequisite: TTE 3004 or equivalent. This course provides an extensive introduction for complex multi-modal transportation systems and their components with a focus on transportation planning, economics, modeling, investment, operations, and maintenance. Topics covered include network analysis, optimization techniques, demand and supply models, simulation practices, planning and forecasting models and other social, political, and economic aspects of the transportation system. Emphasis is given to the tie between the theory and practice with a focus on the sustainability and resiliency of the critical infrastructure.

TTE 5501. Transportation Economics (3). Prerequisite: TTE 3004 or equivalent. This course provides an introduction to transportation economics and financial aspects of transportation policy and planning, stressing the demand, supply and other economic issues. Microeconomics concepts that are critical for transportation systems will be extensively studied with a focus on the transportation demand and supply models, discrete choice analysis, cost models, traffic congestion and pricing.

Other Courses

CGN 5301. Analysis of Social-Ecological-Technical Systems (3). Prerequisite: MAP 3305 or instructor permission. This course analyzes and models simplified social-ecological-technical systems using one- or two-dimensional differential applications. Methods such as logistic growth models, resource-harvest models, and Susceptible, Infected and Recovered (SIR) models are applied to issues involving community resilience and development.

CGN 5307. Infrastructure System of Systems Analysis and Planning (3). This course teaches students how to define, characterize, model, and analyze a system of systems (SoS) and address SoS problems within the operation of critical infrastructure.

CGN 5615. Infrastructure Engineering and Management (3). Prerequisites: Prior course related to Transportation Engineering, Statistics, and a basic structural understanding of roadway pavements and bridges; or instructor permission. This course is an introduction to engineering and management aspects of infrastructure systems. Topics include application of methods to develop models for repair and inspection decisions and other advanced developments related to infrastructure systems.

CGN 5825. Site Development (3). Prerequisites: CEG 2202, CEG 2202L, CWR 4202, CWR 4203, TTE 3004, TTE 4201, or TTE 4804 or equivalents. This course is a practice-oriented land development design course integrating geometric layout, earthwork grading, storm water management, potable water distribution, wastewater collection, regulatory compliance, and financial considerations.

CGN 5905r. Directed Individual Study (1–6). (S/U grade only). May be repeated to a maximum of six semester hours when topics change.

CGN 5910r. Supervised Research (1–5). (S/U grade only). May be repeated to a maximum of five semester hours and a maximum of three semester hours may apply to the master's degree.

CGN 5930r. Special Topics (1–6). This course covers special topics in civil engineering with emphasis on recent developments. May be repeated to a maximum of six semester hours. Consult instructor.

CGN 5931r. Mechanical Engineering Comprehensive Exam (0). (P/F grade only.) All Masters of Engineering students must enroll in the course the semester they intend to graduate. May be repeated once.

CGN 5935. Civil Engineering Seminar (0). (S/U grade only). Prerequisite: graduate student status. Graduate students are expected to enroll in the course every semester they are enrolled at FAMU or FSU. The students should attend at least seventy-five percent of the seminars offered each semester to obtain a satisfactory grade.

CGN 5971r. Master's Thesis Research (1–12). (S/U grade only). This course provides a means of registering for thesis research work and recording progress toward its completion. Student must consult with the academic department for appropriate registration of course credit hours. May be repeated to a maximum of forty-five (45) credit hours; repeatable within the same term.

CGN 6942. Supervised Teaching (3). (S/U grade only). Prerequisite: Doctoral candidate status. Students receive credit for teaching an undergraduate course under supervision of graduate faculty.

CGN 6960r. Preliminary Exam Preparation (1-9). (S/U grade only.) Prerequisites: Completion of all course hours prior to or during the semester of enrollment in this course, and approval of dissertation advisor. This course guides a doctoral student to develop the research plan for the preliminary exam. The preliminary exam is the most important milestone for a doctoral student, where the student demonstrates the ability to conduct independent research. May be repeated to a maximum of twenty-four (24) credit hours.

CGN 6972. Master's Thesis Defense (0). (P/F grade only.) Prerequisite: CGN 5971. Required of students enrolled in the master's thesis option. Students must register in the semester they plan to defend their thesis.

CGN 6980r. Dissertation (1–24). (S/U grade only). Prerequisite: Doctoral candidate status. This course provides a means of registering for dissertation and recording progress toward completion. A dissertation representing twenty-four semester hours of academic work is a requirement for the PhD degree in civil engineering. May be repeated as often as approved by the supervisory committee. A maximum of twenty-four semester hours may be applied toward the PhD degree.

CGN 8985r. Dissertation Defense (0). (P/F grade only.) Prerequisite: Doctoral candidate status. Must be included in the final semester schedule for all doctoral students. May be repeated once.

CGN 8988r. Doctoral Preliminary Exam (0). (P/F grade only.) All doctoral students must enroll in the course the semester they intend to take the qualifying exam. May be repeated once.

EGN 5458. Statistical Applications for Engineers (3). Prerequisites: STA 2122, MAC 2311, MAC 2312, and MAC 2313 or equivalent. This course provides rigorous introduction to fundamentals of data analysis and statistics motivated by engineering applications with the use of modern software. Emphasis is placed on real-world applications to engineering problems.

EGN 5465. Applied Simulation Modeling of Transportation Systems (3). This course is an overview of simulation as a modeling approach, analysis of complex transportation systems using simulation, evaluation of distribution/transportation processes, discrete/continuous/hybrid simulation, disruptive simulation, development of custom simulation logics, programming within simulation, scenario analysis automation.

EGN 5480. Metaheuristics and Hybrid Algorithms (3). Prerequisites: Instructor permission. This course covers problem complexity, review and design of metaheuristics, evolutionary computation, local search heuristics, exact optimization procedures, hybridization techniques.

EGN 5950. Research Methods in Engineering (3). This course introduces graduate students to standard and advanced procedures and tools for scientific and engineering research. The course provides or expands the required knowledge for respectable research work, documentation, and presentation. It exposes students to the all/most stages generally needed for empirical and analytic engineering research. Students work closely with the instructor to ensure all assignments are based on individual needs, such that guidance for thesis or dissertation research and writing can be provided.

DEPARTMENT OF ELECTRICAL & COMPUTER ENINEERING

UNDERGRADUATE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://www.eng.famu.fsu.edu/ece

Chair: Sastry Pamidi; **Associate Chair for Undergraduate Programs**: Bruce A. Harvey; **Associate Chair for Graduate Programs**: M. Omar Faruque; **Professors**: Andrei, L. DeBrunner, V. DeBrunner, Foo, H. Li, Meyer-Baese, Pamidi, Perry, Roberts, Yu; **Associate Professors**: Anubi, Bernadin, Faruque, Harvey; **Assistant Professors**: Arigong, Cheetham, Dusanowski, F. Li, Moon, Pan, Takiddin, Vasconcelos; **Teaching Faculty I**: Manzak, Noroozi; **Teaching Faculty II**: Chuy, Hadi, Hooker; **Teaching Faculty III**: Brooks, Rajput; **Courtesy Professor**: Boebinger, McGinnis

Bachelor of Science in Electrical Engineering—Program Educational Objectives

Our BS in Electrical Engineering graduates will:

- Have successful careers in the field of electrical engineering making important contributions in the technical areas of digital systems, digital signal processing, control systems, electronics, power systems, or electromagnetics.
- Be enrolled in or have completed a graduate program or have shown a commitment to life-long learning and continuous self-improvement.
- Maintain high ethical standards and will have participated in the research, development, or application of engineering solutions that make a positive impact on industry and society.
- Make contributions to workforce diversity by functioning in local and global multicultural and multidisciplinary environments.

Bachelor of Science in Computer Engineering—Program Educational Objectives

Our BS in Computer Engineering Graduates will:

- Have successful careers in the field of computer engineering making important contributions in the technical areas of embedded systems, digital systems, digital signal processing, computer networks, artificial intelligence, or cybersecurity.
- Be enrolled in or have completed a graduate program or have shown a commitment to life-long learning and continuous self-improvement.
- Maintain high ethical standards and will have participated in the research, development, or application of engineering solutions that make a positive impact on industry and society.
- Make contributions to workforce diversity by functioning in local and global multicultural and multidisciplinary environments.

Program Review

The departmental faculty has established a process to periodically review and revise its two programs' educational objectives after obtaining feedback from its primary constituent groups. The faculty also is committed to teaching professional and ethical responsibility by example and by practice. The active sponsored research activities of the faculty ensure the program curricula remain contemporary and motivate the need for life-long learning.

Technical Electives

Technical electives provide the student an opportunity to achieve a greater breadth of knowledge and some degree of specialization in selected areas of special interest. Electives are offered in both electrical engineering and computer engineering application areas.

Electives are offered in the following electrical and computer engineering application areas:

Microelectronics deals with all aspects of solid-state electronic devices, the analysis and design of analog and digital circuits, their implementation and fabrication using microelectronic techniques, and their application in a wide variety of systems.

Digital signal processing and control systems concentrate on the design and analysis of systems in which discrete and continuous signals are used for conveying information and controlling physical systems and processes. Included are the encoding, decoding, and representation of information in both the time and frequency domain.

Communications is concerned with the preparation, transmission, and reception of encoded information via media ranging from wires to fiber optic cables and space. Included are topics such as AM, FM, and pulse modulation techniques; telecommunication systems; satellite telemetry; and wireless and computer networks.

Electromagnetics in the broadest sense is the study of the relationship between electric current, electric and magnetic fields, and their interactions. It is the foundation of electrical and electronic technology. The practical applications of this theory include the design of antennas, transmission lines, RF, microwave and optical transmission facilities, and radar.

Power systems engineering is concerned with the design and operation of electric power generation, transmission, and distribution for an increasing customer demand. It involves the modeling, analysis, and design of power system components including power transformers, electric motors, synchronous generators, and high voltage power transmission and distribution networks. Power system engineering also includes the investigation of alternative methods for generating electrical energy, the control and reliability of complex power networks, power quality, economic factors, and environmental effects.

Electives are offered in following computer engineering application areas:

Digital hardware design includes the design of specialized hardware that comprise digital systems, such as those required for facial recognition, microprocessor design, or digital communication.

Embedded computer system design focuses on the design of resource-limited (e.g., price, power dissipation, memory or storage) microprocessor-based systems which do not have the typical components of a computer like keyboard, monitor, or mouse.

Cybersecurity is concerned with the protection of information — stored and processed by computer-based systems — that is vulnerable to unintended exposure and misuse. Cyber-physical systems security concentrates on the secure design and analysis of systems in which independently interacting information, communication, and control components operate on different spatial and temporal scales. Examples include smart grid, autonomous automobile systems, medical monitoring, and industrial control systems.

Computer Networks includes the design and implementation of networks that allow the communication between computers and other digital systems including topics such as Internet of Things (IoT), Ad Hoc networks, smart grid communications, security, wireless sensor networks (WSN), and cyber physical systems.

Digital signal and image processing concerns the design and implementation of systems that are used to extract information found in noisy signals and measurements of many dimensions, and their use in enhancement (filtering), synthesis (computer generated audio and video) and analysis (computer recognition).

Honors in the Major

The Department of Electrical and Computer Engineering offers a program of honors in electrical engineering to encourage talented students to extend their undergraduate experience by participating in directed or independent research on a topic relative to electrical engineering that is not included in the regular curriculum. For requirements and other information, see the "University Honors Office and Honor Societies" chapter of this General Bulletin.

Digital Literacy Requirement

Students must complete at least one course designated as meeting the Digital Literacy Requirement with a grade of "C–" or higher. Courses fulfilling the Digital Literacy Requirement must accomplish at least three of the following outcomes:

- Evaluate and interpret the accuracy, credibility, and relevance of digital information
- Evaluate and interpret digital data and their implications
- Discuss the ways in which society and/or culture interact with digital technology
- Discuss digital technology trends and their professional implications
- Demonstrate the ability to use digital technology effectively
- Demonstrate the knowledge to use digital technology safely and ethically

Each academic major has determined the courses that fulfill the Digital Literacy requirement for that major. Students should contact their major department(s) to determine which courses will fulfill their Digital Literacy requirement. Undergraduate majors in electrical and computer engineering satisfy this requirement by earning a grade of "C–" or higher in COP 3014.

Coordination with CoreFSU Curriculum Requirements

In addition to satisfying the undergraduate computer skill competency, several courses required for undergraduate majors in electrical and computer engineering also satisfy some of the CoreFSU Curriculum Requirements. Undergraduate majors in electrical and computer engineering will satisfy these requirements by earning a grade of "C" or higher in the following courses listed.

CoreFSU Curriculum Requirement

Required Electrical or Computer Engineering Course

Scholarship in Practice

EEL 4911C - Senior Design Project I

Formative Experience

EEL 4914C - Computer Engineering Senior Design Project II

OR

EEL 4915C - Electrical Engineering Senior Design Project II

Computer Competency

EEL 3705L - Digital Logic Laboratory

Upper Division Writing

EEL 3927 - Engineering Design Concepts

Oral Communication Competency

EEL 4911C - Senior Design Project I

State of Florida Common Program Prerequisites for Electrical Engineering

The Florida Virtual Campus (FLVC) houses the statewide, internet-based catalog of distance learning courses, degree programs, and resources offered by Florida's public colleges and universities, and they have developed operational procedures and technical guidelines for the catalog that all institutions must follow. The statute governing this policy can be reviewed by visiting https://www.flsenate.gov/Laws/Statutes/2021/1006.73.

FLVC has identified common program prerequisites for the degree program in Electrical Engineering. To obtain the most up-to-date, state-approved prerequisites for this degree, visit: https://cpm.flvc.org/programs/379/285.

Specific prerequisites are required for admission into the upper-division program and must be completed by the student at either a community college or a state university prior to being admitted to this program. Students may be admitted into the University without completing the prerequisites but may not be admitted into the program.

Common Required Courses for Bachelor of Science Degrees

All candidates for Bachelor of Science in Electrical Engineering (BSEE) and Bachelor of Science in Computer Engineering (BSCpE) are required to complete a total of 76 credit hours of common required courses, of which 21 hours are English, social science, and humanities courses; 33 hours are engineering core courses (listed below); and 22 hours are common electrical and computer engineering courses (listed below).

Engineering Core Courses

COP 3014 Programming I (3)

MAC 2311 Calculus with Analytical Geometry I (4)

MAC 2312 Calculus with Analytical Geometry II (4)

MAC 2313 Calculus with Analytical Geometry III (5)

MAP 2302 Ordinary Differential Equations (3)

MAS 3105 Applied Linear Algebra I (4)

PHY 2048C General Physics A (5)

PHY 2049C General Physics B (5)

Common Required Electrical and Computer Engineering Courses

EEL 3002L ECE Engineering Tools Lab (2)

EEL 3135 Signal and Linear Systems Analysis (3)

EEL 3705 Digital Logic Design (3)

EEL 3705L Digital Logic Laboratory (1)

EEL 3927 Engineering Design Concepts (3)

EEL 4021 Statistical Topics in Electrical Engineering (3)

EEL 4746 Microprocessor-Based System Design (3)

EEL 4746L Microprocessor-Based System Design Laboratory (1)

EEL 4911C Senior Design Project I (3)

Requirements for a Major in Electrical Engineering

Students majoring in electrical engineering require one 128 credit hours to graduate including:

- Seventy-six hours of common required courses (listed above),
- Thirty credit hours of additional required courses for the electrical engineering majors (listed below)
- Twelve credit hours of required Tier-2 electrical engineering courses (listed below), and
- Ten credit hours are technical elective courses.

The additional required courses for the electrical engineering majors are:

CHM 1045/L General Chemistry I & Lab (3/1)

OR

BSC 2010/L Biological Science 1 & Lab (3/1)

EEE 3300 Electronics (3)

EEE 3300L Electronics Laboratory (1)

EEL 3111 Introductory Circuit Analysis (3)

EEL 3112 Advanced Circuits with Computers (3)

EEL 3112L Advanced Circuits with Computers Laboratory (1)

EEL 3472 Electromagnetic Fields I (4)

EEL 4515 Digital Communication Systems (3)

EEL 4915C Electrical Engineering Senior Design Project II (3)

All electrical engineering majors are required to complete three of the six 4-hour EE Technical Electives courses listed below (at least 12 credit hours):

EEE 4301/EEE 4301L Electronic Circuits and Systems Design (3/1)

EEL 3216/EEL 4217L Fundamentals of Power Systems (3/1)

EEL 3473C Electromagnetic Fields II (4)

EEL 4652 Analysis and Design of Control Systems (4)

EEL 4710/L Introduction to Field Programmable Logic Devices (3/1)

EEL 4742/L Advanced Microprocessors (3/1)

The technical electives for electrical engineering majors include:

- Nine credit hours must be Electrical Engineering (EE) technical electives, and
- Six credit hours may be an EE technical elective or a non-EE technical elective.

Any EEL or EEE prefixed course which is not required is considered an Electrical Engineering (EE) technical elective with the exception of EEL 3003 and EEL 3003L. Refer to the ECE Department website (https://eng.famu.fsu.edu/ece) or consult with the Department for information on available ECE technical electives.

The non-EE technical elective must be selected from a list of departmentally approved courses offered by other departments at Florida State University. Courses not on the list may be taken with prior approval of the department.

Requirements for a Major in Computer Engineering

Students majoring in computer engineering require one hundred 28 credit hours to graduate including:

- Seventy-six hours of common required courses (listed above),
- Ten credit hours of computer science courses (listed below),
- Twenty-one credit hours of additional required computer engineering courses (listed below),
- Nine credit hours of required Computer Engineering (CpE) Core electives (listed below), and
- Twelve credit hours are technical elective courses.

The required Computer Science Courses (ten credit hours) are:

COP 3330 Object Oriented Programming (3)

COP 3353 Introduction to UNIX (1)

COP 4530 Data Structures, Algorithms and Generic Programming (3)

MAD 2104 Discrete Mathematics I (3)

The additional engineering courses required for the computer engineering majors are:

CHM 1045/L General Chemistry I & Lab (3/1)

OR

BSC 2010/L Biological Science 1 & Lab (3/1)

EEL 3003 Introduction to Electrical Engineering (3)

EEL 4710/L Introduction to Field Programmable Logic Devices (3/1)

EEL 4713 Computer Architecture and Organization (3)

EEL 4742/L Advanced Microprocessors & Lab (3/1)

EEL 4914C Computer Engineering Senior Design Project II (3)

All computer engineering majors are required to complete three of the following six CpE Core Electives (nine credit hours):

EEL 4347 Introduction to Cybersecurity (3)

EEL 4759 Digital Image Processing (3)

EEL 4781 Computer Networks (3)

EEL 4887 Programming Languages in CpE (3)

EEL 4872 Artificial Intelligence (3)

EEL 4510 Digital Signal Processing

The technical electives for computer engineering majors include:

- Six credit hours must be Computer Engineering (CpE) technical electives, and
- Six credit hours may be CpE technical elective OR non-CpE technical electives.

Any EEL or EEE prefixed course which is not required is considered a Computer Engineering (CpE) technical elective with the exception of EEL 3111, EEL 3112, and EEL 3112L. Refer to the ECE Department Website (https://eng.famu.fsu.edu/ece) or consult with the Department for information on available EE technical electives.

The non-CpE technical elective must be selected from a list of departmentally approved courses offered by other departments at Florida State University. Courses not on the list may be taken with prior approval of the department.

Dual Major in Electrical Engineering and Computer Engineering

Students are NOT encouraged to pursue a dual degree in electrical and computer engineering except under exceptional circumstances. Students instead are encouraged to apply for the 4+1 BS/MS program.

Academic Requirements and Policies

In accordance with ABET criteria, all engineering students are subject to a uniform set of academic requirements agreed to by Florida A&M University and Florida State University. These requirements have been established to ensure that program graduates receive a quality education and make reasonable progress toward satisfying engineering major degree requirements. Students are directed to the "FAMU–FSU College of Engineering" chapter of this General Bulletin and the departmental website (https://www.eng.famu.fsu.edu/ece) for a list of all academic requirements and policies.

With the adoption of ABET EC-2000 policies, program requirements, educational objectives, course content and offerings, and departmental policies are subject to periodic revision and change. Students are strongly urged to obtain current information from their academic advisor, the academic coordinator, or by visiting the departmental Website at https://www.eng.famu.fsu.edu/ece.

ECE Course Prerequisite Requirement

In addition to the college course prerequisite requirements, the Department of Electrical and Computer Engineering requires students to have obtained a grade in the range of "C-" or better in all courses listed as prerequisites for the department's engineering core courses.

Definition of Prefixes

CES—Civil Engineering Structures

EEE—Engineering: Electrical and Electronic

EEL—Engineering: Electrical

EGN— Engineering: General

Undergraduate Courses

EEE 3300. Electronics (3). Prerequisite for Electrical and Computer Engineering Majors: EEL 3002L (C- or better); Corequisite for Electrical and Computer Engineering Majors MAP 2302 (C- or better). Additional Prerequisite for only Electrical Engineering Majors: EEL 3111 (C- or better). Additional Prerequisite for only Computer Engineering Majors: EEL 3111. This course covers diode models and circuits, DC biasing of bipolar-junction and field-effect transistors, small- and large-signal transistor models, and frequency analysis of single-stage AC amplifiers.

EEE 3300L. Electronics Laboratory (1). Prerequisites: EEL 3112 (C- or better) and EEL 3112L (C- or better); Corequisites: EEE 3300 (C- or better). Corequisite: EEE 3300. This laboratory supports EEE 3300, Electronics.

EEE 4288. Biomimetic Sensors and Signal Processing (3). Prerequisite: EEL 3135. In this course, biomimetic implies the mimicry of biology. This course covers biologically-inspired structure and function concepts used for novel sensor designs and signal processing. Cursory descriptions of biological phenomena are followed by electronic sensor designs and natural signal processing algorithms. This course focuses on natural sensory systems and innovative engineering applications inspired by them.

EEE 4301. Electronic Circuits and Systems Design (3). Prerequisites: EEE 3300 and EEE 3300L.Corequisite: EEE 4301L. This course uses computer-aided design programs and covers multistage amplifier analysis and design. The course focuses on feedback and operational amplifiers, A-to-D and D-to-A converters, and waveshaping and waveforming generators, including oscillators, voltage regulators, and power circuits.

EEE 4301L. Electronic Circuits and Systems Laboratory (1). Prerequisites: EEE 3300 and EEE 3300L.Corequisite: EEE 4301. This course is an advanced electronic laboratory.

EEE 4313. CMOS Digital IC Design (3). Prerequisite for Electrical Engineering Majors: EEE 3300; Prerequisite for Computer Engineering Majors: EEL 3003. This is an elective course that introduces students to the design of CMOS digital IC circuits using IC layout techniques.

EEE 4330. Microelectronics Engineering (3). Prerequisites: EEE 3300 and EEE 3300L. This course covers design and fabrication of solid-state devices. Topics include oxidation, diffusion, metallization, photolithography, and device characterization.

EEE 4351. Solid-State Electronic Devices (3). Prerequisites: EEE 3300 and EEE 3300L. This course covers solid-state physics as applied to electronic devices. The course focuses on semiconductor materials, conduction process in solids, device fabrication, diffusion processes, and negative conduction devices.

EEE 4376C. Introduction to Analog IC Design (3). Prerequisite: EEE 4301. This course covers the design and analysis of bipolar and MOS analog integrated circuits. The course focuses on operational amplifier design, analog multipliers, active loads, current sources, and active filters.

EEE 4377. Mixed Signal ICs (3). Prerequisite: EEL 4313 or EEL 4376C. This course introduces mixed-signal processing using analog and digital integrated circuits. The course focuses on fundamentals of sampled data systems, nonlinear and dynamic analog circuits, Nyquist-rate data converters, over-sampling data converters and digital filters, as well as the use of computer-aided design programs.

EEE 4450. Modeling and Simulation of Semiconductor Devices (3). Prerequisite: EEE 3300. This course covers various numerical techniques for the modeling and simulation of semiconductor devices, such as pn-junctions, metal-oxide semiconductor contacts, metal-oxide-semiconductor field effect transistors, and bipolar devices. Special emphasis is on the description and simulation of electron and hole transport in semiconductor devices.

EEE 4510. Digital Signal Processing (3). Prerequisite: EEL 3135. This course covers topics such as sinusoids, periodic signals, and Fourier spectra. Sampling of continuous-time signals, aliasing. Impulse response of linear, discrete-time systems, convolution. FIR filters and implementation. Frequency response of FIR filters. Z-transforms. IIR filters, poles and zeros, frequency response. Realization of IIR filters. Discrete Fourier transform and the FFT algorithm. MATLAB exercises are assigned.

EEE 4550. Radar (3). Prerequisites: EEL 3473 and EEL 3135. Corequisite: EEL 4021. This course examines basic concepts of radar systems including radar range equation, radar cross-section calculations, random processes and noise, array antennas, beamsteering, doppler and range processing, FM and CW systems, pulse compression, synthetic aperture radar, and clutter.

EEE 4773. Machine Learning (3). Prerequisites: EEL 3135, MAS 3105, knowledge of Matlab and/or Python, and instructor permission. This course is designed for senior undergraduate students from engineering disciplines and introduces students to the theory and engineering applications of machine learning including neural networks, fuzzy logic, genetic algorithms, supervised and unsupervised learning algorithms. This course places emphasis on engineering applications in controls, power systems, and robotics.

EEE 4872. Artificial Intelligence (3). Prerequisites: COP 4530 and EEL 4021. This course instructs students in basic artificial intelligence (AI) techniques of search, machine learning, natural language processing, robotics, and image processing. In this course, potential/current limitations are analyzed; as are human interaction in a decision-making environment.

EEL 3002L. ECE Engineering Tools Lab (2). Corequisite: EEL 3111 (C- or better). This is an introductory laboratory for students entering the electrical and computer engineering programs. The basic topics include: lab safety issues; solving engineering problems using software tools such as MATLAB and Mathematica; electric circuit simulations using c software packages such as Multisim and OrCAD; electric circuit design and instrumentation; the proper use of test and measurement equipment.

EEL 3003. Introduction to Electrical Engineering (3). Prerequisites: MAC 2312 (C- or better) and PHY 2049C (C- or better). This course is an introduction to electrical engineering concepts for non-electrical engineering majors. The course focuses on circuit theory for interfacing sensors and actuators. Operational Amplifiers are included. Not accepted for credit toward BSEE and BSCpE.

EEL 3003L. Introduction to Electrical Engineering Laboratory (1). Prerequisites: MAC 2312 and PHY 2049C. Corequisite: EEL 3003. This laboratory supports EEL 3003. Must be taken concurrently with first enrollment in EEL 3003. Must be dropped if EEL 3003 is dropped.

EEL 3111.Circuit Analysis I (3). Prerequisite: MAC 2312 (C- or better). Corequisite: PHY 2049C (C- or better). This course explores topics such as current, voltage, and power; resistors, inductors, and capacitors; network theorems and laws; operational amplifiers, phasors; impedances; sinusoidal steady-state analysis.

EEL 3112. Circuit Analysis II (3). EEL 3112 Prerequisites: EEL 3111 (C- or better) and EEL 3002L (C- or better); Corequisites: MAP 2302 (C- or better). This course examines sinusoidal steady-state power analysis; three-phase circuits; operational amplifier; transient and forced response; frequency response; two-port networks; and circuit analysis.

EEL 3112L. Advanced Circuits with Computers Laboratory (1). Prerequisites: EEL 3111 (C- or better) and EEL 3002L (C- or better); Corequisites: EEL 3112 (C- or better) and MAP 2302 (C- or better). This laboratory provides hands-on experience to electrical engineering majors in the fundamental topics of circuit analysis. It reinforces concepts introduced in the associated lecture.

EEL 3135. Signal and Linear System Analysis (3). Prerequisites: EEL 3135: Electrical/Computer Eng Majors - Prerequisites (C- or better): MAP 2302 and MAS 3105; Corequisites: (C- or better): EEL 3003 (Computer Eng Majors); EEL 3112 (Electrical Eng Majors). This course focuses on the classification and representation of signals and systems; Laplace transform; Z-transform; convolution; state variable techniques; stability and feedback.

EEL 3216. Fundamentals of Power Systems (3). Prerequisite: EEL 3112. This course is an introduction to the fundamentals of energy conversion; structure of power systems; and power system components: transformers, rotating machines, and transmission lines. The operation and analysis of power systems are presented.

EEL 3472. Electromagnetic Fields I (3). Prerequisites: EEL 3112, MAP 2302 or MAP 3305, MAS 3105 or MAP 3306, and PHY 2049C. This course explores electrostatic field—Gauss's law; boundary conditions; capacitance; Laplace's and Poisson's equations; energy, forces, and torques. The steady electric current. The magnetostatic field-vector potential; Ampere's and Biot-Stavart laws; inductance; energy, forces, and torques. Quasistatic fields; electromagnetic induction.

EEL 3473. Electromagnetic Fields II (3). Prerequisite: EEL 3472. This course examines topics such as Maxwell's equations, plane electromagnetic waves, group velocity, polarization, Poynting vector, boundary conditions, reflection and refraction of plane waves, skin effect, transmission line analysis, impedance matching, wave guides and cavity resonators, fundamentals of radiation and antennas.

EEL 3705. Digital Logic Design (3). Corequisites: COP 3014 and EEL 3705L. This course covers fundamental topics in digital logic design, including the use of a hardware description language, as well as number systems Boolean algebra, logic simplification, combinational, and sequential logic circuits.

EEL 3705L. Digital Logic Laboratory (1). Corequisite: EEL 3705. This laboratory supports EEL 3705. This course introduces Electrical and Computer Engineering majors to various practical aspects of Digital Logic. This includes analysis, design and testing of digital logic circuits. Design and implementation are covered using Altera devices.

EEL 3927. Engineering Design Concepts (3). Prerequisites for EE students: ENC 1101 and ENC 2135. Corequisite for EE students: EEL 3112. Prerequisites for CpE students: ENC 1101, ENC 2135, and EEL 4746. This course introduces the skills and knowledge necessary to effectively complete a capstone project. Students are presented with concepts in design, systems engineering, project management, engineering team organization, ethics, and professionalism.

EEL 4005. Measurements and Instrumentation for Electrical Engineers (3). Prerequisite: EEL 3112. This course introduces various measurement methods and instrumentation techniques used in electrical engineering practice and research.

EEL 4021. Statistical Topics in Electrical Engineering (3). Prerequisites: EEL 3112 and MAP 3306 or MAS 3105. This course examines the use of probability and statistical concepts in electrical engineering applications. Elementary probability—sets, sample spaces, axioms, joint and conditional probability. Random variables—distribution and density functions. Operations in random variables—expectation, moments, transformation of random variables. Introduction to random processes. Multiple random variables. Elements of statistics: parameter estimation and hypothesis testing.

EEL 4070. Introduction to Energy Storage (3). Prerequisite: EEL 3003 or EEL 3111. This course introduces students to energy storage technologies and devices with major focus on electrochemical storages including advanced rechargeable batteries, electrochemical capacitors, and fuel cells.

EEL 4113. Advanced Linear Networks (3). Prerequisite: EEL 3135. This course explores topics such as synthesis of LC one-port networks, synthesis of LC two-port networks; operational amplifier applications; active filters; approximation methods; switched-capacitor filters.

EEL 4213. Power Systems I (3). Prerequisite: EEL 3216. This course focuses on the analysis of electric power systems using system modeling for large-scale power networks; admittance and impedance matrix formation; power flow; optimal dispatch; symmetrical components; balanced and unbalanced fault analysis; and transient stability studies.

EEL 4217L. Power and Energy Lab (1). Prerequisite: EEL 3216. This course is intended to give the student practical experience with motors, generators, transformers and power system instrumentation equipment. Students learn the principles of electromechanical energy conversion by connecting, operating, and controlling induction, synchronous, and dc machines. Transport of electrical energy through transmission lines is also explored.

EEL 4220. Electromechanical Dynamics (3). Prerequisites: EEL 3216 and EEL 3472. This course focuses on the study of magnetic circuits, electromagnetic torques, and induced voltages. Topics covered include induction motors, variable speed drives, Park's transforms, synchronous machines and generator controls, DC machines, controls, and drives.

EEL 4231. Converter Modeling and Control (3). Prerequisite: EEL 4243. This course provides a study of DC-AC and DC-DC converter-modeling techniques and control schemes. Topics include average switch models, voltage-source and current-source converter models, current programmed control, and active filter control.

EEL 4243. Power Electronics (3). Prerequisites: EEE 3300 and EEL 3135. This course is designed to develop a basic understanding of using switched electronic circuits for the conversion and regulation of power. The course focuses on the basic converters and their steady state analysis. Dynamic modeling analysis, controller design, power semiconductor device, and simulation also are covered.

EEL 4244. Power Conversion and Control (3). Prerequisites: EEE 3300 and EEL 3112. This course introduces solid-state power conversion and control circuits, including analysis and design of nonlinear multiple-phase circuits with sinusoidal and non-sinusoidal variables; constant-frequency and variable-frequency input conversions; variable-frequency inverters; sensing and processing circuits supporting control systems; and embedded microprocessor control systems.

EEL 4280. Renewable Energy Generation I (3). This course is an introduction to renewable energy generation. Topics covered include smart grid system, hybrid electric vehicle, and grid-connected PV inverters. Emphasis is placed on the energy conversion techniques applied in the renewable energy source and energy storage elements.

EEL 4281. Photovoltaics (3). Prerequisites: EEE 3000. This course educates students in the design and applications of solar energy technology. This course focuses on theoretical fundamentals of solar energy conversion, types of solar cells and their operations, optical engineering, and energy storage and distribution systems. The course covers solar energy needs, current trends in photovoltaic energy engineering, solar cell material science, design and installation of solar panels for residential and industrial applications and connections to the national grid and cost analysis of the overall system.

EEL 4282. Renewable Energy Generation II (3). This course is an introduction to renewable energy generation. Topics covered include smart grid system, hybrid electric vehicle, and grid-connected PV inverters. Emphasis is placed on the energy conversion techniques applied in the renewable energy storage elements.

EEL 4347. Introduction to Cybersecurity (3). Prerequisites: COP 3014 and EE: 3705. This course is an introduction to computer security: symmetric ciphers, public-key cryptosystems, digital signatures, hashes, message authentication codes, key management and distribution, authentication protocols, vulnerabilities and malware, access control, and network security.

EEL 4435L. Electromagnetics Laboratory (1). Prerequisite: EEL 3473. This course focuses on the applications of electromagnetic field theory. Experiments include field mapping, transmission lines, spectrum analysis, impedance matching, waveguides, antennas, radar, and fiber optics.

EEL 4452. Optical Sensors (3). Prerequisite: EEL 3473. This course examines the basic concepts of optical sensors and essential optics. Topics include intensity, phase, and frequency modulated optical fiber sensors and their applications, distributive sensing systems, and optical fibers in signal processing.

EEL 4461. Antenna Systems (3). Prerequisite: EEL 3473. This course covers topics such as antenna theory, including Hertzian dipoles, thin linear antennas, aperture antennas, arrays, loop antenna, slots, horns, and waveguides.

EEL 4515. Digital Communication Systems (3). Prerequisite: EEL 3135 (C- or better). Corequisite: EEL 4021 (C- or better). This course covers topics such as sampling principle, spectral analysis of digital waveforms and noise, pulse and digital transmission systems, digital multiplexing, error probabilities, and system performance.

EEL 4595. Wireless Communications and Networking (3). Prerequisites: COP 3014 or equivalent, EEL 3135, and EEL 4021. This course covers the fundamentals of wireless communications and systems. The core topics include radio-wave propagation characteristics of wireless channels; modulation and demodulation techniques for mobile radio; reception techniques for wireless systems; fundamentals of cellular communications; multiple access techniques; wireless networking; and hybrid networking of a wireless system and the Internet.

EEL 4652. Analysis and Design of Control Systems (4). Prerequisite: EEL 3135. This course focuses on the control of linear time-invariant systems with an emphasis on continuous system modeling, stability analysis of linear systems, frequency response methods, the root locus method, and state-space methods.

EEL 4710. Introduction to Very High Speed Integrated Circuit Hardware Description Language (3). Prerequisites: EEL 3705 and EEL 3705L. This course offers an introduction to the VHDL hardware description language: data type, operations, combinational, sequential, components, functions, and procedures using VHDL. The course provides an overview of FPL devices and design tools.

EEL 4710L. Introduction to VHDL Laboratory (1). Prerequisites: EEL 3705 and EEL 3705L. Corequisites: EEL 4710. This course supports EEL 4710. The course introduces Electrical and Computer Engineering majors to various practical aspects of circuit design using Very High-Speed Integrated Circuits Hardware Description Language (VHDL).

EEL 4713. Computer Architecture (3). Prerequisites: COP 3014 and EEL 4746. This course presents modern computer architectures by studying how the relationships between hardware and software impact performance, machine language definition, processor data path and control designs, interfacing, and advanced topics.

EEL 4727. Digital Signal Processing with Field Programmable Gate Arrays (3). Prerequisite: EEL 4710. This course is a review of Field Programmable Gate Arrays (FPGAs), HDL, mathematics, signals and systems. Computer arithmetic concepts, DSP system design of FIR filters, IIR filters, DFT, FFT, and wavelets filter banks are also covered.

EEL 4735. Advanced Digital Hardware (3). Corequisite: EEL 4710. This course covers number representations, addition/subtraction, multiplication, division, real arithmetic, hardware algorithms for function evaluation, and implementation issues.

EEL 4742. Advanced Microprocessor-Based System Design (3). Prerequisites: EEL 4746 and EEL 4746L. Corequisite: EEL 4742L. This course covers advanced concepts in microprocessor-based system design. Topics include microprocessor architectures, hardware/software synchronization, interrupts, interface protocols, power management, and introduction to real-time operating systems.

EEL 4742L. Advanced Microprocessor-Based System Design Laboratory (1). Prerequisites: EEL 4746 and EEL 4746L. Corequisite: EEL 4742. This course is a laboratory in support of EEL 4742 Advanced Microprocessor-Based System Design.

EEL 4746. Microprocessor-Based System Design (3). Prerequisites: COP 3014 (C- or better), EEL 3705 (C- or better), and EEL 3705L (C- or better). Corequisite: EEL 4746L (C- or better). This course explores fundamental concepts in microprocessor-based system design. Topics include: C and assembly level programming, computer architecture and organization, hardware timers, interrupt controllers, and device interfacing utilizing parallel and serial I/O.

EEL 4746L. Microprocessor-Based System Design Laboratory (1). Prerequisites: EEL 3705 (C- or better) and EEL 3705L (C- or better). Corequisite: EEL 4746 (C- or better). Laboratory course in support of EEL 4746.

EEL 4759. Digital Image Processing (3). Prerequisite: MAP 2302. This course is an introduction to image processing techniques, including theoretical development, analysis, and practical implementation. A project that includes implementation grounds the successful student in current engineering practice.

EEL 4781. Computer Networks (3). Prerequisite: COP 3330. This course covers the fundamentals of computer network design and analysis; network architecture using layered approach; analysis and examples of network protocols and standards; techniques for evaluating network performance selecting network protocols.

EEL 4873. Embedded Microprocessor System Design (3). Prerequisite: EEL 3705. This course teaches students to be able to design, configure, and implement a complete embedded microprocessor system using soft-core, parameterized, or hard core microprocessors for FPGAs including required peripherals and software tools.

EEL 4887. CpE Languages: Introduction to Python, Verilog, and MatLab/Simulink (3). Prerequisite: EEL 4710. Corequisite: COP 3330. In this course, computer programming is used to improve quantitative problem-solving skills. This is a comprehensive course using the PYTHON, VERILOG, and MATLAB/SIMULINK programming languages.

EEL 4905r. Directed Individual Study (1–3). Prerequisites: Junior standing and “B” average in electrical engineering courses. Normally may be repeated to a maximum of six semester hours. Requires department approval.

EEL 4906r. Honors Work in Electrical Engineering (1–6). Prerequisite: Admission to the honors program. This course consists of independent or directed research in a specialized area beyond the current curriculum in electrical engineering. May be repeated to a maximum of nine (9) credit hours; repeatable within the same term.

EEL 4911C. Senior Design Project I (3). Prerequisite: Prerequisites: EEL 3111, EEL 3112, EEL 3135, EEL 3705, EEE 3300, EEL 3472, EEL 4021, EEL 4515, EEL 4746, EEL 4710 and COP 4530. This course exposes senior students to concepts in design, project management, engineering team organization, and professionalism. Students are grouped into design teams where these principles are put into practice in organizing, proposing, and developing an engineering project. Periodic written reports and oral presentations and a final written proposal are required. The lecture material and texts provide instructions on project management, ethics, and design skills.

EEL 4914C. Computer Engineering Senior Design Project II (3). Prerequisite: EEL 4911C. This course exposes senior students to the concepts in design, project management, engineering team organization, ethics, design skills, and professionalism. Students are grouped into design teams where these principles are put into practice in organizing, proposing, and developing an engineering project. Periodic written reports and oral presentations, and a final written report are required.

EEL 4915C. Electrical Engineering Senior Design Project II (3). Prerequisite: EEL 4911C. This course exposes senior students to the concepts in design, project management, engineering team organization, ethics, design skills, and professionalism. Students are grouped into design teams where these principles are put into practice in organizing, proposing, and developing an engineering project. Periodic written reports and oral presentations, and a final written report are required.

EEL 4930r. Special Topics in Electrical Engineering (3). This course covers special topics in electrical engineering with emphasis on recent developments. Topics vary; consult the instructor. May be repeated to a maximum of twelve (12) credit hours.

EGN 1004L. First-Year Engineering Laboratory (1). This course is intended to generate and maintain students' interest in the engineering disciplines so that they are motivated to become active learners, responsible students, and ethical engineering professionals.

DEPARTMENT OF ELECTRICAL & COMPUTER ENINEERING

GRADUATE STUDIES

Information for Graduate Students in Electrical and Computer Engineering

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://eng.famu.fsu.edu/ece

Website: https://eng.famu.fsu.edu/ece

Chair: Sastry Pamidi; **Associate Chair for Undergraduate Programs**: Bruce A. Harvey; **Associate Chair for Graduate Programs**: Md Omar Faruque; **Professors**: Andrei, L. DeBrunner, V. DeBrunner, Foo, H. Li, Meyer-Baese, Pamidi, Perry, Roberts, Yu; **Associate Professors**: Bernadin, Harvey, Faruque, Anubi; **Assistant Professors**: Moon, Pan, Arigong, Vasconcelos, Takiddin, Cheetham, Dusunowski, Liu ; **Teaching Faculty I**: Hooker, Noroozi, Manzak; **Teaching Faculty II:** Chuy, Hadi; **Teaching Faculty III**: Brooks, Rajput; **Courtesy Professors**: Boebinger, McGinnis

The Department of Electrical and Computer Engineering offers programs leading to the Master of Science (MS) degree in electrical engineering and the Doctor of Philosophy (PhD) degree in electrical engineering. The MS program is designed to provide advanced coursework and experience in independent problem solving with a moderate degree of both breadth and specialization. The master's thesis and its defense provide for independent in-depth study of current electrical engineering topics.

The PhD program is intended to provide students with an independent mastery of a significant portion of the field of electrical engineering. The PhD program prepares students for a career in industry, research, and/or teaching. Successful candidates must demonstrate, through original research, a substantial contribution to their field of specialty.

Areas of specialization in these programs generally coincide with the research interests of the faculty. Current specialization areas supported include computer engineering, computer security, electromagnetics, communications, digital signal processing and controls, power systems, power electronics, renewable energy, energy storage, energy conversion, robotics, and nanoelectronic engineering.

Facilities and Research Programs

Aeropropulsion, Mechatronics and Energy Center

The Aero-Propulsion, Mechatronics and Energy (AME) Center at Florida State University focuses on the development of transformational research programs to foster cross-cutting technologies while integrating with exemplary educational and professional training programs.

Center for Advanced Power Systems

The Center for Advanced Power Systems (CAPS), initially funded by the Office of Naval Research (ONR), is the preeminent center for multidisciplinary research, development, and education for advanced electrical power technologies serving electric ship, transportation and utility systems. The Center has developed an academic-industrial consortium focused on recent advances in power areas such as smart grid, cyberphysical system security, semiconductors, power electronics and converters, materials, advanced controls, and superconductivity applied to power system technologies. CAPS is a nationally renowned research center in power systems technology built around extensive simulation capabilities that will provide both off-line and real-time simulation of power systems with high power hardware-in-the-loop-based testing capability.

Major equipment and facilities include multiple large scale real-time simulators such as RTDS, Opal-RT systems, a 5-MW dynamometer system, a 5-MVA AC-DC-AC converter, a 0-24kV 5MW MVDC system, a 200-kV impulse testing laboratory, a superconductor ac-performance evaluation laboratory, a center wise multi-agent industrial control testbed, and two additional small laboratories.

Machine Intelligence Laboratory

The Machine Intelligence Laboratory with funding from the Department of Defense focuses on research in the areas of computer vision, pattern recognition, data mining, field-programmable-gate-array (FPGAs) for parallel computations, neural networks, evolutionary algorithms, biologically inspired systems, and evolvable random number generators.

Applied Laser Laboratory

Applied Laser Laboratory involves development of novel materials for specific applications. This lab performs fundamental and applied research in areas including nano-structural materials and solid thin films growth and characterization, and photonic and chemical sensors fabrication and modeling. The accomplishments include development of metal oxide semiconductor nanobelts, insulator-semiconductor-superconductor thin films, wideband photodiodes, and chemical nano-sensors. The lab is equipped with excellent facilities including a pulsed laser deposition system consisted with an excimer laser and a vacuum chamber with multi-target rotator and RHEED probe.

Power Sciences Laboratory

Power Sciences Laboratory is a fully equipped facility for conducting new energy sources development and involves development of high energy and high-power densities power sources including fuel cells, batteries, ultracapacitors, and hybrid power devices. The accomplishments include development of highest energy and power densities ultracapacitors, a method for enhancing the dielectric breakdown strength of polymer films, and novel monolithic hybrid fuel cells. The fundamental research includes understanding of the capacity degradation mechanisms in Li-ion and Li-polymer rechargeable batteries and development of theories for energy density of ultracapacitors and hybrid capacitors. The lab is equipped with four battery test systems, a fuel cell test system, AC impedance spectrometer, electronic load, surface analyzer, and glove box.

Electromagnetics Research Laboratory

The Electromagnetics Research Laboratory is a comprehensive research facility involved in studies of electromagnetics with emphasis on optical fiber technology and millimeter waves. The optics area of the laboratory investigates fiber-optic sensors and switches, high-resolution imaging systems, opto-mechanical and interferometric sensors, and optical fiber characterization. The millimeter waves area researches contactless material characterization, beam waveguides and open resonator techniques, mechanical and interferometric sensors, quasi-optics, and bioelectromagnetics. Other activities include microwave circuits and striplines, slot-lines, and antenna arrays. The laboratory is equipped with high-quality optical equipment including a precision reflectometer, an optical spectrum analyzer, lasers, detectors, power meters, optical benches, and translation gauges. The millimeter waves area has several state-of-the-art W-band (80 to 110 GHz) millimeter-wave sources, a high-resolution spectrum analyzer, detectors, and support equipment.

High-performance Computing and Simulation Research Laboratory

The High-performance Computing and Simulation (HCS) Research Laboratory focuses on research in advanced computer architectures, networks, systems, services, and applications for critical applications in reconfigurable, parallel, distributed, and fault-tolerant computing. This multi-university laboratory is headquartered in the ECE Department at the University of Florida (HCS-Gainesville), with the FAMU-FSU College of Engineering (HCS-Tallahassee) participating as a partner lab site. Both sites house key facilities linked by the Florida Lambda Rail. The lab has been cited by the NSA as a Research Center of Excellence in High-Performance Computing and Networking.

Activities focus on core areas in high-performance computer engineering whose contributions are critical for scalable, high-performance, dependable, and secure communications and computations far into the new century. Researchers address key issues that span the entire spectrum, from low-level hardware to grand-challenge applications, in a manner that emphasizes both theoretical and applied research to bring to fruition new concepts, models, techniques, and tools.

Information Processing and Transmission Engineering Research Laboratory

The research activities of the IPTEL group are oriented toward the convergence of information sensing, processing, and transmission. The goal is to address the many technical challenges in the design of seamless and integrated wireless sensors for practical applications. The latest research efforts are focused on two key areas: wireless sensor networks and signal processing. The thrust of the wireless sensor networks research efforts is to develop intelligent wireless sensor networks that exhibit swarm behavior. The main research topics currently being investigated include architectures, optimal protocols, data privacy, and fault tolerance for swarm-intelligent wireless sensor networks. The thrust of the signal processing research efforts is to develop innovative signal processing techniques and algorithms suited for automatic target detection, classification, and tracking. The emphasis is placed on approaches that are based on physical principles, detection theory, statistical techniques, multi-resolution signal processing, neural networks, genetic algorithms, and swarm intelligence.

Wireless Intercommunication Laboratory

The Wireless Intercommunication Laboratory, initially started and funded by the NASA Kennedy Space Center, studies wireless voice and data communication as an extension of the existing digital intercommunication system. The research engaged in the laboratory includes wireless communication systems, real-time embedded digital signal processing, spread-spectrum rapid synchronization, wireless network protocols, and error control coding. Other research conducted in the laboratory has focused on reliability of wired and wireless communication systems in the high lightning environment of the state of Florida.

The department also is an active contributor to the Florida Engineering Education Delivery System (FEEDS), which provides graduate education throughout the state of Florida using tutored video. A two-way television link between the College of Engineering and the Florida State University Panama City campus provides live, interactive instruction for students in the Panama City area and allows students in Tallahassee to benefit from faculty teaching on the Panama City campus.

Assistantships

Financial assistance often can be provided for graduate students through teaching or research assistantships and tuition fee waivers. Teaching assistantships involve assisting in the supervision of laboratory courses, grading, and related duties. Students awarded research assistantships participate in departmental or externally sponsored research projects under the guidance of a faculty member. Selection is competitive and is based upon potential for teaching (including language skills), Graduate Record Examinations (GRE) test scores, grade point average (GPA), and recommendations. Application for departmental financial assistance should be made directly to the graduate program director through the web link on the Department of Electrical and Computer Engineering webpage.

Master of Science

Admission

To be considered for admission, candidates must have earned a bachelor of science degree (or equivalent) in electrical engineering, or a closely related discipline, from an Accreditation Board of Engineering and Technology (ABET)-approved program, a grade point average (GPA) of at least 3.0 on a 4.0 scale for all work attempted beyond 60 credit hours of undergraduate study, and a minimum score of 148 points for the quantitative section and 145 points for the verbal section of the GRE. GRE can be waived under special circumstances (please see the ECE website).

International candidates must also pass TOEFL and obtain a minimum of 80 on the Internet-based exam or 550 on the paper-based exam, or IELTS and obtain a minimum of 6.5 points.

Students with a bachelor's degree in a field other than electrical engineering may be required to complete a department-designated sequence of undergraduate courses with grades of “B” or better prior to attempting graduate electrical engineering work.

Students interested in obtaining a teaching assistantship should submit the TA/Grader Application Form as soon as they have been admitted to the program. Students who are not native speakers of English should take the speaking section of the TOEFL test (and obtain a score of twenty-six points or higher) or the SPEAK test at FSU (and obtain a score of forty-five points or higher) in order to be eligible to apply to for a teaching assistantship. More information about teaching assistantships can be found on the TA/ Grader Application Form.

Course Work Requirement Thesis Option

Students must complete a minimum of 30 credit hours of course work to obtain the degree. The 30 credit hours should satisfy:

- Six credit hours should be from the list of core courses (see the Core Courses section for the list of core courses).
- At least three credit hours should consist of a course in advanced mathematics, typically a 5000-level course or above, or a departmental approved substitute.

- At least six credit hours of EEL 6971r (MS thesis).
- At least 15 credit hours should be from letter grade elective courses.

No DIS or supervised research is counted towards this degree.

Course Work Requirement Non-Thesis Option

Students must complete a minimum of 30 credit hours of course work to obtain the degree. The 30 credit hours should satisfy:

- Six credit hours should be from the list of core courses (see the Core Courses section for the list of courses).
- At least three credit hours should consist of a course in advanced mathematics, typically a 5000-level course or above, or a departmental approved substitute.
- At least 24 out of 30 credit hours should be in the Department of Electrical and Computer Engineering (EEL or EEE). The 24 credit hours in the Department of Electrical and Computer Engineering cannot include transfer courses.

No Directive Independent Studies (DIS) will be allowed for this degree.

Core Courses

All graduate students need to take at least two out of the following four core courses:

EEE 5317 Power Electronics (3)

EEE 6353 Semiconductor Device Theory (3)

EEL 5173 Signal and System Analysis (3)

EEL 5764 Computer System Architecture (3)

Graduate Seminar

All full-time MS degree candidates are required to enroll in the graduate seminar, EEL 6932r, for each term that they are enrolled in the graduate program. The details of the seminar are given under "Course Listing".

Advisor and Supervisory Committee

Each student must identify an advisor (also called major professor) by the end of the first term of course work and is required to submit a plan of study by the time he or she has completed 12 credit hours of graduate studies. The plan of study must be approved by the departmental Graduate Coordinator and the student's advisor. The student's advisor will also assist the student in forming the Student's Supervisory Committee (also called thesis committee).

The Supervisory Committee of a master's degree thesis program student must have at least three faculty members from the student's home department with Graduate Faculty Status (GFS). Additional members may be added provided they have GFS in their home department. At least one Tallahassee campus faculty member with GFS must serve on a thesis committee chaired or co-chaired by a Panama City Campus faculty member. One Panama City Campus faculty member with GFS must be annually appointed by the ECE department chair to serve on the ECE graduate committee.

The chair of the Supervisory Committee must be granted the privilege of chairing master's level thesis committees prior to the student's defense of his or her thesis. Granting of this privilege requires an affirmative majority vote of the GFS faculty of the department and approval by the department chair. Faculty holding this privilege will be reviewed periodically by the department chair. Those not meeting performance expectations may have this privilege revoked upon recommendation of the department chair, an affirmative majority vote of the GFS faculty of the department, and approval of the academic dean.

Thesis Requirements (Thesis)

All Master of Science (MS) thesis program students must complete a written thesis. Upon completion of the thesis, an oral defense is required, which consists of a public presentation of the student's work to the department and the student's supervisory committee. Students must register for EEL 8976, Master's Thesis Defense, during the term they plan to graduate. The thesis should be in the hands of the major professor and the examining committee at least ten days before the date of the oral examination.

It is the student's responsibility to post the thesis defense announcement within the department and the College of Engineering at least one week prior to the defense. The announcement should include: thesis title; student's name; student's department; major professor and committee members; date, time and location of student's defense.

Master's Comprehensive Exam Requirements (Non-Thesis)

All students in the non-thesis MS degree program must register for and successfully pass the Master's Comprehensive Exam, EEL 8966. The students must apply to take the examination in the Department of Electrical and Computer Engineering office by the end of the prior term. A maximum of two attempts will be permitted.

The exam is taken over a five-week period. In preparing for the examination, the student shall present a forty-page literature review report to a committee demonstrating an understanding of the theoretical framework in a given area of research based on an in-depth literature review. In demonstrating an understanding of the literature, the student must include a discussion that identifies the state-of-the-art and knowledge gaps in that area. Upon submission of the literature review report, the committee will respond to the student with questions related to the report itself and the area of research. The following is a schedule of events for the successful completion of the examination:

The student must make arrangements with the advisor to schedule a five-week time period for the examination. The examination committee should contain at least three faculty members with GFS status from the ECE Department.

With the consultation of the advisor, the student will submit a research review report to the examination committee. This document should abide by the format of each university's PhD thesis and the topic should be determined by the student and major advisor. The student is encouraged to submit the research review report by the middle of the term for which he/she registered for the Preliminary Examination. The student should abide by the IEEE plagiarism policy.

The committee will submit written questions to the advisor for collection by the student two weeks after submission of the research review report. These questions will relate to the research review report.

The student will have two weeks to develop written responses to the questions in preparation of the oral exam. These responses will be submitted to the advisor, who will then distribute the responses to the committee members. The student should submit a complete bound set of answers to each committee member.

The oral examination will be held within one week of submission of the written responses. This examination will be primarily related to the research area and the student's written responses. Appropriate related fundamental concepts may also be covered.

Pass/Fail is determined on the combined written and oral responses to committee questions. A majority of committee votes and a pass vote by the committee chair is required to pass.

Transfer Credits

A maximum of six credit hours of graduate courses not counted toward a previous degree from another regionally accredited graduate school may be transferred from another academic institution(s) to the student's current master's degree program, with the approval the ECE Departmental Graduate Committee. A grade of "B" or better is required in all transferred coursework.

Doctor of Philosophy

Admission

To be considered for admission, candidates must have earned a bachelor's degree or a master's degree (or equivalent) in electrical engineering, or in a closely related discipline, from an Accreditation Board of Engineering and Technology (ABET)-approved program, a grade point average (GPA) of 3.3 on a 4.0 scale on all baccalaureate coursework and any graduate work attempted, and a minimum score of 151 points for the quantitative section and 145 points for the verbal section of the GRE.

International candidates must also pass TOEFL and obtain a minimum of 80 on the Internet-based exam or 550 on the paper-based exam or pass IELTS and obtain a minimum of 6.5 points.

Students with a bachelor's degree in a field other than electrical engineering may be required to complete a department-designated sequence of undergraduate courses with grades of "B" or better prior to attempting graduate electrical engineering work.

Students interested in obtaining a teaching assistantship should submit the TA/Grader Application Form as soon as they have been admitted to the program. Students who are not native speakers of English should take the speaking section of the TOEFL test (and obtain a score of twenty-six points or higher) or the SPEAK test at FSU (and obtain a score of forty-five points or higher) in order to be eligible to apply to for a teaching assistantship. More information about teaching assistantships can be found on the TA/ Grader Application Form.

Course Work Requirement

The course work requirement depends on the previous degree obtained by the student. Thus, we distinguish five tracks:

- BS-to-PhD: if the student has a BS degree in EE or related areas.
- MS/EE-to-PhD: if the student has a MS degree in electrical engineering or equivalent.
- MS-to-PhD: if the student has a MS degree in Physics, Mathematics, or other Engineering Fields.
- MS/Thesis-to-PhD: if the student has a MS degree in EE from the FAMU-FSU College of Engineering and has graduated with the thesis option.
- MS/Non-Thesis-to-PhD: if the student has a MS degree in EE from the FAMU-FSU College of Engineering and has graduated with the non-thesis option.

The default track for students enrolling in the PhD program is BS-to-PhD. PhD students that want to follow a different track need to fill in PhD Track Approval Form at the beginning of their program. The number of credits required for each of the five tracks is summarized in the table below:

From: **To:**	**BS** **PhD**	**MS/EE** **PhD**	**MS** **PhD**	**MS/Thesis** **PhD**	**MS/Non-Thesis** **PhD**
Core Courses	6	6	6	0	0
Electives/Supervised Research/DIS	21	9	15*	3	3
Dissertation Hours	24	24	24	24	24
Total	51	39	45	27	27

*Up to six credit hours can be 4000-level courses, however, they will not be counted towards the calculation of GPA.

Graduate Seminar Requirement

All full-time PhD candidates are required to enroll in the graduate seminar, EEL 6932r, for each term that they are enrolled in the graduate program.

In addition, all the PhD candidates need to make at least one oral presentation about their research in the Graduate Seminar, after passing the PhD Preliminary Examination and before graduation.

Advisor and Supervisory Committee

The Graduate Director is by default the initial advisor of all incoming graduate students. However, students are strongly encouraged to select another advisor among the current faculty members as soon as they arrive in the ECE Department by filling in the Advisor Form. The student should be in contact with the advisor on a regular basis and all the decisions related to the course work and the plan of studies development of the student should be approved by the advisor. The student's advisor also will assist the student in forming the Student's Supervisory Committee (also called dissertation committee) by the end of the first year of studies.

The Supervisory Committee of a doctoral degree thesis program student must have at least at least four members with Graduate Faculty Status (GFS). Three of the four members must be faculty members from the student's home department. The fourth member, the University Representative, must be a tenured member of the faculty holding GFS from outside the ECE department.

The chair of the Supervisory Committee must have experience in chairing a master's thesis committee or serving on a doctoral dissertation committee prior to earning the privilege of chairing a dissertation committee. Granting of this privilege requires an affirmative majority vote of the GFS faculty of the department and approval by the department chair. Faculty holding this privilege will be reviewed periodically by the department chair. Those not meeting performance expectations may have this privilege revoked upon recommendation of the department chair, an affirmative majority vote of the GFS faculty of the department, and approval of the academic dean. FSU Panama City Campus faculty with GFS cannot serve as a chair of a doctoral dissertation committee.

PhD Preliminary Examination

The Preliminary Examination is the final requirement for doctoral candidacy. This exam is taken over a five-week period. It must be successfully completed by the student's fourth term (for the BS-to-PhD track), or third term (for all the other tracks). The student is allowed to retake the exam only once.

In the term the student intends to take the Preliminary Examination, he/she needs to register for the zero-credit hour EEL 8964 (Prelim Exam). This registration must be done only once.

The exam is taken over a five-week period. In preparing for the examination, the student shall present a forty-page literature review report to a committee demonstrating an understanding of the theoretical framework in a given area of research based on an in-depth literature review. In demonstrating an understanding of the literature, the student must include a discussion that identifies the state-of-the-art and knowledge gaps in that area. Upon submission of the literature review report, the committee will respond to the student with questions related to the report itself and the area of research. The following is a schedule of events for the successful completion of the examination:

The student must make arrangements with the advisor to schedule a five-week time period for the examination. The examination committee should contain at least three faculty members with GFS status from the ECE Department.

With the consultation of the advisor, the student will submit a research review report to the examination committee. This document should abide by the format of each university's PhD thesis and the topic should be determined by the students and major advisor. The student is encouraged to submit the research review report by the middle of the term for which he/she registered for the Preliminary Examination. The student should abide by the IEEE plagiarism policy.

The committee will submit written questions to the advisor for collection by the student two weeks after submission of the research review report. These questions will relate to the research review report.

The student will have two weeks to develop written responses to the questions in preparation of the oral exam. These responses will be submitted to the advisor, who will then distribute the responses to the committee members. The student should submit a complete bound set of answers to each committee member.

The oral examination will be held within one week of submission of the written responses. This examination will be primarily related to the research area and the student's written responses. Appropriate related fundamental concepts may also be covered.

Pass/fail is determined on the combined written and oral responses to committee questions. A majority of committee votes and a pass vote by the committee chair is required to pass.

After the examination is completed the Preliminary Examination Report Form should be filled and submitted to the ECE Graduate Coordinator. A student who passes the examination will be recognized as a candidate for the PhD Degree.

Prospectus Examination

After passing the PhD Preliminary Examination, the student should pass the Prospectus Examination. This examination is usually passed by the end of the third year and needs to take place at least eight months before the graduation date. The student must submit a Prospectus Examination Application/Approval Form to the ECE Graduate Committee. The student's advisory committee administers this exam, which may be in the form of a written or a combination of written and oral examination. The content and scope of the exam are at the discretion of the committee. The Prospectus Examination represents the defense of the Dissertation Proposal.

Dissertation Defense Announcement

It is the student's responsibility to post the dissertation defense announcement within the department and the College of Engineering at least two weeks prior to the defense. The announcement should include: dissertation title; student's name; student's department; major professor and committee members; date, time, and location of student's defense. Academic courtesy requires that the dissertation be submitted to each member of the supervisory committee at least four weeks before the date of the oral examination.

Dissertation and Defense

The PhD dissertation must be an achievement in original research constituting a significant contribution to knowledge and represent a substantial scholarly effort on the part of the student. It is the responsibility of the major professor to supervise the preparation of the prospectus and the dissertation. The manuscript must be prepared according to the style and form prescribed by the department and must conform to the University requirements regarding format.

The student must submit a PhD Presentation and Defense Application/Approval Form to the ECE Graduate Committee. Please refer to the Graduate Student Handbook from your university for further details.

The defense of the dissertation will be oral. All committee members and the student must attend the entire defense in real time, either by being physically present or participating via distance technology.

Transfer Credits

A maximum of six credit hours of graduate courses not counted toward a previous degree from another regionally accredited graduate school may be transferred from another academic institution(s), with the approval of the ECE Graduate Committee. A grade of “B” or better is required in all transferred coursework.

Journal Paper Submission Requirement

All PhD students are required to publish, or have accepted for publication, at least one refereed article to a journal in their field of interest before their graduation will be approved.

Definition of Prefixes

CES—Civil Engineering Structures

EEE—Engineering: Electrical and Electronic

EEL—Engineering: Electrical

Graduate Courses

CES 5835. Design of Masonry Structures (3). Prerequisites: CES 3100 and CES 4702. This course covers properties, specifications, and construction requirements for clay and concrete masonry structures; and, analysis and design of masonry structures including a comprehensive diaphragm / shearwall masonry structure design project.

EEE 5280. Biomimetic Systems Theory (3). Prerequisite: Graduate standing or instructor permission. This course covers natural systems and signal-processing theory as revealed by biological sensory systems. Focus is on innovative engineering applications inspired by nature sensory systems. Application of the biomimetic theory is reinforced through a course project which demonstrates successful mimicry of a natural sensory system concept.

EEE 5315. Digital Integrated Circuit Design (3). Prerequisite: EEL 4301. This course covers the design of integrated circuits, applications, solid-state-device switching characteristics, memory, computer-aided design, and layout.

EEE 5317. Power Electronics (3). Prerequisites: EEE 3300 and EEL 3135. This course helps students develop a basic understanding of using switched electronic circuits for the conversion and regulation of electric power. The course focuses on basic converters and their steady state analysis and covers dynamic-modeling analysis, converter-controller design, power-semiconductor device, and converter simulation.

EEE 5378. Mixed Signal Integrated Circuits (3). Prerequisite: EEL 5315. This course introduces mixed-signal processing using analog and digital integrated circuits. The course covers fundamentals of sampled data systems, nonlinear and dynamic analog circuits, Nyquist-rate data converters, over-sampling data converters, and digital filters, as well as the use of computer-aided design programs.

EEE 5452. Analysis of Quantum Scale Semiconductor Devices (3). Prerequisite: Graduate standing or instructor permission. This course presents techniques for the analysis and simulation of nanometric-scale semiconductor devices (SDs), and focuses on the analysis of quantum-induced effects on the electronic transport and characteristics of SDs. The course covers generation-recombination processes in semiconductors, quantum and semiclassical modeling of SDs, noise and fluctuations in SDs, and numerical techniques for the simulation of SDs.

EEE 5542. Random Processes (3). Prerequisites: EEL 3135 and EEL 4021. This course covers topics such as random processes; analysis and processing of random signals; modeling of engineering systems by random processes; selected applications in detection; filtering; reliability analysis; and system performance modeling.

EEE 5557. Radar (3). This course introduces basic concepts of radar systems including radar range equation, radar cross section calculations, random processes and noise, array antennas, beamsteering, and doppler and range processing. FM and CW systems, pulse compression, synthetic aperture radar, and clutter also are covered.

EEE 5776. Machine Learning (3). Prerequisites: Knowledge of Linear Algebra, Signals and Systems, and Statistical Topics, and instructor permission. This course is designed for first-year graduate students from engineering disciplines and introduces students to the theory and engineering applications of machine learning including neural networks, fuzzy logic, genetic algorithms, supervised and unsupervised learning algorithms. This course places emphasis on engineering applications in controls, power systems, and robotics.

EEE 6353. Semiconductor Device Theory (3). Prerequisite: EEE 3300 or equivalent. This course covers solid-state physics as applied to electronic devices, semiconductor materials, conduction processes in solids, device fabrication, diffusion processes, and semiconductor devices.

EEE 6502. Digital Signal Processing I (3). Prerequisite: EEL 5173. This course discusses the fundamentals of digital signal processing and design of a variety of digital processors and filters. Introduction to DFT-FFT and spectral estimation theory and practice.

EEL 5025. Computational Electrical Engineering (3). Prerequisites: EEL 3135, EEL 3300 (at FAMU) and EEE 3300 (at FSU), EEL 3472, and COP 2221 (at FAMU) and COP 3014 (at FSU), or instructor permission. This course covers a broad range of computational methods and their applications to electrical engineering. Methods include solution of equations, matrices, differentiation, integration, solution of differential equations, Fourier analysis, and boundary-value problems. Applications include circuit analysis, signal processing, electromagnetics, and optics.

EEL 5040. Measurements and Instrumentation for Electrical Engineers (3). Miscellaneous Requirement: Students should have an undergraduate-level understanding of AC and DC electrical circuits. This course introduces various measurements methods and instrumentation techniques used in electrical engineering practice and research.

EEL 5075. Introduction to Energy Storage (3). Prerequisite: EEL 3003, EEL 3111, or graduate standing. This course provides students with an overview on energy storage technologies and devices with focus on electrochemical storages including advanced rechargeable batteries, electrochemical capacitors, and fuel cells.

EEL 5173. Signal and System Analysis (3). Prerequisite: EEL 3135 or EEL 4652. This course focuses on continuous and discrete dynamic models with an emphasis on state variable models; Laplace transform, z-transform, and the time domain solutions. Includes real-time digital simulation and sampling theory.

EEL 5250. Power Systems Analysis (3). This course examines power system planning and operational problems. Subjects covered include load flow, economic dispatch, fault studies, transient stability, and control of problems. System modeling and computer solutions are emphasized through class projects.

EEL 5270. Power System Transients (3). Prerequisite: EEL 4213. In this course, topics include electrical transients in power systems; study of time domain, frequency domain and traveling wave techniques for transient analysis; study of switching transients associated with loads, capacitors, faults, line reclosing and single-pole switching; study of interaction between lighting and power systems; introduction to insulation coordination.

EEL 5284. Photovoltaics (3). Prerequisite: EEE 3300 or knowledge of electronics and semiconductor physics. This course educates students in the design and applications of solar energy technology. This course focuses on theoretical fundamentals of solar energy conversion, types of solar cells and their operations, optical engineering, and energy storage and distribution systems. The course covers solar energy insolation and global energy needs, current trends in photovoltaic energy engineering, solar cell material science, design and installation of solar panels for residential and industrial applications and connections to the national grid and cost analysis of the overall system.

EEL 5285. Renewable Energy Generation I (3). This course is an introduction to renewable energy generation. Topics covered include smart grid system, hybrid electric vehicle, and grid-connected PV inverters. Emphasis is placed on the energy conversion techniques applied in the renewable energy source and energy storage elements.

EEL 5286. Renewable Energy Generation II (3). This course is an introduction to renewable energy generation. Topics covered include smart grid system, hybrid electric vehicle, and grid-connected PV inverters. Emphasis is placed on the energy conversion techniques applied in the renewable energy source and energy storage elements.

EEL 5288. Integration of Distributed Generation (3). Prerequisite: EEL 3216. This course introduces the concept of integration of alternate renewable resource-based power generation technologies known as 'Distributed Generation'. The course familiarizes students with various DG sources such as Wind, Solar, Hydro, Wave and Tidal, Geothermal, and Bio-fuel based energy generation technologies, however, PV and wind technologies are studied in detail. The course also covers the modeling and simulation of distribution networks, modeling of PV and wind technologies, their integration technologies with the grid, possible impacts on grid due to the integration of DG, tariffs (feed-in tariff, net-metering etc.) for DG integrations, impact of variability, microgrids and its controls, IEE interconnection standards etc.

EEL 5348. Introduction to Cybersecurity (3). Prerequisites: Instructor permission. This course provides an introduction to computer security: symmetric ciphers, public key cryptosystems, digital signatures, hashes, message authentication codes, key management and distribution, authentication protocols, vulnerabilities and malware, access control, and network security.

EEL 5427. RF/Microwave Circuits II (3). Prerequisite: Graduate standing or instructor permission. This course focuses on active RF/microwave design. Topics include two-port characterization of RF/microwave transistors; matching networks; RF/microwave transistor amplifier design using low-noise, high-gain, broadband and high-power design methods; and RF/microwave transistor oscillator design.

EEL 5454. Optical Sensors (3). Prerequisite: EEL 3512, EEL 3473 or equivalent. This course examines the basic concepts of optical sensors and essential optics. Topics include intensity, phase, and frequency modulated optical fiber sensors and their applications; distributive sensing systems; and optical fibers in signal processing.

EEL 5465. Antenna Theory (3). Prerequisite: EEL 3473 or EEL 4461. This course covers topics such as electromagnetic fields; radiation from simple sources and apertures; receiving antennas; arrays-uniformly spaced, non-uniform, pattern synthesis; cylindrical antennas and arrays; radiation from conical and spheroidal structures; slot antennas; open waveguides and small horns.

EEL 5486. Advanced Electromagnetic Theory (3). Prerequisite: EEL 3473. This course discusses advanced concepts and theorems in electromagnetic fields; plane, cylindrical, and spherical wave functions; perturbation and variational techniques; microwave networks.

EEL 5591. Wireless Communications and Networking (3). Prerequisites: EEL 3135, EEL 4021, EEL 4514; "C" programming or equivalent. This course covers the fundamentals of wireless communications and systems. The core topics include radio-wave propagation characteristics of wireless channels; modulation and demodulation techniques for mobile radio; reception techniques for wireless systems; fundamentals of cellular communications; multiple access techniques; wireless networking; and hybrid networking of a wireless system and the Internet.

EEL 5613. Foundations for Advanced Control Methods (3). This course introduces the basic background for most control theoretic developments. The course considers standard treatments of the necessary mathematical background for such development. In this course, mathematical techniques are developed that required for advanced control design, including: Linear Algebra, Numerical Optimization, and Nonlinear Analysis.

EEL 5667. Robot Kinematics and Dynamics (3). Prerequisite: EEL 4652. This course is an introduction to robot kinematics and dynamics, including forward kinematics, inverse kinematics, and differential kinematics. Also covers rigid motion and homogenous transformations, velocity and force/torque relations and resolved motion rate control; serial, parallel and kinematically redundant manipulators.

EEL 5707. ASIC Systems Design I (3). Prerequisite: EEL 3705. This course is an introduction to Application Specific Integrated Circuit (ASIC) families. Overview of programmable ASICs. Introduction to the VHDL design entry and simulation language. Programmable ASIC design methodology is introduced.

EEL 5722. Digital Signal Processing with Field Programmable Gate Arrays (3). Prerequisite: Graduate standing. This course is a review of Field Programmable Gate Arrays (FPGAs), HDL, mathematics, signals and systems. Computer arithmetic concepts, DSP system design of FIR filters, IIR filters, DFT, FFT, and wavelets filter banks are also covered.

EEL 5764. Computer System Architecture (3). This course focuses on advanced topics, including memory hierarchy such as caching and virtual memory, pipelining, and others.

EEL 5766. Advanced Digital Hardware (3). Prerequisites: Graduate standing or instructor permission. Corequisite: EEL 4710 or equivalent. This course covers number representations, addition/subtraction, multiplication, division, real arithmetic, hardware algorithms for function evaluation, and implementation issues.

EEL 5769. Advanced Microprocessor-Based System Design (3). Prerequisites: EEL 4746 and EEL 4746L. Corequisite: EEL 5769L. This course explores advanced concepts in microprocessor-based system design/ Topics for this course include microprocessor architectures, hardware/software synchronization, interrupt interface protocols, power management, and an introduction to real-time operating systems.

EEL 5769L. Advanced Microprocessor-Based System Design Laboratory (1). Prerequisites: EEL 4746 and EEL 4746L. Corequisite: EEL 5769. This course examines advanced concepts of microprocessor architecture and application. Students develop the required skills to implement these devices into complex embedded systems that include multiple peripherals.

EEL 5784. Computer Networks (3). Prerequisite: COP 3330. This is a first course in the fundamentals of computer network design and analysis. The course presents network architecture using a layered approach. Analysis and examples of network protocols and standards and techniques for evaluating network performance and selecting appropriate network protocols are covered.

EEL 5820. Digital Image Processing (3). Prerequisite: EEL 3135 or instructor permission. This course is an introduction to image processing techniques, including theoretical development, analysis, and practical implementation. In this course, a project that includes implementation grounds the successful student in current engineering practices.

EEL 5875. Artificial Intelligence (3). Prerequisites: EEL 4021 and COP 4530. This course examines basic artificial intelligence (AI) techniques of search, machine learning, natural language processing, robotics, and image processing. The course analyzes potential/current limitations and human interaction in a decision-making environment.

EEL 5877. Embedded Microprocessor System Design (3). Prerequisite: EEL 3705. This course teaches students to be able to design, configure, and implement a complete embedded microprocessor system using soft-core, parameterized, or hard-core microprocessors for FPGAs including required peripherals and software tools.

EEL 5905r. Directed Individual Study (1–3). (S/U grade only). Prerequisite: Instructor permission. Students can enroll in EEL 5905 during multiple semesters and take at most 9 credits per semester, however, these credits cannot be used towards the minimum credit requirement for the MS of PhD degrees.

EEL 5910r. Supervised Research (1–5). (S/U grade only). Prerequisites: Graduate standing and departmental approval. This course cannot be used as credit toward degree. May be repeated to a maximum of three semester hours for candidates in master's degree, and five semester hours for candidates in doctoral degree.

EEL 5930r. Special Topics in Electrical Engineering (3). This course examines special topics in electrical engineering at the graduate level with emphasis on recent research and developments. Content, credit, and prerequisites vary; consult instructor. May be repeated to a maximum of twelve semester hours.

EEL 6237. Modern AC Drives (3). Prerequisite: EEL 4220. This course offers an advanced study of AC drives. Topics covered include pulse-width modulation, drive system modeling, and vector controls. Emphasis is placed on the drives of induction and synchronous machines.

EEL 6266. Power Systems Operation and Control (3). Prerequisite: EEL 5250. This course examines modern power system operational and control problems and solution techniques, including state estimation, contingency analysis, load-frequency control, and automatic generation control. Additional subjects covered include load-flow analysis, unit commitment, and external equivalents for steady-state operations.

EEL 6930r. Special Graduate Topics in Electrical Engineering (3). This course explores special topics in electrical engineering at the graduate level with emphasis on recent research and developments. Content, credit, and prerequisites vary—consult instructor. May be repeated to a maximum of twelve semester hours.

EEL 6932r. Electrical and Computer Engineering Seminar (0). (S/U grade only). May be repeated a maximum of ten times. Presentations by faculty, students and visiting scholars. All full-time graduate students must enroll each semester.

EEL 6971r. Master's Thesis Research (1-12). (S/U grade only.) Prerequisites: Graduate standing and instructor permission. This course provides a means of registering for thesis research work and recording progress towards its completion. Student must consult with the academic department for appropriate registration of course credit hours.

EEL 6980r. Dissertation (1–12). (S/U grade only). May be repeated to a maximum of forty-eight semester hours.

EEL 8964r. Preliminary Doctoral Examinationw (0). (P/F grade only.) May be repeated one time.

EEL 8966r. Master's Comprehensive Examination (0). (P/F grade only.) May be repeated a maximum of two times.

EEL 8976. Master's Thesis Defense (0). (P/F grade only.)

EEL 8985r. Dissertation Defense (0). (P/F grade only.) May be repeated to a maximum of three times.

DEPARTMENT OF INDUSTRIAL & MANUFACTURING ENGINEERING

Undergraduate Department of Industrial & Manufacturing Engineering

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://www.eng.famu.fsu.edu/ime

Chair: Zeng; **Professors**: Awoniyi, Liang, Okoli, Vanli, Zeng, M. Zhang; **Associate Professors**: Dickens, Sun, Wang, Yu; **Assistant Professors**: Cai, Gnanasambandam, Li, Sweat, White; **Research Faculty**: Park; **Teaching Faculty**: Garcia, Georgiadis, Gross, Taylor, Tibi

The mission of the Department of Industrial and Manufacturing Engineering is to provide for students a solid industrial engineering curriculum coupled with a strong research program driven by the economic and technological development needs of society.

The Industrial Engineering degree provides a broad technical background with special emphasis on manufacturing systems, computer modeling, costs, quality, management, and human factors. Industrial engineering draws upon specialized knowledge and skills in the mathematical, physical, and social sciences, together with the principles and methods of engineering design and analysis, to specify, predict, and evaluate industrial systems.

The program of study includes engineering analysis for the optimization of industrial systems, design of man-machine systems, and the scientific management of activities. Specialized training is available in the use of modern engineering tools and techniques such as computer-aided design (CAD), computer integrated manufacturing (CIM), and ergonomic (human factors) engineering.

Industrial engineers pursue careers in manufacturing, service industries, and government. In addition, many industrial engineers are now being employed in nontraditional fields such as hospitals, banks, insurance, and information processing. The present and future demand for IE's appears to be very high. Industrial engineers are increasingly being called upon to act as productivity catalysts in manufacturing and service organizations in order to meet regional, national, and international demand and competition.

Program Educational Objectives

The Bachelor of Science in Industrial Engineering (BSIE) curriculum is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD, 21202-4012, phone (410) 347-7700. The Bachelor of Science in Industrial Engineering (BSIE) curriculum is designed to comply with the ABET criteria for accrediting engineering programs. The educational objectives are that, within the first few years following their graduation, graduates should have:

- Been employed in industrial, service, or governmental organizations applying the industrial engineering skills in developing, designing, analyzing, implementing, or improving integrated systems that include people, materials, information, equipment, and energy
- Completed or enrolled in a graduate program
- Participated in a multicultural and diverse workplace
- Utilized teamwork, communication, and engineering management skills.

To achieve these objectives, all industrial engineering students must demonstrate or exhibit specific program outcomes. Students are instructed to contact their academic advisor or visit the departmental website at https://www.eng.famu.fsu.edu/about/accreditation to obtain the current list of industrial engineering program outcomes.

Digital Literacy Requirement

Students must complete at least one course designated as meeting the Digital Literacy Requirement with a grade of "C–" or higher. Courses fulfilling the Digital Literacy Requirement must accomplish at least three of the following outcomes:

- Evaluate and interpret the accuracy, credibility, and relevance of digital information
- Evaluate and interpret digital data and their implications
- Discuss the ways in which society and/or culture interact with digital technology
- Discuss digital technology trends and their professional implications
- Demonstrate the ability to use digital technology effectively
- Demonstrate the knowledge to use digital technology safely and ethically

Each academic major has determined the courses that fulfill the Digital Literacy requirement for that major. Students should contact their major department(s) to determine which courses will fulfill their Digital Literacy requirement. Undergraduate majors in industrial engineering satisfy this requirement by earning a grade of "C–" or higher in COP 3014 (preferred) or CGS 3406.

State of Florida Common Program Prerequisites for Industrial Engineering

The Florida Virtual Campus (FLVC) houses the statewide, internet-based catalog of distance learning courses, degree programs, and resources offered by Florida's public colleges and universities, and they have developed operational procedures and technical guidelines for the catalog that all institutions must follow. The statute governing this policy can be reviewed by visiting https://www.flsenate.gov/Laws/Statutes/2021/1006.73.

FLVC has identified common program prerequisites for the degree program in Industrial Engineering. To obtain the most up-to-date, state-approved prerequisites for this degree, visit: https://cpm.flvc.org/programs/368/283.

Specific prerequisites are required for admission into the upper-division program and must be completed by the student at either a community college or a state university prior to being admitted to this program. Students may be admitted into the University without completing the prerequisites but may not be admitted into the program.

Engineering Core Courses

COP 3014 Programming I (3)

EGN 2123 Computer Graphics for Engineers (2)

EGN 3613 Principles of Engineering Economy (2)

EGM 3512 Engineering Mechanics (4)

EML 3100 Thermodynamics (2)

MAS 3105 Applied Linear Algebra I (4)

Requirements for a Major in Industrial Engineering

It is the policy of the Department of Industrial and Manufacturing Engineering that a student must receive satisfactory ("C–" or better) grades in all prerequisite courses prior to enrolling in an industrial engineering course. Concurrent registration in a course and its prerequisites is not allowed. All prerequisites to prerequisites must be completed. Failure to abide by this policy will result in the cancellation of enrollment in the course at any time during the semester and with no refund of fees. Corequisite courses must be taken concurrently or satisfactorily completed prior to enrolling in the course.

A candidate for the Bachelor of Science (BS) degree in industrial engineering is required to successfully complete the following courses, in addition to the other College of Engineering core requirements:

EGN 2123 Computer Graphics for Engineers (2)

EGN 3443 Statistical Topics in Industrial Engineering (3)

EGN 3613 Principles of Engineering Economy (2)

EIN 3104 Introduction to Engineering Management (3)

EIN 3010 Industrial and Manufacturing Engineering Tools (3)

EIN 3390C Engineering Materials and Manufacturing Processes I (3)

EIN 4394C Engineering Materials and Manufacturing Processes II (3)

EIN 4243 Ergonomics (3)

EIN 4333 Design of Integrated Production Systems and Facilities Layout (3)

EIN 4621 Manufacturing Systems Engineering (3)

EIN 4890 Industrial Engineering Senior Design Project I (3). - First of two semester sequence

EIN 4892 Industrial Engineering Senior Design Project II (3). - Second of two semester sequence

ESI 3312 Operations Research I: Deterministic (3)

ESI 3628 Computing Topics in Industrial Engineering (3)

ESI 4234 Quality Control and Reliability Engineering (3)

ESI 4313 Operation Research II: Nondeterministic (3)

ESI 4523 Simulation of Industrial Engineering Systems (3)

XXX XXXX Introduction to Data Engineering (3)

XXX XXX Essentials of Data Analytics for Industrial Engineering (3)

XXX XXXX Department Electives (3)

Industrial engineering majors are required to consult with their IE undergraduate advisor before enrolling for the next academic term. Students must obtain current IE degree requirements and course offering schedules from the IE department.

Honors in the Major

The Department of Industrial and Manufacturing Engineering offers an Honors in the Major program in Industrial Engineering to encourage talented juniors and seniors to undertake independent and original research as part of the undergraduate experience. For requirements and other information, see the "University Honors Office and Honor Societies" chapter of this General Bulletin, or visit https://honors.fsu.edu/honors-major.

Grade Requirements

In addition to University and college requirements regarding grades and grade point average (GPA), the Department of Industrial and Manufacturing Engineering requires that the IE major achieve a grade within the "C" range or higher for all required IE courses. In accordance with College of Engineering policy, a student may request that one course completed with a grade of "D+", "D", or "D–" be counted toward the BSIE degree. Recommendation by the IME undergraduate advisor(s) and approval by the department chairperson are required for the course to be counted toward graduation credit.

Definition of Prefixes

EEL—Engineering: Electrical

EGN—Engineering: General

EIN—Industrial Engineering

EMA—Materials Engineering

EOC—Ocean Engineering

ESI—Industrial/Systems Engineering

PRO—Prosthetics/Orthotics

Undergraduate Courses

EGN 1004L. First Year Engineering Laboratory (1). This laboratory includes an emphasis on student time management, a variety of products and processes, and computer-aided problem solving. Product/process involves sketching and drawing pertinent diagrams by hand, and learning the history and engineering concepts involved.

EGN 1500. Digital Technology and Engineering Marvels I (2). The basis of the modern enterprise and technology is knowledge of the digital world. This course provides students with a conceptual understanding and hands-on practice into digital mathematic approaches as related to engineering and manufacturing.

EGN 1501. Digital Technology and Engineering Marvels II (1). Prerequisite: EGN 1500. This course is a research-based and exploratory techniques study program. Research and characterization are explored from the perspective of applied research and their techniques, with a focus on manufacturing.

EGN 2123. Computer Graphics for Engineers (2). Corequisite: MAC 2311. This course covers principles of engineering graphics: visualization, spreadsheet applications, graphical calculus, and descriptive geometry. Also introduces the engineering design process and CAD systems.

EGN 3443. Statistical Topics in Engineering (3). Prerequisite: MAC 2312. This course explores basic statistical analysis, samples and populations, variability, hypothesis formulation, and data analysis. Use of computer software and interpretation of results.

EGN 3613. Principles of Engineering Economy (2). Prerequisite: MAC 2313 or equivalent. This course emphasizes discrete cash flow diagrams, cash flow equivalence factors, standard criteria for comparing project proposals, special cash flow topics, special analysis, and case studies.

EGN 4060. Big Data Analytics in Engineering (3). Prerequisite: EGN 3443. This course introduces fundamentals of big data analytics including data loading, cleaning, transformation, visualization, predictive analytics, and data-driven decision making. An emphasis is placed on computer implementation using state-of-the-art data analytics language.

EIN 3010. Industrial and Manufacturing Engineering Tools (3). Prerequisite: Major status. This course teaches, from an engineering viewpoint, fundamental topics that are important for the practicing industrial engineer, including technical writing, oral communication and presentation of technical topics, managerial and cost accounting for production organizations and databases and management information systems.

EIN 3104. Introduction to Engineering Management (3). Prerequisites: EGN 2123 and EGN 3613. This course focuses on topics such as the evolution, history, emergence, and ethics of engineering and industrial engineering. Emphasis is placed on the management of technology and on the engineering method for product conceptualization, design, development, and production. Fundamental sciences, engineering methods, information systems, economics, and behavior theory contained in engineering management principles and practices.

EIN 3390C. Engineering Materials and Manufacturing Processes I (3). Prerequisite: CHM 1045 and CHM 1045L. Corequisite: EGN 2123. This course is an introduction to industrial materials and their composition, properties, metallography, and heat treatment. Introduction to the manufacturing processes of machine industries including hot working, cold working, and metal removal.

EIN 3905r. Directed Independent Study (3). Prerequisite: Permission from the department chairperson. Topics vary and each case must be approved by the department chairperson. May be repeated to a maximum of six semester hours.

EIN 4214. Occupational Safety and Hazard Control (3). This course covers the history of safety, safety in the workplace, government regulations, methods of accident prevention, system safety, reliability, and fault tree analysis.

EIN 4243. Ergonomics (3). Prerequisites: EGM 3512, EGN 3443, and EIN 4394C. This course examines human characteristics and limitations in relation to physical work, mental work, and job design. This course utilizes case studies and design exercises to explore human physiological variables in relation to industrial work environments and product design.

EIN 4333. Design of Integrated Production Systems and Facilities Layout (3). Prerequisites: EGN 2123, EGN 3613, and ESI 3312C. This course explores basic functions: demand forecasting, process planning, master scheduling, expediting, and quality control. Inventory control. Formation of systems from those basic functions. Case studies and design exercises with computer implementation.

EIN 4394C. Engineering Materials and Manufacturing Processes II (3). Prerequisite: EIN 3390C. This course is an introduction to engineering materials used in industry from the perspectives of composition, microstructures, properties, and heat treatment, various traditional and non-traditional manufacturing processes, basic mathematical descriptions for selected processes, and the application of these concepts to process selection and planning.

EIN 4395. Manufacturing Systems Engineering (3). Prerequisite: EIN 3390C. This course introduces modern manufacturing systems, with a special focus on the integration of manufacturing resources through the use of computers. Students consider design, planning, analysis, and control of computer integrated manufacturing systems.

EIN 4444. Technology Entrepreneurship and Commercialization (3). This course simulates, in an academic environment, the process of creating and analyzing business models and commercialization plans for technology-based products or services to meet a need or solve a problem.

EIN 4611. Industrial Automation and Robotics (3). Prerequisite: EIN 3390C. This course introduces modern manufacturing systems, with a special focus on the integration of manufacturing resources using computers. Featured subjects include design, planning, analysis, and control of computer-integrated manufacturing systems.

EIN 4621. Manufacturing Systems Engineering (3). Prerequisite: EIN 4934C. This course introduces modern manufacturing systems, with a special focus on the integration of manufacturing resources using computers. Featured subjects include design, planning, analysis, and control of computer-integrated manufacturing systems.

EIN 4890. Industrial Engineering Senior Design Project I (3). Prerequisite: Must be in final year of the degree program. This course is the first in a two-part course sequence, this capstone class represents the culmination of the industrial-engineering design sequence and draws upon student training from all previous courses. This course utilizes the six-sigma methodology to reduce variation and defects to deliver products and services that meet customer requirements.

EIN 4892. Industrial Engineering Senior Design Project II (3). Prerequisite: EIN 4890, and must be in final year of the degree program. This course is the second in a two-part course sequence, this capstone class represents the culmination of the industrial-engineering design sequence and draws upon student training from all previous courses. This course utilizes the six-sigma methodology to reduce variation and defects in order to deliver products and services that meet customer requirements.

EIN 4934r. Honors Thesis (3). May be repeated to a maximum of six semester hours.

EIN 4936r. Selected Topics in Industrial Engineering (3). Topics are determined by a departmental committee on special topics, taking into consideration the needs of students who are about to graduate. May be repeated to a maximum of nine credit hours. May be repeated within the same term.

EIN 4940. Industrial and Manufacturing Engineering Practicum (2). Prerequisite: EIN 4621. This course illustrates the design principles required for industries to preserve a competitive enterprise.

ESI 3312C. Operations Research I: Deterministic (3). Prerequisite: MAS 3105. This course covers the following topics with emphasis on validation of algorithm linear programming, assignment problems, CPM, network flows, discrete optimization, and branch-and-bound solution method.

ESI 3628. Computing Topics in Industrial Engineering (3). Prerequisite: COP 3014. This course focuses on state of the art computing techniques for industrial engineers. Applications of structured programming, mathematical analysis software, and engineering databases. Use in engineering of GUI languages, Internet communication, and UNIX.

ESI 4234. Quality Control and Reliability Engineering (3). Prerequisite: EGN 3443. This course is an introduction to quality and reliability engineering. This course examines statistical quality control techniques, process capability analysis, design and analysis of experiments for quality and reliability improvement.

ESI 4313C. Operations Research II: Nondeterministic (3). Prerequisites: EGN 3443 and MAP 3305. This course focuses on the development and application of nondeterministic, analytic models including PERT/CPM, discrete and continuous time Markov chains, queuing models including queuing networks, inventory models, and decision analysis. Case studies and design exercises.

ESI 4523. Simulation of Industrial Engineering Systems (3). Prerequisite: ESI 4234. This course focuses on simulation modeling and computer solution of industrial engineering systems. Modeling strategies, probability considerations, simulation languages, simulation verification, and engineering case studies.

ESI 4626. Managing Supply Chains for Resilience (3). Prerequisite: ESI 3312C. This course covers key concepts, models, and analytical tools of supply chain management, including facility location, supply-chain network design, aggregate planning, inventory management, risk-pooling strategies, product-design strategies for supply-chain management, distribution strategies, the bullwhip effect, and distribution management.

ESI 4682. Introduction to Machine Learning (3). Prerequisites: EGN 3443, ESI 3312, and MAS 3105. This course is an introduction to machine learning geared toward advanced undergraduates or first-year graduate students.

ESI 4686. Deep Learning in Practice (3). Prerequisites: EGN 3443, ESI 3312C, and MAS 3105. This course introduces three main neural networks (ANN, CNN, and RNN) and the realization in Python. Students learn the basics such as forward propagation, backward propagation, and gradient descent algorithms, as well as up-to-date neural network projects like (YOLO, VGG19, Resnet50, etc.)

DEPARTMENT OF INDUSTRIAL & MANUFACTURING ENGINEERING

GRADUATE STUDIES

Information for Graduate Students in Industrial & Manufacturing Engineering

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://eng.famu.fsu.edu/ime

Chair: Okoli; **Professors**: Awoniyi, Liang, Okoli, Zeng, Zhang; **Associate Professors**: Dickens, C. Park, Vanli, Wang, Yu; **Assistant Professors**: Li, Sun, Sweat; **Research Faculty**: Hao, J.G. Park; **Teaching Faculty**: Devine, Georgiadis, Gray, Gross, Taylor; **Adjunct Instructor**: Ferreiro, Gomez; **Professor Emeritus**: Braswell

The Department of Industrial and Manufacturing Engineering offers three graduate degree programs: the Master of Science (MS) and Doctor of Philosophy (PhD) in Industrial Engineering and the Master of Science (MS) in Systems Engineering (MSSE). MSSE is also offered as a fully online degree.

Industrial Engineering is a broad discipline that encompasses education and basic/applied research concerning the design, improvement, and installation of integrated systems of people, material, information, equipment, and energy. Graduate instruction and research are broadly grouped into three categories: manufacturing engineering, quality engineering, and industrial systems. Current research interests include manufacturing processes and systems; statistical; quality control; failure and life cycle analysis; mathematical optimization of complex production systems; condition monitoring; reliability engineering; statistical machine learning; distributed sensor networks; manufacturing process monitoring and diagnosis; set-covering theory; simulation environments; polymeric materials; nanomaterials processing and applications; additive thin-film manufacturing; printed electronics; carbon nanotube based functional materials; advanced composites and multi-scale materials; simulation for material processing; composite material processing.

Systems engineering (SE) is an interdisciplinary field of engineering that focuses on how to design and manage complex engineering systems over their life cycles. SE studies systems, processes, and practices required to develop them. These engineers are dedicated to ensuring all stakeholder needs are met in the best, most efficient way possible. SE facilitates deep integration of technical systems and helps ensure the systems developed are coherent, effective, and sustainable solutions to fulfill the system needs. SE professionals work with all facets of a system, from hardware to facilities, personnel to procedures. Our systems engineering program integrates engineering disciplines with industrial and management practices. Through the program, students will develop skills required in the national workforce for growing areas in the technology-driven global economy.

Research Facilities

The Department of Industrial and Manufacturing Engineering provides an excellent environment for instruction and research. The department has the following laboratories housed in the College of Engineering: Materials and Product Property Characterization, Computer Integrated Manufacturing, Precision Manufacturing, and Quality Engineering. In addition, the students have access to the 44,000 square foot state-of-the-art labs at Florida State University's High-Performance Materials Institute (see https://hpmi.research.fsu.edu/), which houses the following laboratories: Mechanical Testing Lab, Chemical and Thermal Analysis, Additive Manufacturing Lab, Manufacturing Lab, and Characterization Lab.

Each laboratory in the Department is equipped with state-of-the-art research and instructional equipment. Some of the available equipment in the labs are: 3D printers, Laser Scanner (Additive Manufacturing Lab); MTS Insight Testing System, MTS Landmark Servohydraulic System (Mechanical Testing Lab); Differential Scanning Calorimeter, Thermomechanical Analyzer (Chemical and Thermal Analysis); Scanning Electron Microscope, FTIR, UV-Vis, and Raman Spectroscopes, X-ray Differentiation and Scattering Machine, Atomic Force Microscope, Electromechanical and Electrochemical Testing Station (Materials and Product Property Characterization Lab); Twin Screw Extruder, Autoclave, Laser Cutting Machine, High-Power Sonicator, Temperature-Humidity Test Chamber (Manufacturing Lab).

Students have access to computer facilities, which includes both IBM-compatible PCs and high-performance engineering workstations. The Department offers access to a wide variety of software for CAD/CAM optimization, simulation, and statistical analysis, including Matlab, Minitab, Design Expert, R, Arena, and Simio computing environments. The Department also has access to the full Siemens PLM software suite for digital manufacturing, life cycle management, manufacturing operation management, and integrated solution for computer-aided design, manufacturing, and engineering. The statistical and simulation software and computing facilities are located in the Quality Engineering Lab. The solid modeling and CAD/CAM software are located in the Computer Integrated Manufacturing Lab. Technical support for software and hardware maintenance are provided by the Department and the College. In addition, the students have access to the Florida State University High Performance Computing (HPC) Cluster for intensive distributed-memory parallel computations.

Master of Science (MS)

The department offers a variety of Master of Science in Industrial Engineering (MSIE) program options to accommodate students' needs and specializations. Students may pursue a traditional MS or an MS with specialization in engineering management. The traditional MS program is research based, requiring the students to write and defend a thesis in their chosen area. The Master of Science with specialization in engineering management (MSIE-EM) does not require a thesis. The department also offers a BS-MS combined pathway, which provides students with a unique opportunity to complete graduate education on an accelerated schedule. Additionally, the department offers an MS in Systems Engineering (MSSE), a course-based, non-thesis degree designed for both full-time students and full-time working professionals. MSSE is also offered as a fully online program. The Industrial Engineering Graduate Handbook, which is available from the department, provides a complete description of all programs and requirements.

Admissions

Candidates for admission to graduate study in industrial engineering must meet university and departmental criteria. In some cases, students may be admitted on a provisional basis pending successful completion of prerequisite work. In all matters concerning admission, decisions made by the departmental graduate committee are final. Students who do not have a bachelor's degree in industrial engineering are required to complete the following prerequisite courses before undertaking graduate study:

- EGN 3443 Statistical Topics in Industrial Engineering (3)
- MAC 2313 Calculus with Analytic Geometry III (5) OR MAS 3105 Applied Linear Algebra (4) OR equivalent course as determined by the graduate committee.
- ESI 3312C Operations Research I: Deterministic (3) OR ESI 4313 Operations Research II: Nondeterministic (3) OR equivalent course as determined by the graduate committee
- a class in FORTRAN, PASCAL, C, or other modern programming language (required as evidence of proficiency in programming).

Admission Requirements for Traditional MSIE

- A BS in industrial engineering (or a related field) from an accredited college or university, with a GPA of at least 3.0 in all work attempted while registered as an upper-division undergraduate student working toward a baccalaureate degree
- Minimum scores of at least 155 on the quantitative portion and 146 on the verbal portion of the GRE
- A minimum score of 80 (iBT) on the TOEFL or a minimum of 6.5 on the IELTS (international students only)
- Three letters of recommendation, addressed to the Director of Graduate Studies, assessing the applicant's potential to do graduate work
- A statement of professional goals

Admission Requirements for MSIE with Specialization in Engineering Management

Requirements for admission to this program are identical to the MSIE admission requirements, except that, (1) GRE minimum score requirements are 151 in quantitative and 146 in verbal, and (2) applicants' BS degree can be in engineering, computer science, mathematics, physics, or a related area as determined by the Director of Graduate Studies.

The department also offers a BS-MS combined pathway toward MSIE-EM. Well-qualified students, who are expected to have a GPA of 3.3 or better in the undergraduate studies, are eligible to apply for the combined BS-MS pathway during the spring term of their third year in the College. Qualified undergraduate students interested in the program should meet with the undergraduate academic advisor and the department graduate program director in the spring term of their third year to determine whether they are eligible to apply and to plan their study in the senior year. Application to the undergraduate portion of the program will be reviewed by the department graduate committee and admission will be decided by the graduate program director with recommendation from the graduate committee and undergraduate academic advisor. Once admitted, students can proceed with taking 3 graduate level industrial engineering courses in their senior year to replace eight credit hours in the existing undergraduate program. Admitted students should carry a course load of no more than 15 credit hours, and need to receive the approval of the dean, the department chair, and the undergraduate advisor prior to registration. Students will register the course at the graduate level and be graded as graduate students. Student will have the option to graduate with BS degree with the three graduate level courses.

For admission to the graduate portion of the program the students must make a formal graduate application in their senior year. Students who are interested in enrolling in the graduate program should meet with the director of graduate studies in the senior year to determine admission requirements and whether they are eligible to apply. Application, evaluation, and admission will follow the standard IME department requirements for MS in Engineering Management.

Admission Requirements for MS Systems Engineering

Requirements for admission to this program are identical to the MSIE admission requirements, except that, (1) GRE minimum score requirements are 151 in quantitative and 146 in verbal and (2) applicants' BS degree can be in engineering, computer science, mathematics, physics, or a related area as determined by the Director of Graduate Studies.

Degree Requirements

Thesis Option

Each MSIE student who intends to complete a thesis is required to take a minimum of 30 credit hours (24 credit hours of course work and six credit hours of thesis). At least 18 credit hours of the course work hours must be taken in the Industrial and Manufacturing Engineering Department. Students must maintain an overall GPA of 3.0 or above in order to graduate.

When filing a degree plan, students must specify one of the department's areas of concentration as their major: manufacturing systems and engineering or quality engineering and industrial systems. If the desired area of concentration differs from the initial area assigned (based on the student's graduate application), a petition to the Director of Graduate Studies must be submitted requesting the change.

There are three sets of courses under the traditional MSIE program: core courses, specialization industrial engineering courses, and electives:

Core Courses. Every student choosing the thesis option must take the following courses and receive a grade of “B” or better in each: ESI 5408, Applied Optimization; ESI 5247, Engineering Experiments; ESI 5525, Modeling and Analysis of Manufacturing and Industrial Systems; and EIN 5936, Graduate Seminar.

Specialization Courses. These courses are used to define minimum requirements for each specialization area. Each student is required to take at least three from those courses listed in his or her chosen area of specialization. Substitutions may be made with the approval of the student's advisory committee and the Director of Graduate Studies. Please refer to the departmental website at https://www.eng.famu.fsu.edu/ime.

Electives. Elective courses provide program variation for students. An industrial engineering graduate course may be selected as an elective course. With the consent of the advisory committee, the student may take courses from other engineering departments or other academic schools or colleges at the two universities.

Non-Thesis Option

Under exceptional circumstances, students may be allowed into the MSIE non-thesis option. In such cases, students are required to complete a minimum of 30 credit hours of course work at the graduate level, at least twenty-four of which must be taken in the Department of Industrial Engineering. Each student must obtain an overall GPA of 3.0 or above in order to graduate. Students should contact the department to learn more about specific course requirements for this program.

Specialization in Engineering Management

Students are expected to complete 30 credit hours of course work and will not be required to complete a thesis. Industrial Engineering Core courses constitute 18 credit hours, Management core courses constitute three credit hours, and the elective courses constitute nine credit hours. At least three credit hours of the electives must be taken at the College of Engineering. Students must maintain a minimum GPA of 3.0 at all times while enrolled in the program in order to graduate. Students should contact the department to learn more about specific course requirements for this program.

Combined Pathway

All BS-MS students must take the following distribution of courses for a total of 30 credit hours to receive the combined BS-MS degree. Nine of the 30 credit hours must be taken during the senior year of the student's BS degree program as the shared credits. The remaining 21 credit hours are taken as part of the MS degree program. Students have the option to graduate with only the BS degree at the completion of the nine credit hours of the graduate courses.

MS Systems Engineering

Students are expected to complete 30 credit hours of course work. The program requires seven core courses and three technical electives. Students must maintain a minimum GPA of 3.0 at all times while enrolled in the program in order to graduate. Students should contact the department to learn more about specific course requirements for this program. MSSE is offered as both traditional and fully online program.

Doctor of Philosophy (PhD)

The PhD in industrial engineering is designed for students and professionals who wish to pursue academic careers or to achieve advanced standing in the field. The general requirement is a minimum of 45 credit hours of work beyond the baccalaureate degree, excluding any credits earned for a master's degree thesis, or a minimum of 33 credit hours beyond the master's degree.

Typically, 12 of the 45 credit hours will have been satisfied by a student who has earned a master's degree in industrial engineering, or a closely related field. Of the remaining required hours, nine must be letter-graded course work combined with a minimum of twenty-four additional hours of dissertation research. The course work beyond the master's consists of: 1) eighteen credit hours of breadth-requirement core courses and 2) up to six or more credit hours of depth-requirement courses, as determined by the student's doctoral supervisory committee. Residency and time-for-completion requirements are determined by the student's university of enrollment. Students must maintain a minimum GPA of 3.4 at all times while enrolled in the program. Students must also pass several milestone examinations as detailed in The Industrial Engineering Graduate Handbook. Doctoral candidates must meet the department publication requirements before the viva voce of their dissertation.

Admissions

Note: The following standards also pertain to students who wish to pursue a PhD but have not yet obtained their master's degree.

Applicants must meet the following minimum requirements:

- Have a baccalaureate or master's degree in industrial engineering (or related field) from an accredited college or university, with a grade point average (GPA) of at least 3.0 on a 4.0 scale, and at least 3.4 GPA on master's degree work
- Have a minimum score of 155 on the Quantitative portion and 150 on the Verbal portion of the GRE
- Have a minimum score of 80 on the TOEFL iBT (580 paper based) or a minimum of 6.5 on the IELTS (international students only)
- Three letters of recommendation, addressed to the Director of Graduate Studies, assessing the applicant's potential to do graduate work
- A statement of professional goals

Core Courses for PhD Students

All PhD students are required to take the following courses as soon as possible after their admission to the PhD program. These courses provide students with a common, solid background in mathematics, statistics, and industrial engineering.

During the first calendar year of the PhD program, students must select a single course from each of the Mathematics and Computational course groups and must earn a grade of "B" or higher. Students who do not satisfy this requirement may be dismissed from the program.

Mathematics Course Group

MAA 5306 Advanced Calculus I (3)

MAP 5345 Elementary Partial Differential Equations I (3)

STA 5323 Introduction to Mathematical Statistics (3)

Computational Course Group

EIN 5930r Specialized Topics in Industrial Engineering (1–6)

MAD 5403 Foundations of Computational Methods I (3)

MAP 5395 Finite Element Methods (3)

OR

EIN 5930 Special Topics in Industrial Engineering (1–6)

Note: The required topic is "Finite Elements Methods" for three (3) credit hours.

STA 5106 Computational Methods in Statistics I (3)

IE Core Course Group

The following courses are required if the student did not take them to fulfill requirements for the master's degree: ESI 5247 Engineering Experiments; ESI 5408 Applied Optimization; ESI 5525 Modeling and Analysis of Manufacturing and Industrial Systems; EIN 5020 Research Methodology; and EIN 5936 Graduate Seminar.

Core courses cannot be taken on a pass/fail (S/U) basis.

Preliminary Examination

Following completion of the required coursework as defined in the degree plan, and upon certification of the doctoral supervisory committee that the student has 1) maintained a minimum 3.4 GPA and 2) progressed sufficiently in the study of industrial engineering and its research tools to begin independent research in the area of the proposed dissertation, the student is ready to take the preliminary examination.

The purpose of the preliminary examination is to test the adequacy of a student's background related to the student's area of concentration and to determine if the student is adequately prepared to formulate and undertake acceptable dissertation research. The procedures are available from the department.

Proposal and Dissertation

After completion of the preliminary examination, the student is admitted to formal candidacy for the PhD. After a period of preliminary research as determined by the doctoral committee, a research proposal must be successfully presented to the committee by the doctoral candidate.

The research proposal is a description of the research which the student intends to undertake, which will be reported in a detailed, comprehensive fashion in the completed dissertation. The research proposal must be submitted to the supervisory committee after the student passes the preliminary exam (usually one year after the preliminary exam) and before beginning dissertation research. The student must also provide an oral presentation to the committee at least one week after submitting the proposal. The proposal offers the student an opportunity to convince the supervisory committee of the appropriateness of the research topic, as well as of his/her capability to pursue the projected topic to a successful conclusion.

Subject to approval of the doctoral candidate's committee confirming the candidate's readiness to defend his/her dissertation, and upon meeting the department publication requirements, the candidate may proceed to defend their dissertation research. A doctoral dissertation then must be completed on a topic approved by the candidate's doctoral supervisory committee. To be acceptable, it must be an achievement in original research constituting a significant contribution to knowledge and representing substantial scholarly effort on the part of the student. The doctoral supervisory committee, department chairperson, and such other members of the faculty as appointed by the academic dean or specified by university regulations will conduct the examination. Publication of the dissertation shall conform to the regulations of the university in which the student is registered.

During the dissertation defense, all committee members and the student must be physically present. In cases where this is not possible, the department allows no more than one member to participate in the defense in real time via distance technology. The distance technology must allow two-way audio and visual links.

Definition of Prefixes

EEL—Engineering: Electrical

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PRO—Prosthetics/Orthotics

Graduate Courses

EEL 5606. Introduction to Mobile Robotics and Unmanned Systems (3). This course provides a thorough technical overview of autonomous vehicles for engineering students interested in understanding the basics of unmanned systems. The principles and methodology involved for the systems development is discussed. The course uses practical examples of developing autonomous unmanned vehicle systems.

EEL 5688. Principles of Autonomous Systems (3). Prerequisite: EEL 5605. This course provides an in-depth review of the principles of autonomy by reviewing probability theory and covering topics in pattern recognition, computer vision/perception, localization/SLAM, planning, and unsupervised/supervised learning.

EGN 5444. Big Data Analytics in Engineering (3). Prerequisites: EGN 3443. This course introduces the fundamentals of big data analytics, including data loading, cleaning, transformation, visualization, predictive analytics and data-driven decision making, with an emphases on computer implementation and engineering applications.

EIN 5020. Research Methodology (3). This course provides a structured and easily understandable step-by-step approach for students to learn the key components that compromise a sound research process.

EIN 5182. Engineering Management (3). This course introduces the principles, tools, and techniques of modern engineering management using the framework of the product/project life cycle.

EIN 5184. Systems Engineering Leadership (3). This course provides systems engineers with effective and tailored leadership training to successfully develop and lead multi-disciplinary teams throughout a system's life cycle.

EIN 5328. Environmentally Conscious Design and Manufacturing (3). Prerequisite: Graduate standing. This course offers a review of basic concepts and fundamentals of environmentally conscious design and manufacturing. The topics include ecology and environment; review of environmental laws and regulations pertaining to design and manufacturing; the global picture of environmental concerns; integration of environmentally conscious design and manufacturing within a company; and life-cycle analysis for product and process design.

EIN 5353. Engineering Economic Analysis (3). Prerequisites: EGN 3443 and MAP 3305. This course includes feasibility science, mathematics and engineering focused on the engineering economic analysis of design and system alternatives for high technology operations.

EIN 5356C. Cost Estimating for Engineering Economic Analysis (3). Prerequisite: Instructor permission. This core course provides an improved understanding and application of engineering economics and cost analysis, which are critical in a Systems Engineer's toolkit. The course include cost aspects of systems engineering, exploring cost from a decision-making perspective.

EIN 5392. Manufacturing Processes and Systems (3). Prerequisite: EGN 4000. Material forming, material removal and material joining processes. Shop floor layout topics. Material flow topics. Information system topics. System integration topics. Manufacturing system evaluation topics. Case studies and design exercises.

EIN 5396. Materials by Design (3). Prerequisites: MAC 2313, MAS 3105, and PHY 2048C, or instructor permission. The interdisciplinary course focuses on the mechanics, software, science, principles, and practices of designing composite materials. Students explore advanced concepts in materials science, applying theoretical knowledge and innovative design principles to optimize material properties and performance in various engineering applications.

EIN 5445C. Technology Entrepreneurship and Commercialization (3). This course simulates, in an academic environment, the process of creating and analyzing business models and commercialization plans for technology-based products or services.

EIN 5622. Computer-Aided Manufacturing (3). Prerequisite: EIN 3390C. CAD/CAM. Numerical Control (NC) and Computer Numerical Control (CNC). Programmable automation. Computer-aided process planning.

EIN 5905r. Directed Individual Study (1–3). (S/U grade only). Prerequisite: Instructor permission. May be repeated to a maximum of six semester hours.

EIN 5930r. Special Topics in Industrial Engineering (3–6). This course discusses topics in industrial engineering with emphasis on recent developments. Topics and credits vary; consult the instructor. May be repeated to a maximum of twelve (12) credit hours; repeatable within the same term.

EIN 5931. Leadership and Communications (3). Prerequisites: Graduate standing and EGN 3613. Course topics include leadership theories, motivation, goal setting, planning, proposal writing and technical presentations. Presentations given by business leaders are planned.

EIN 5936r. Graduate Seminar (0). (S/U grade only). Research presentations by faculty, students, and guests from industry.

EIN 6901r. Master's Thesis (1–12). (S/U grade only). Prerequisite: Approval by department. This course provides a means of registering for thesis research work and recording progress towards its completion. May be repeated to a maximum of forty-five (45) credit hours; repeatable within the same term.

EIN 8976r. Master's Thesis Defense (0). (P/F grade only.)

EMA 5015C. Nanomaterials and Nanotechnology (3). This course is designed to provide students the basic understanding and up-to-date knowledge on nanostructured materials, characterization methods, nano-devices, and nano-fabrication through class lectures, literature reading, and hands-on lab experiments.

EMA 5182. Composite Materials Engineering (3). Prerequisite: Instructor permission. Course provides basic understanding of composite materials. Topics include introduction to composite materials, properties and forms of constituent materials, consideration of composite behavior and failure modes, characterization of material performance and testing, introduction to available manufacturing techniques, laboratory demonstrations, and case studies.

EOC 5518. Marine Vehicles Engineering Principles (3). This course provides a thorough technical overview of naval architecture of advanced marine vehicles. As an introduction to naval architecture and marine vehicles, this course provides the practicing systems engineer the basic knowledge and skills necessary to lead a team of engineers with marine vehicles as part of the mission and project.

EOC 5519. Marine Systems Engineering Principles (3). In this course, students apply strategic and critical thinking principles to the development of marine systems, and develop a comprehensive approach to the integration of hull, propulsion, and mission systems into marine vehicle design.

ESI 5000. Design Considerations for Systems Engineering (3). This course provides students with knowledge and practical experience in quality and reliability measures for systems engineering. The course covers principles of Failure Mode and Effects Analysis (FMEA), reliability specifications, design for reliability, human centered design, accelerated testing, mechanical stress and analysis, software reliability, cybersecurity, supplier reliability, mathematical and statistical models for process control, life distributions and concepts, design for quality, focus on customers, six sigma, total quality, and the importance of quality in design.

ESI 5001. Systems Test and Evaluation (3). This course provides students with knowledge and practical experience in system test and evaluation (T&E) as practicing systems engineers and discusses how tests are defined, designed, and conducted; it examines how data from the tests are evaluated against the system requirements. Test and evaluation techniques of system design and performance are analyzed throughout the course, and the feedback loop of data analysis is introduced to identify the need for design changes to improve safety, correct failures, verify supportability of the systems, and support investment decisions.

ESI 5228. Introduction to ISO 9000 (3). Prerequisite: Instructor permission. This course utilizes case studies and demonstrations to introduce students to the ISO 9000 quality system standards, quality auditing, audit report writing, and documenting the requirements.

ESI 5243. Engineering Data Analysis (3). Prerequisite: EGN 3443 and instructor permission. This course provides students with an understanding of the methods for the analysis of data from engineering systems, and it focuses on empirical model building using observational data for characterization, estimation, inference, and prediction of engineering systems.

ESI 5247. Engineering Experiments (3). Prerequisites: EGN 3443, ESI 5243. This course introduces designing experiments and analyzing the results. It is intended for engineers and scientists who perform experiments or serve as advisors to experimentation in industrial settings. Students must have an understanding of basic statistical concepts. A statistical approach to designing and analyzing experiments is provided as a means to efficiently study and comprehend the underlying process being evaluated. Insight is gained that leads to improved performance and quality.

ESI 5249. Response Surfaces and Process Optimization (3). Prerequisite: ESI 5247. This course explores combined statistical experiment designs, empirical model building, and optimization methods. Topics include restrictions on randomization, mixture experiments, and robust design. Emphasis is placed on software tools to build designs and perform appropriate analyses.

ESI 5324. Managing Supply Chains for Resilience (3). Prerequisite: ESI 3312C. This course covers key concepts, models, and analytical tools of supply chain management, including facility location, supply-chain network design, aggregate planning, inventory management, risk-pooling strategies, product-design strategies for supply-chain management, distribution strategies, the bullwhip effect, and distribution management.

ESI 5353. Engineering Risk Analysis and Decision Making with Uncertainty (3). This course provides students with the knowledge and practical experience in risk analysis, risk identification, risk mitigation strategy development, ethics in risk management, communicating uncertainties, and risk leadership in complex organizations. Stochastic modeling and probabilistic theoretical models are exercised, and students are expected to understand probability basics.

ESI 5408. Applied Optimization (3). Prerequisite: ESI 3312C or equivalent. This course examines optimization topics relevant to industrial operations and systems. Emphasis on basic modeling assumptions and procedure implementation.

ESI 5440. Integer Programming (3). Prerequisite: Instructor permission. This course is designed to equip students with the necessary skills to discover the unique underlying structure of an optimization problem, analyze the polyhedral characteristics of IP formulations, develop good IP reformulations, and design rigorous solution approaches which can efficiently solve the problem.

ESI 5451. Project Analysis and Design (3). Prerequisites: EGN 3613 and ESI 3312C. This course focuses on project analysis and evaluation, utilizing networks and graph theory, advanced engineering economy, simulation procedures and other evaluation software. Project implementation topics include resource shortfalls and expediting. Students consider case studies and design exercises.

ESI 5510. Fundamentals of Systems Engineering (3). This course provides students with a fundamental understanding of Systems Engineering (SE). The course introduces multidisciplinary SE technical processes over the life cycle of a system including growing a deep awareness and understanding of analyzing and documenting user needs.

ESI 5512. System Requirements Analysis and Knowledge Management (3). The course provides students with the knowledge and practical experience in system requirement development and analysis as practicing systems engineers. The course introduces key knowledge management principles and practices along with a thorough understanding of methods to codify intellectual property and tacit knowledge into explicit knowledge for the betterment of the organization and the system people, processes, and products supported.

ESI 5522. Complex Systems Modeling and Simulation (3). Prerequisite: Graduate standing. ESI 5510 is recommended. This course prepares students to propose, develop, validate, and utilize small and large scale simulations to specific problems in systems engineering.

ESI 5525. Modeling and Analysis of Manufacturing and Industrial Systems (3). Prerequisites: EIN 4333, ESI 4523, and instructor permission. This course discusses the modeling and analysis of material flow systems, flow-shop and job-shop scheduling, material handling system analysis, mathematical and simulation modeling for general manufacturing and industrial systems.

ESI 5536. Model Based Systems Engineering and Simulation (3). This course provides students with knowledge and practical experience in Model Based Systems Engineering (MBSE) and simulation. The International Council on Systems Engineering (INCOSE) defines MBSE as the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The course introduces de facto industry standard MBSE modeling software and tools, and their use in the design and optimization of systems.

ESI 5554. Systems Engineering Principles for Aerospace. (3). Prerequisites: Graduate standing academic success; ESI 5510 is recommended. This is an elective course of the Master of Science in Systems Engineering (MSSE) curriculum, designed to provide the student with a fundamental understanding of systems engineering as applied to aerospace systems including aircraft and spacecraft.

ESI 5556. Digital Transformation for Systems Engineering. (3). The goal of this course is to educate system engineers on the fundamentals of data science, with a focus on the process for developing and executing successful engineering projects that involve the collection, analysis, and modelling of empirical data. All lessons flow from the systems engineering and data science life-cycle framework. It is preferred, but not required, for students to have already taken ESI 5110 and ESI 5563.

ESI 5590. Human Factors for Systems Engineering (3). This is an elective course of the Master of Science in Systems Engineering (MSSE) curriculum, providing a fundamental understanding of human characteristics, abilities, and limitations as well as their consideration in requirements and design of systems.

ESI 5617. Data-Driven Informatics for Intelligent Systems (3). Prerequisites: EGN 3443 and MAS 3105. This course introduces multi-dimensional data modeling and monitoring tools for predicting variational behaviors of industrial systems. Students learn how analytics help build intelligent systems to improve quality and productivity. Cutting edge research on analytics for Industrial Internet of things is also introduced.

ESI 5681. Deep Learning in Practice (3). Prerequisites: EGN 3443, ESI 3312C, and MAS 3105. This course introduces three main neural networks (ANN, CNN, and RNN) and the realization in Python. Students learn the basics such as forward propagation, backward propagation, and gradient descent algorithms, as well as up-to-date neural network projects like (YOLO, VGG19, Resnet50, etc.)

ESI 5685. Introduction to Machine Learning (3). Prerequisites: EGN 3443, ESI 3312, and MAS 3105, or instructor permission. This course is an introductory course to machine learning, aiming at advanced undergraduates or first-year graduate students.

ESI 5705. Cybersecurity for Systems Engineering (3). This course provides an overview and systems level understanding of applying cyber security principles and best practices to the system engineering process throughout the entire lifecycle of a system. This course prepares systems engineers to manage cyber risks in a preemptive and proactive manner encouraged by systems engineering.

Doctoral

EIN 6980r. Dissertation (1–12). (S/U grade only). Prerequisite: Admission to doctoral candidacy. This is a mandatory class for all PhD seeking students. May be repeated to a maximum of forty-eight (48) semester hours within the same term.

EIN 8964. Preliminary Doctoral Examination (0). (P/F grade only.) Prerequisite: Doctoral candidate standing.

EIN 8985r. Dissertation Defense (0). (P/F grade only.) Prerequisite: Doctoral candidate standing.

DEPARTMENT OF MECHANICAL ENGINEERING

Undergraduate Department of Mechanical Engineering

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://www.eng.famu.fsu.edu/me

Chair: Rajan Kumar; **Professors:** Alvi, Clark, Dean De, Gibson, Guo, Hellstrom, Kalu, Kumar, Larbalestier, Oates, J. Ordòñez, Shih; **Associate Professors:** Balachandran, Chen, Hollis, Hruda, Hubicki, Kametani, Krick, Moore, Shoele, Wu, Yaghoobian; **Assistant Professors:** Berger, Cai, Higgins, Nair; **Teaching Faculty:** Ali, Campbell, Capeheart (Panama City), Chagas (Panama City), Larson, McConomy, C. Ordòñez, Traynham (Panama City); **Adjunct Faculty:** Larson, Vanderlaan; **Affiliated Faculty:** Hussaini, Kopriva, Tam; **Research Faculty:** Gustavsson, Tuna; **Professors Emeriti:** Buzyna, Cartes, Krothapalli, Luongo, Van Dommelen, Van Sciver

The Bachelor of Science (BS) program in the Department of Mechanical Engineering is designed to provide background for a wide variety of careers. The discipline of mechanical engineering is very broad, but generally emphasizes an appropriate mix of thermal science, mechanics and materials, dynamic systems, and design. Graduates typically enter various energy, aerospace, automotive, and product manufacturing industries, or government laboratories.

The undergraduate program is designed to impart a broad knowledge in basic and engineering sciences and to provide a solid understanding of contemporary engineering practices. The program also seeks to provide students with a foundation in communications skills, principles of economics, and other fundamentals upon which they will draw in their professional careers. Special emphasis is placed on communications skills by requiring extensive written laboratory reports and design project presentations. Computer literacy is bolstered by a variety of course assignments throughout the program and especially in the design courses, wherein students are exposed to several design software programs widely used in the engineering industry.

Beyond the basic core curriculum, the Mechanical Engineering courses are grouped into five major area streams: thermal and fluid systems, mechanical systems, mechanics and materials, dynamic systems, and engineering design. The courses in each of these areas give students a foundation in the relevant engineering sciences with a strong orientation in design and extensive laboratory experience. The design curriculum culminates with a one-year (two-term) capstone design course in which the students design and implement a full system or product, usually under industrial sponsorship.

Several undergraduate teaching laboratories provide extensive experimental apparatus for laboratory courses. The fluid mechanics laboratory, heat transfer laboratory, solid mechanics laboratory, dynamic systems laboratory, and controls and robotics laboratory are all well equipped with the latest tools and equipment for experimentation, data acquisition, post processing, and analysis. The College of Engineering provides several computer labs running a variety of standard design and analysis software packages, including COMSOL FEA software, PTC's Creo software suite, MSC ADAMS, and MathWorks' MATLAB.

Program Educational Objectives

Consistent with the missions of Florida State University, Florida A&M University, and the College of Engineering, and in accordance with the Accreditation Board for Engineering and Technology (ABET) criteria, the department has developed the following program educational objectives. We expect our graduates in the first five years upon graduation from our program to:

- Make career progress in industrial, research, or graduate work in mechanical engineering or allied fields
- Design and analyze devices, products, or processes that meet the needs of an employer, organization, or customer, based on sound scientific knowledge and engineering practices
- Become engineering professionals by engaging in professional activities and continuous self-development
- Function in multicultural and multidisciplinary environments across regional and national borders

Program Outcomes

After completing the mechanical engineering program, graduates should have the following attributes:

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
- 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;
- An ability to communicate effectively with a range of audiences;
- 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 social contexts;
- 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;

- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions;
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Digital Literacy Requirement

Students must complete at least one course designated as meeting the Digital Literacy Requirement with a grade of "C–" or higher. Courses fulfilling the Digital Literacy Requirement must accomplish at least three of the following outcomes:

- Evaluate and interpret the accuracy, credibility, and relevance of digital information
- Evaluate and interpret digital data and their implications
- Discuss the ways in which society and/or culture interact with digital technology
- Discuss digital technology trends and their professional implications
- Demonstrate the ability to use digital technology effectively
- Demonstrate the knowledge to use digital technology safely and ethically

Each academic major has determined the courses that fulfill the Digital Literacy requirement for that major. Students should contact their major department(s) to determine which courses will fulfill their Digital Literacy requirement. Undergraduate majors in mechanical engineering satisfy this requirement by earning a grade of "C" or higher in EML 4550 Engineering Design Methods.

Upper Division Writing (UDW)

Undergraduate majors in mechanical engineering satisfy the Upper Division Writing (UDW) requirement by earning a grade of "C–" or higher in EML 3012L.

Scholarship in Practice (SIP), Formative Experiences (FE), and Oral Communication Competency Requirement (OCCR)

Undergraduate majors in mechanical engineering satisfy both the Scholarship in Practice (SIP) and Oral Communication Competency requirements by earning a grade of "C" or higher in both EML 4551C and EML 4552C.

State of Florida Common Program Prerequisites for Mechanical Engineering

The Florida Virtual Campus (FLVC) houses the statewide, internet-based catalog of distance learning courses, degree programs, and resources offered by Florida's public colleges and universities, and they have developed operational procedures and technical guidelines for the catalog that all institutions must follow. The statute governing this policy can be reviewed by visiting https://www.flsenate.gov/Laws/Statutes/2021/1006.73.

FLVC has identified common program prerequisites for the degree program in Mechanical Engineering. To obtain the most up-to-date, state-approved prerequisites for this degree, visit: https://cpm.flvc.org/programs/373/284.

Specific prerequisites are required for admission into the upper-division program and **must** be completed by the student at either a community college or a state university prior to being admitted to this program. **Students may be admitted into the University without completing the prerequisites but may not be admitted into the program.**

Core Program

A candidate for the Bachelor of Science (BS) in mechanical engineering is required to successfully complete the following engineering core courses (in addition to the mechanical engineering curriculum):

CHM 1045 General Chemistry I (3)

CHM 1045L General Chemistry I Laboratory (1)

COP 3014 Programming I (3)

EEL 3003 Introduction to Electrical Engineering (3)

EGN 1004L First Year Engineering Laboratory (1)

MAC 2311 Calculus with Analytical Geometry I (4)

MAC 2312 Calculus with Analytical Geometry II (4)

MAC 2313 Calculus with Analytical Geometry III (5)

MAP 2302 Ordinary Differential Equations (3)

PHY 2048C General Physics A (5)

PHY 2049C General Physics B (5)

Students must earn a minimum grade in the "C" range in each of the college core courses, as well as the required and technical elective courses below. Students must meet the minimum overall grade point average (GPA) under the general requirements of the University. Students also must meet the prerequisite requirements specified by the College of Engineering. Please refer to the "College of Engineering" chapter in this *General Bulletin* for the specific college-level requirements.

Students are urged to obtain the most current information on the mechanical engineering requirements from their advisors or from the student affairs coordinator.

Mechanical Engineering Curriculum

Key features of the curriculum in mechanical engineering include the integration of relevant topical material, integration of engineering design with engineering science, the introduction to engineering design at an early stage in the curriculum, and the use of cooperative learning methodologies. The curriculum is in keeping with current trends in engineering education, industry expectations and needs, and the ABET 2003 accreditation guidelines.

The following core courses comprise the mechanical engineering curriculum:

EML 3002L Mechanical Engineering Tools Lab (3)

EML 3004 Engineering Statics (3)

EML 3011 Mechanics of Materials (3)

EML 3012 Intermediate Mechanics and Materials (3)

EML 3012L Mechanics and Materials Lab (1)

EML 3013 Dynamics (3)

EML 3014C System Dynamics & Vibrations (3)

EML 3015C Thermal-Fluids I: Fluid Mechanics (4)

EML 3016 Thermal-Fluids II: Heat Transfer (3)

EML 3017C Mechanical Systems I (4)

EML 3018C Mechanical Systems II (4)

EML 3102 Engineering Thermodynamics (3)

EML 3234 Materials Science and Engineering (3)

EML 3811 Introduction to Mechatronics (1)

EML 3811L Mechatronics Lab (2)

EML 4304 Experiments in Thermal and Fluid Sciences (2)

EML 4304L Experiments in Thermal and Fluid Sciences L ab (1)

EML 4550 Engineering Design Methods (3)

EML 4551C Senior Design Project I (3)

EML 4552C Senior Design Project II (3)

XXX XXXX Math Option (3)

XXX XXXX Technical Electives (12)

Technical electives are generally intended to develop depth in an area of interest and should form a coherent area of concentration or multidisciplinary focus. A minimum of three technical electives (nine credit hours) must be in Mechanical Engineering. All technical elective courses must be selected from the approved list of suitable technical elective courses posted on the Departmental Website. A total of four Technical Electives are required.

The math option is intended to provide additional math expertise oriented toward various areas of engineering. Students must choose from the following list of approved classes: MAS 3105 or STA 3032, Alternates: EGN 3454, MAP 3306, MAD 3401, MAD 3703, or MAP 4341.

EML 3004 includes a math/physics test based on the material covered in Calculus I, Calculus II, and Physics I.

Honors in the Major

The Department of Mechanical Engineering offers a program in honors in mechanical engineering to encourage talented juniors and seniors to undertake independent and original research as a part of the undergraduate experience. For requirements and other information, see the “University Honors Office and Honor Societies” chapter of this *General Bulletin*.

Combined BS/MS Pathway

The department offers a five-year combined bachelor's/master's pathway leading to the Bachelor of Science (BS) and Master of Science (MS) degrees. The objective of this pathway is to produce, in five years of full-time study, an engineer who is fully qualified to enter into professional practice in industry. Students begin taking core graduate courses in their fourth year. Successful completion of the fourth year of the five-year curriculum will give the student enough credit and breadth of subject matter to satisfy university requirements for the BS degree, should individual circumstances arise that preclude a student from taking the fifth year. This pathway also includes a Summer internship in industry between the fourth and fifth years.

Admission to the combined BS/MS pathway is open to juniors who have attained a GPA of 3.2 in the mechanical engineering curriculum and whose applications are reviewed by a faculty committee. Applicants are normally invited in the Spring, during the second term of the students' junior year, for Fall entry. Details on the curriculum may be obtained from the Mechanical Engineering Department Office.

Definition of Prefixes

EAS—Aerospace Engineering

EGM—Engineering Science

EGN—Engineering: General

EMA—Materials Engineering

EML—Engineering: Mechanical

Undergraduate Courses

EAS 4101. Fundamentals of Aerodynamics (3). Prerequisites: EML 3015C and EML 3016C. This course is a technical elective course designed for senior-level engineering students in the Aeronautics Track and area of thermal and fluid sciences. The course includes fundamental fluid mechanics and aerodynamic principles in the design of airfoil and aircraft wings. It provides a comprehensive review concerning applications, technological advances, and social impacts on the development of a modern flight vehicle. The course provides an overview of the guiding principles and experimental observations to analyze basic aerodynamic characteristics of an aircraft configuration.

EGM 3512. Engineering Mechanics (4). Prerequisites: MAC 2312 and PHY 2048. Corequisite: MAC 2313. This course covers statics and dynamics of particles and rigid bodies. Topics include free-body diagrams, couples, resultants, equilibrium of particles and rigid bodies in two and three dimensions, and forces in trusses, frames, and machines. Other topics include centroids, centers of mass, internal shear forces and bending moments in beams, shear and moment diagrams, friction, area moments of inertia, parallel axis theorem, work/energy, as well as impulse and momentum methods.

EGN 1004L First-Year Engineering Laboratory (1). This course is intended to generate and maintain students' interest in the engineering disciplines so that they are motivated to become active learners, responsible students, and ethical engineering professionals.

EGN 3454. Numerical Methods for Mechanical Engineers (3). Prerequisites: MAC 2313 and MAP 2302. Miscellaneous requirement: Understanding of linear algebra. This course teaches programming and numerical methods to solve engineering/scientific problems in an effective and efficient manner to meet the needs of industry, government, and academia. The course leverages the use of MATLAB which is widely used for scientific computing. Students develop practical programming skills. The course relies heavily on in-class programming to provide feedback to students.

EMA 4225. Mechanical Metallurgy (3). Prerequisite: EML 3012C. This course focuses on tensile instability, crystallography, theory of dislocations, plasticity, hardening mechanisms, creep and fracture, electron microscopy, composite materials.

EMA 4501. Electron Microscopy (3). Prerequisite: EML 3234 or instructor permission. This course covers fundamentals and techniques of electron microscopy as applied to the determination of physical, chemical, and structural properties of materials and materials behavior in practice.

EMA 4513. Microstructural Characterization of Materials (3). Prerequisite: EML 3234 or equivalent. The course introduces the tools for characterizing microstructure in materials: diffraction techniques (x-ray, neutron and electron), electron microscopy (scanning and transmission), spectroscopy (electron, x-ray), and surface and scanning probe methods. Selecting the right tool for a materials problem is also a focus of the course.

EML 3002L. Mechanical Engineering Tools Lab (3). Prerequisites: MAC 2311 and PHY 2048C. Corequisite: EML 3002. This course covers computer aided design and drafting, programming, machining, and a basic introduction to the mechanical engineering profession and ethics. Course includes building and testing a simple Stirling engine. Course is subject to an additional materials fee.

EML 3004. Engineering Statics (3). Prerequisites: MAC 2312 (C- or better) and PHY 2048 (C- or better). This course covers engineering statics and a basic introduction to engineering design and analysis. It equips students with the fundamental knowledge and tools required for their subsequent courses in the broad area of engineering mechanics.

EML 3011. Mechanics of Materials (3). Prerequisites: CHM 1045, CHM 1045L, EML 3002L, EML 3004, and MAC 2313. Corequisites: MAP 3305 or MAP 2302. This course is the first part of a two-part sequence integrating concepts of strength of materials and principles of materials. It provides students with an introduction to the analysis of the behavior of machine components and structures under various types of loading.

EML 3012. Intermediate Mechanics and Materials (3). Prerequisites: EML 3011 and PHY 2049C. Corequisite: EML 3234. This course is the second part of a two-part sequence, integrating principles of mechanics and materials science. Special emphasis is placed on measurement techniques and experimental methods in solid mechanics and materials science, including analysis and reporting of experimental data and results.

EML 3012L. Mechanics and Materials Lab (1). Prerequisites: EML 3011 and PHY 2049C. Corequisite: EML 3012 and EML 3234. This lab course is designed to give students practical hands-on experience in measurement techniques and experimental methods in solid mechanics and materials science.

EML 3013. Dynamics (3). Prerequisites: EML 3002L and EML 3004. This course is the first part of an integrated sequence in dynamics, vibrations, and controls. Material in this first course includes the following: kinematics and kinetics of particles and rigid bodies, and energy and momentum methods. In addition, the course emphasizes on the utilization of computational tools to solve or simulate equations of motion of mechanical systems.

EML 3014C. System Dynamics and Vibrations (3). Prerequisite: EML 3013C, MAP 2302, and MAP 3305. This course is the second part of an integrated sequence in dynamics, vibrations, and controls. Material in this second course includes the development of the equations of motion for translational and rotational mechanical systems, electrical systems, and electromechanical systems; system response using standard differential equation solution techniques and Laplace transforms; frequency response and impedances; linearization of nonlinear system models; and block diagrams and feedback control strategies.

EML 3015C. Thermal-Fluids I: Fluid Mechanics (4). Prerequisites: EML 3002, and MAC 2313. Corequisite: EML 3013. This course introduces fluid mechanics, which covers the following: dimensional analysis, hydrostatics, control volume analysis, basic equations in differential form, inviscid incompressible flow, viscous flows in pipes and ducts, estimation of head losses in fluid systems, and external flows.

EML 3016. Thermal-Fluids II: Heat Transfer (3). Prerequisite: EML 3015C and MAP 2302 or MAP 3305. Corequisite: EML 4304L. This course introduces heat transfer, which covers the following: basic concepts of heat transfer; steady and time dependent conduction; natural and forced convection and radiation; and analysis of heat exchanger.

EML 3017C. Mechanical Systems I (4). Prerequisites: EML 3011, EML 3013, and MAP 3305 or MAP 2302. This course is the first in a sequence of two courses intended to provide the essential tools for the design and analysis of mechanical systems. Emphasis is on linkages; constraints and degrees of freedom; position, velocity, and acceleration analysis; cams, gears, and gear trains, static and dynamic analysis; computer simulations and models of components and systems; team class projects involving dissection of existing machines and design and manufacture of new mechanical systems.

EML 3018C. Mechanical Systems II (4). Prerequisite: EML 3017C. Corequisite: EML 3012. This course is the second in a sequence of two courses intended to provide the essential tools for the design and analysis of mechanical systems. Emphasis is on materials; stress analysis; shaft design; bearings and lubrication; fasteners and connectors; joints; clutches, brakes, couplings, and flywheels; flexible elements; shafts; computer simulations and models of components and systems; team class projects involving dissection of existing machines and design and manufacture of new mechanical systems.

EML 3100. Thermodynamics (2). Prerequisites: CHM 1045, MAC 2312, and PHY 2048. This course discusses the fundamentals of thermodynamics. System description, common properties. Properties of pure substances. Mathematical foundations. First and Second Laws of Thermodynamics, closed and open systems. Equations of state and general thermodynamic relations. For non-mechanical engineering majors.

EML 3102. Engineering Thermodynamics (3). Prerequisites: MAC 2311 and PHY 2048C. This course introduces basic concepts in engineering and thermodynamics; thermodynamic properties of solids, liquids, and gases; and the first and second laws of thermodynamics.

EML 3234. Materials Science and Engineering (3). Prerequisite: CHM 1045 and PHY 2048C. Corequisite: EML 3004. This course includes concepts of materials science and their relevance to engineering design. Recent advances in engineering materials science.

EML 3811. Introduction to Mechatronics (1). Prerequisites COP 3014 or approved equivalent in C, C++, Python, or Java. Corequisite: EML 3811L. This course offers an introduction to basic electronics, embedded controllers and their programming. It covers interfacing of micro controllers with sensors and actuators of interest to the mechanical engineer.

EML 3811L. Mechatronics Lab (2). Prerequisites: COP 3014 or approved equivalent in C, C++, Python, Java (C++ preferred). Corequisite: EML 3811. This course offers a hands-on introduction to basic electronics, embedded controllers, and their programming. It covers interfacing of microcontrollers with sensors and actuators of interest to the mechanical engineer.

EML 4042. Modeling and Simulation for Mechanical Systems (3). Prerequisites 3014C and EML 3018C. This course introduces various concepts of modeling and simulation of mechanical systems, including models of systems, numerical solutions of ODEs, software tools for modeling and simulation of complex mechanical systems.

EML 4161. Cryogenics (3). Prerequisites: EML 3015C, EML 3106, and EML 3234. Miscellaneous requirement: EML 4512 and PHY 3101 are recommended. This course focuses on the fundamental aspects of cryogenic system engineering: properties of materials and fluids at low temperatures; cryogenic heat transfer and fluid dynamics; low temperature refrigeration and system engineering.

EML 4221. Acoustics (3). Prerequisites: EML 3015C and EML 3106C. Corequisites: EML 4711 or EML 5725. This course introduces physical acoustics with an emphasis on a thermal-fluids perspective.

EML 4288. Vehicle Design (3). Prerequisites: EML 3014C and EML 3018C. This introductory course in vehicle design emphasizes vehicle dynamics. Content covers the primary performance related features of vehicle design (suspension, steering, chassis, and tires). Using the latest industry-standard software, the course examines various design parameters that influence vehicle performance and handling.

EML 4304. Experiments in Thermal and Fluid Sciences (2). Prerequisites: EML 3015C. Corequisite: EML 3016C and EML 4304L. This course covers the theory required in engineering experimentation and includes the following topics: concepts of design of experiments; measurement devices and their performance characteristics; error analysis; measurement techniques; measurements of fluid and thermal properties; pressure, velocity; temperature; and calibration procedures.

EML 4304L. Experiments in Thermal and Fluid Sciences - Lab (1). Prerequisites: EML 3012C and EML 3015C. Corequisite: EML 3016C. This engineering laboratory explores measurements in fluid and thermal applications and includes experiments in fluid flow and heat transfer; design of engineering experimental systems; laboratory work; and report writing.

EML 4312. Design and Analysis of Control Systems (3). Prerequisite: EML 3014C. This course focuses on mathematical modeling of continuous physical systems. Frequency and time domain analysis and design of control systems. State variable representations of physical systems.

EML 4316. Advanced Design and Analysis of Control Systems (3). Prerequisite: EML 4312. This course emphasizes design of advanced control systems (using time and frequency domains). Implementation of control systems using continuous (operational amplifier) or digital (microprocessor) techniques are addressed and practiced.

EML 4421. Fundamentals of Propulsion Systems (3). Prerequisite: EML 3016C. This course is an analysis of the performance of propulsion systems using fundamental principles of thermodynamics, heat transfer, and fluid mechanics. Systems studied include turbojet, turbofan, ramjet engines, as well as piston type internal combustion (IC) engines.

EML 4450. Energy Conversion Systems for Sustainability (3). Prerequisites: EML 3016C and senior standing in engineering. This course presents the challenge of changing the global energy system so it addresses reducing dependence on finite fossil energy sources and moving to environmentally sustainable energy sources. The emphasis is on greenhouse gas emissions-free energy production strategies, including renewable energy sources such as solar, wind and biomass. Topics include photovoltaic cells, fuel cells, and thermoelectric systems.

EML 4452. Sustainable Power Generation. (3). Prerequisites: EML 4450 or EML 5451. This course is a continuation of energy-conversion systems for sustainability and focuses on solar electricity, biopower, biofuels, and hydrogen as energy media. The course also explores whether hydrogen-based transportation is a practical option.

EML 4501. Machine Design (3). Prerequisite: EML 3018C. This course focuses on the design of mechanical systems and the components needed for their operation. Emphasis is placed on fasteners and connectors; joints; clutches and brakes; couplings and flywheels; flexible elements; shafts; machine dynamics; computer simulations and models of components and systems; team class projects involving the design and manufacture of mechanical systems.

EML 4512. Thermal-Fluid Design (3). Prerequisite: EML 3016C. This course is intended to develop the student's awareness and understanding of the relationship between fluid mechanics, thermodynamics, and heat transfer in consideration of design. Emphasis is placed upon energy systems components such as heat-exchangers, piping networks, and pumps. Includes a student project.

EML 4536. Design Using FEM (3). Prerequisite: EML 3018C. This course explores the Finite Method - what it is; elementary FEM theory; structures and elements; trusses, beams, and frames; two-dimensional solids; three-dimensional solids; axisymmetric solids; thin-walled structures; static and dynamic problems; available hardware and software; basic steps in FEM analysis; pre/post processing; interpretation of results; advanced modeling techniques; design optimization; advanced materials using FEM.

EML 4542. Materials Selection in Design (3). Prerequisites: EML 3012C and senior standing in mechanical engineering. This course examines the selection and application of materials predicated on material science and engineering case studies covering most engineering applications.

EML 4550. Engineering Design Methods (3). Prerequisites: EML 3002L and EML 3004. This is a formal lecture component of the mechanical engineering 'capstone' senior design course project. The course covers the product design cycle from problem identification and need assessment, to specification, concept generation and selection, preliminary design, materials selection, and final design. The design process is placed in context by presenting topics such as legal and ethical issues, product reliability and liability considerations, engineering economics, and optimal design.

EML 4551C. Senior Design Project I (3). Prerequisites: EML 3012C, EML 3014C, EML 3016C, EML 3018C, and EML 4550. This course is the first in a two-part course sequence presenting an integrated system design approach for engineering product realization. Course blends the perspectives of market research and planning, design cycle, project management and teamwork, and technical reporting. This is the 'capstone' course for mechanical engineering students. This course offers weekly sessions in which teams are coached during the different phases of the project, plus frequent and extensive design reviews. This course is structured to closely resemble 'on the job' engineering education.

EML 4552C. Senior Design Project II (3). Prerequisite: EML 4551C. This is the second in a two-part course sequence presenting an integrated system design approach for engineering product realization. The course blends the perspectives of market research and planning, design cycle, project management and teamwork, and technical reporting. The course structure closely resembles 'on-the-job' engineering education. This is the capstone course for Mechanical Engineering students.

EML 4711. Introduction to Gas Dynamics (3). Prerequisite: EML 3016C. This course is a thorough one-dimensional treatment of compressible flows and applications to nozzle, diffuser, sound waves, tunnel, and shock tube flows.

EML 4800. Introduction to Robotics (3). Prerequisite: EML 3014C. This course explores the basic elements of a robot, robot actuators, and servo control; sensors, senses, vision, and voice; microprocessor system design and computers; kinematic equations; motion trajectories.

EML 4804. Mechatronics II (3). Prerequisite: EML 3811. This course focuses on developing greater competence in the application of electromechanical components to solve engineering problems and build 'smart' systems. The course focuses on the design interplay between electrical and mechanical systems. Students use microprocessors, circuits, sensors, and actuators in both labs and projects to develop multi-purpose electromechanical devices. The course provides instruction and practical exercises in: programming, electronics, signal conditioning, communication protocols, mechanical design, prototyping techniques, and system integration.

EML 4830. Introduction to Mobile Robotics (2). Prerequisites: EML 3811 and EML 3811L. Corequisite: EML 4830L. This course introduces students to kinematic modeling and simulation of mobile robots; mobile robot sensors; fundamental methods of computer vision; Kalman filtering and mobile robot localization; introductory concepts of mapping; path; trajectory planning, and obstacle avoidance; and intelligent control architectures.

EML 4830L. Mobile Robotics Lab (3). Prerequisites: EML 3811 and EML 3811L. Corequisite: EML 4830. This course offers a hands-on implementation of core mobile robotics algorithms. In addition, it introduces widely used mobile robotics software packages.

EML 4841. Bio/Robotic Locomotion (3). Prerequisite: EML 3014C, or instructor permission. This course introduces the fundamental concepts for biological and robotic locomotion with limbs. Muscular-skeletal biomechanics for vertebrate and invertebrate animals are briefly reviewed including an overview of the function of muscles. Morphology, gaits, posture, and the effect of scale on legged locomotion are discussed. The history of legged robots is reviewed. Reduced-order dynamic models of walking and running are introduced. Techniques for analyzing the stability of these periodic hybrid-dynamic systems are covered. The course includes the development and analysis of simulation and hardware platforms of locomotion systems.

EML 4905r. Directed Individual Study (1–3). Prerequisites: Junior standing and a "B" average in mechanical engineering courses. May be repeated to a maximum of twelve semester hours.

EML 4930r. Special Topics in Mechanical Engineering (1–4). Prerequisite: Instructor permission. This course explores topics in mechanical engineering with emphasis on recent developments. Content and credit varies. May be repeated within the same term to a maximum of twelve semester hours.

EML 4945r. Practical Work in Mechanical Engineering (1–3). (S/U grade only.) Prerequisite: Advisor permission. May be repeated to a maximum of three semester hours.

EML 4970r. Honors in the Major Research (1–6). Prerequisite: Acceptance into honors program. In this course, students accepted into the Honors in the Major program complete an original research or creative project in their major area of study. This course must be repeated at least twice to complete a minimum of six (6) credit hours total, but may be repeated up to a maximum of twelve credit hours in total.

DEPARTMENT OF MECHANICAL ENGINEERING

GRADUATE STUDIES

Information for Graduate Students in Mechanical Engineering

Website: https://eng.famu.fsu.edu/me

Chair: Rajan Kumar; **Professors:** Alvi, Clark, Dean De, Gibson, Guo, Hellstrom, Kalu, Kumar, Larbalestier, Oates, J. Ordòñez, Shih; **Associate Professors:** Balachandran, Chen, Hollis, Hruda, Hubicki, Kametani, Krick, Moore, Shoele, Wu, Yaghoobian; **Assistant Professors:** Berger, Cai, Higgins, Nair; **Teaching Faculty:** Ali, Campbell, Capehart (Panama city), Chagas (Panama City), Larson, McConomy, C. Ordòñez, Traynham (Panama City); **Adjunct Faculty:** Larson, Vanderlaan; **Affiliated Faculty:** Hussaini, Kopriva, Tam; **Research Faculty:** Gustavsson, Tuna; **Professors Emeriti:** Buzyna, Cartes, Krothapalli, Luongo, Van Dommelen, Van Sciver

The Department of Mechanical Engineering offers two graduate degrees and one online certificate program: the Master of Science (MS), the Doctor of Philosophy (PhD) and the Aerospace Engineering—Aerodynamics Certificate Program, respectively. The graduate program in mechanical engineering is designed to provide students with the necessary tools to begin a productive career in engineering practice or research, a career that probably will span a period of three to five decades. Although it is not possible to teach everything that one needs to know in the graduate program, the program provides the student with the skills, knowledge, and philosophy that will enable the student to continue to grow throughout his/her career. The graduate training a student receives emphasizes a fundamental approach to engineering whereby the student learns to identify needs, define problems, and apply basic principles and techniques to obtain a solution. This philosophy is incorporated in classroom lectures, laboratory activities, design projects, and research.

It is essential that a successful department cultivates and maintains a diverse and dynamic program that is nationally recognized. The department is actively involved in basic research, which expands the frontiers of knowledge, as well as applied research designed to solve present and future technological needs of society. The major research activities are focused in three primary areas: fluid mechanics and heat transfer, solid mechanics and materials science, and dynamic systems and controls (including mechatronics and robotics). State-of-the-art laboratories are associated with each of these areas. In addition, much of the research is conducted in cooperation with the National High Field Magnetic Laboratory (NHMFL), the Department of Scientific Computing, the Center for Materials Research and Technology (MARTECH), and the Center for Nonlinear and Non-equilibrium Aero Science.

A complete description of the mechanical engineering graduate program, including recent changes, may be found at https://eng.famu.fsu.edu/me.

Research Programs and Facilities

The **Florida Center for Advanced Aero-Propulsion (FCAAP)** has been established to ensure that the State of Florida remains at the forefront of the aerospace industry and maintains a highly skilled workforce to develop, test, transition, and manufacture the next generation of aerospace technologies. The center is a partnership between four state universities, with FSU as the leading institution. The **Advanced Aero-Propulsion Laboratory (AAPL)**, also located at FSU, is the primary experimental and research facility. AAPL contains testing and diagnostic facilities not commonly available at university research centers. These include: a new Hot Jet Anechoic Facility capable of operating supersonic hot jets - up to 2000 Fahrenheit, a STOVL Test Facility, an optical diagnostic development lab, and a supersonic and a large subsonic wind tunnel. In addition to AAPL, the center is home to several state-of-the-art research laboratories led by an experienced team of internationally recognized scientists, researchers, and engineers. In collaboration with government and industry, FCAAP will serve as a technology incubator to promote innovative research and encourage a rapid transition of technologies to market. FCAAP plays a vital role in shaping the next generation of air and spacecraft designs, space transport systems, and aviation safety. FCAAP's current research is focused on Active Flow, Noise and Vibration Control, Aero-optimization, Advanced Propulsion and Turbomachinery Systems, Sensor and Actuator Development, Advanced Diagnostics, Aero-Thermodynamics and Aeroacoustics, High Performance Computation, Smart Materials, Systems and Structures, and other related fields.

The vision of the **Center for Intelligent Systems, Control, and Robotics (CISCOR)** is to use state-of-the-art technology to develop practical solutions to problems in systems, control, and robotics for applications in industry and government. CISCOR is a cooperative research effort in the automated systems area across four departments (Mechanical, Chemical, Electrical, and Civil) in the College of Engineering. The center's goal is to provide a means for the state of Florida to achieve national prominence in the area of automated systems and to assume a leadership role in the state of Florida's technology of the future. Established in 2003, CISCOR has become a leading center in Florida for the development and implementation of technologies related to Intelligent Systems, Control, and Robotics.

The multidisciplinary **High-Performance Materials Institute (HPMI)** performs research for emerging advanced composites, nanomaterials, multifunctional materials and devices, and advanced manufacturing. Currently, HPMI is involved in four primary technology areas: High-Performance Composite and Nanomaterials, Structural Health Monitoring, Multifunctional Nanomaterials Advanced Manufacturing, and Process Modeling. Over the last several years, HPMI has proven several technology concepts that have the potential to narrow the gap between research and practical applications of nanotube-based materials.

The **National High Magnetic Field Laboratory (NHMFL)** is the only facility of its kind in the United States. The National High Magnetic Field Laboratory is the largest and highest-powered magnet laboratory in the world, headquartered in a sprawling 370,000-square foot complex near Florida State University. The lab also includes sites at the Los Alamos National Laboratory in New Mexico and at the University of Florida. Together these three institutions operate the lab, collaborating in a unique interdisciplinary way to advance basic science, engineering, and technology in the 21st century.

The **Applied Superconductivity Center (ASC),** a research division of the National High Magnetic Field Laboratory, was established to advance the science and technology of superconductivity and particularly superconductivity applications by investigating low temperature and high temperature models.

The **Energy and Sustainability Center (ESC)** has been established to address our most challenging energy issues through the development of innovative alternative energy solutions for consumers and industry. The center will develop a portfolio of pre-commercial research programs to explore reliable, affordable, safe, and clean energy technologies. A key objective of ESC is to encourage future commercial application of the technologies that flow from the research. ESC has a number of specialized facilities for technology development and implementation including: a fuel-cell testing laboratory, a water-electrolysis electrode testing laboratory, a solar-thermal system component testing facilities, small-scale electrical power systems laboratory, and other facilities through collaborations with the FAMU-FSU College of Engineering, the Center for Advanced Power Systems (CAPS), and the National High Magnetic Field Laboratory (NHMFL).

The **Institute for Energy Systems, Economics and Sustainability (IESES)** at Florida State University will be an essential component of Florida's leadership in sustainable energy. The Institute is a public resource. We carry out scholarly basic research and analysis in engineering, science, infrastructure, governance, and the related social dimensions; all designed to further a sustainable energy economy. The Institute unites researchers from the disciplines of engineering, natural sciences, law, urban and regional planning, geography, and economics to address sustainability and alternative power issues in the context of global climate change. Our goal is scholarship that leads to informed governance, economics, and decision making for a successful Florida sustainable energy strategy.

The **Active Structures and Microsystems Laboratory** is focused on the mechanics and physics of adaptive materials and their integration into structures and devices. This includes exploring fundamental field-coupled behavior (electric, magnetic, photomechanical, chemical), device and structural dynamics research, and the development of advanced and control designs for broadband performance and precision tracking. This requires synergies between materials science, engineering, and mathematics. We collaborate with several researchers that range in backgrounds that include physics, mathematics, experimental fluid dynamics, and materials science to advance the field.

The **Cryogenics Laboratory,** located in the National High Magnetic Field Laboratory, is a fully developed facility for conducting low-temperature experimental research and development. The laboratory, which occupies about 400 square meters, supports in-house development projects as well as scientific work. The experiment apparatus within the lab includes the following: 1) *Liquid Helium Flow Visualization Facility* (LHFVF): This facility consists of a 5 m long, 20 cm ID horizontal cryogenic vacuum with vertical reservoirs at each end. A variety of experimental test sections can be installed in the facility for measurements of flow and heat transfer including flow visualization studies. The LHFVF is currently being used for PIV studies of forced flow superfluid helium. 2) *Cryogenic Helium Experimental Facility* (CHEF): This facility consists of a 3 m long, 0.6 m ID cryogenic vessel with N2 and He temperature thermal shields. CHEF is equipped with a high-volume flow bellows pump capable of up to 5 liters/s. Currently, CHEF is being used to study high Reynolds number liquid helium flow through orifice plates. 3) *Liquid Helium Research Test Stands*: Numerous conventional vertical access dewars and insert cryostats are available for smaller scale experiments on heat transfer and flow. These include dewars between 10 cin ID with depths to 2 in. 4) Additional equipment: The laboratory contains all necessary equipment to carry out modern cryogenic experiments. Modern instrumentation for data acquisition is available to support experiments. High vacuum equipment includes a mass spectrometer leak detector and two portable turbo pump systems that provide thermal isolation. A high-capacity vacuum pump (500 liter/s) is used to support sub-atmospheric liquid helium experiments as low as 1.5K.

The **Advanced Materials Processing and Applications Laboratory (AMPAL)** is focused on the processing, characterizing, and testing of materials in conjunction with micromechanical modeling. Materials of interest include, but are not limited to, super plastic alloys (Niobium, Copper, Aluminum), structural steel, and high-strength conductors such as Copper-Silver. These materials are employed in several scientific and engineering applications ranging from superconducting and electronic applications (radio frequency cavities, magnetic materials, etc.) to structural applications. Processing involves the development of various sever plastic deformation methods such as tri-axial forging, equal channel angular extrusion (ECAE), rolling, swaging, and wire drawing suitable for producing bulk quantities of ultra-fine-grained material. Also, currently being explored is a novel case hardening technique for both stainless steels and low carbon steels. The laboratory is equipped with various tools for characterization and testing. Some of the equipment include a high-resolution analytical transmission electron microscope, field emission scanning electron microscope equipped with dual beams capable of perming in-situ ion-milling (ion beam), and 2D/3D-electron backscatter diffraction (EBSD) measurements (electron beam). The micromechanics modeling efforts provide an opportunity to correlate the material properties with microstructure. The mechanical modeling effort is being used to explain tension, nano-indentation, shear, and super-plasticity of advanced materials including composite. AMPAL collaborates with various other research groups and institutions both nationally and internationally to achieve our research goals.

The **Scansorial and Terrestrial Robotics and Integrated Design (STRIDe) Laboratory** is dedicated to the design, analysis, and manufacturing of novel and dynamic robotic systems. To imbue robotic systems with the agility and functionality akin to their biological inspirations, it is critical to understand the interplay between the structures' underlying passive dynamics and the control systems that enervate them. Research in this lab involves working closely with biologists to understand the underlying functional principles behind successful animal locomotion. These principles are then encoded in simplified dynamic models. The analysis of these models leads to insight regarding the roles of passive and active elements in creating self-stabilizing dynamic systems. Innovative manufacturing processes, such as Shape Deposition Manufacturing (SDM) and other rapid prototyping techniques, are then applied to build robots capable of moving in a dynamic and agile manner over difficult terrain. To analyze and build these robots, the lab is equipped with dynamic motion analysis equipment as well as a suite of state-of-the-art manufacturing tools.

Graduate students participating in research are provided office space in the laboratories and have access to substantial staff support from their research group.

Definition of Prefixes

EAS—Aerospace Engineering

EGM—Engineering Science

EGN—Engineering: General

EMA—Materials Engineering

EML—Engineering: Mechanical

Graduate Courses

EAS 5102. Fundamentals of Aerodynamics (3). Prerequisites: EML 3015C and EML 3016C. This course includes fundamental fluid mechanics and aerodynamic principles in the design of airfoil and aircraft wings. The course provides a comprehensive review concerning applications, technological advances, and social impacts on the development of a modern flight vehicle.

EGM 5330. Random Data Measurement and Analysis (3). Prerequisite: Graduate standing or instructor permission. This course explores random data, mean values, mean-square values, probability density and distribution functions, moments and characteristic functions, spectral and correlation analysis; bias and random error estimates in data measurements; input-output system models; measurement examples.

EGM 5444. Advanced Dynamics (3). Prerequisite: EGN 3321, EML 3220, and MAP 3306. In this course, topics include particle and rigid body kinematics, particle and rigid body kinetics, D'Alembert Principle, Lagranges equations of motion, system stability, computational techniques, orbital dynamics, multi-body dynamics.

EGM 5611. Introduction to Continuum Mechanics (3). Prerequisite: Graduate standing. Solid and fluid continua. Cartesian tensor theory. Kinematics of infinitesimal deformation, relations between stress, strain, and strain rate for elastic, plastic, and viscous solids and for compressible and viscous fluids. General equations of continuum mechanics, integral forms, and their physical interpretation. Particular forms of equations and boundary conditions for elastic and viscoelastic solids and Newtonian fluids.

EGM 5612. Solid Mechanics and Electromagnetics of Continuous Media (3). Prerequisites: Familiarity with topics of strength of materials, concepts of stresses and strains, a basic understanding of thermodynamics and electromagnetics. This course introduces concepts of continuum thermo-mechanics and electromagnetics with application in solving field-coupled boundary value problems.

EGM 5810. Viscous Fluid Flows (3). Prerequisite: EML 5709. Presents the basic fundamentals underlying the mechanics of gas, air, and fluid flows. Discussion of the possible methods of estimating and predicting the characteristics and parameters governing those flows.

EMA 5226. Mechanical Metallurgy (3). Prerequisites: EML 3234. Tensile instability, crystallography, theory of dislocations, plasticity, hardening mechanisms, creep and fracture, electron microscopy, composite materials.

EMA 5514. Electron Microscopy (3). Prerequisite: Instructor permission. This course focuses on fundamentals and techniques of electron microscopy as applied to the determination of physical, chemical, and structural properties of materials and materials behavior in practice.

EMA 5515. Microstructural Characterization of Materials (3). Prerequisite: EML 3234 or an equivalent introductory course in Materials Science and Engineering. The course introduces the tools for characterizing microstructure in materials: diffraction techniques (x-ray, neutron and electron), electron microscopy (scanning and transmission), spectroscopy (electron, x-ray), and surface and scanning probe methods. Selecting the right tool for a materials problem is also a focus of the course.

EML 5042. Modeling and Simulation of Mechanical Systems (3). Prerequisites: EML 3014C, EML 3018C, or instructor permission. This course is an introduction to various concepts of modeling and simulation of mechanical systems, including models of systems, numerical solutions of ODEs, software tools for modeling and simulation of complex mechanical systems.

EML 5060. Analysis in Mechanical Engineering (3). Prerequisite: Graduate standing in mechanical engineering. Familiarizes the student with methods of analysis in mechanical engineering. Surveys applications of integration and series, ordinary and partial differential equations, and linear algebra.

EML 5061. Analysis in Mechanical Engineering II (3). Prerequisite: EML 5060 or equivalent. This course familiarizes students with applications of vector calculus and partial differential equations in mechanical engineering.

EML 5072. Applied Superconductivity (3). Prerequisites: EEL 3472; EML 3100; EML 3234; PHY 3101. Introduction to superconductivity for applications, fundamentals of the superconducting state, transport current and metallurgy of superconductors, Superconducting electrons and magnets, system engineering.

EML 5107. Thermodynamics for Materials Science (3). Prerequisite: Consent of instructor. This course covers thermodynamic principles with an emphasis on condensed phases.

EML 5152. Fundamentals of Heat Transfer (3). Prerequisite: Graduate standing in mechanical engineering. This is an introductory course in basic heat transfer concepts. Topics include conduction and heat diffusion equation, forced and free convection, radiative heat transfer, boiling heat transfer, and condensation.

EML 5155. Convective Heat and Mass Transfer (3). Prerequisites: EGM 5810; EML 5152. Familiarizes the student with methods to evaluate a convection heat transfer coefficient and a mass transfer coefficient for a variety of engineering applications. Evaluation of the driving force in mass transfer and combined problems.

EML 5162. Cryogenics (3). Prerequisites: EML 3015C, EML 3016, and EML 3234. Miscellaneous requirement: EML 4512 and PHY 3101 are recommended. This course focuses on the fundamental aspects of cryogenics system and engineering properties of materials and fluids at low temperatures; cryogenic heat transfer and fluid dynamics, low temperature refrigeration and system engineering.

EML 5224. Acoustics (3). Prerequisites: EML 3015C, EML 3016C. Corequisite: EML 5710. This course provides an introduction to physical acoustics with an emphasis on a thermal-fluids perspective.

EML 5289. Vehicle Design (3). Prerequisites: EML 3014C and EML 3018C, or instructor permission. This is an introductory course in vehicle design concentrating primarily on vehicle dynamics. Students examine the key features of vehicle design that relate to performance: suspension, steering, chassis, and tires. By using the latest in industry standard software, students consider the various design parameters influencing vehicle performance and handling.

EML 5311. Design and Analysis of Control Systems (3). Prerequisite: MAP 3306. Mathematical modeling of continuous physical systems. Frequency and time domain analysis and design of control systems. State variable representations of physical systems.

EML 5317. Advanced Design and Analysis of Control Systems (3). Design of advanced control systems (using time and frequency domains) will be emphasized. Implementation of control systems using continuous (operational amplifier) or digital (microprocessor) techniques will be addressed and practiced.

EML 5361. Multivariable Control (3). Prerequisite: EML 4312 or 5311. Course covers H2 and H control design for linear systems with multiple inputs and multiple outputs and globally optimal techniques, fixed-structure (e.g., reduced-order) techniques. Includes introductory concepts in robust control.

EML 5422. Fundamentals of Propulsions Systems (3). Prerequisite: EML 3015C, EML 3016C, and graduate standing in mechanical engineering. This course offers an analysis of the performance of propulsion systems using fundamental principles of thermodynamics, heat transfer, and fluid mechanics. Systems studied include turbojet, turbofan, ramjet engines, as well as piston-type internal combustion engines.

EML 5451. Energy Conversion Systems for Sustainability (3). Prerequisites: Requires graduate standing. This course discusses the challenge of making the global energy system independent of finite fossil-energy sources and, instead, dependent on environmentally sustainable energy sources. The course emphasizes strategies for producing energy that is free of greenhouse-gas emissions, including renewable energy sources such as solar, wind, and biomass. The course focuses on direct energy conversion and covers topics such as photovoltaic cells, fuel cells, and thermoelectric systems.

EML 5453. Sustainable Power Generation (3). Prerequisites: EML 4450 or EML 5451 or graduate student standing in engineering or sciences. This course is a continuation of sustainability energy-conversion systems and focuses on solar electricity, biopower, biofuels, and hydrogen. The course also discusses the practicality of hydrogen-based transportation.

EML 5537. Design Using FEM (3). The Finite Element Method - what it is, elementary FEM theory, structures and elements, trusses, beams, and frames, two-dimensional solids, three-dimensional solids, axisymmetric solids, thin-walled structures, static and dynamic problems, available hardware and software, basic steps in FEM analysis, pre/post processing, interpretation of results, advanced modeling techniques, design optimization, advanced materials using FEM.

EML 5543. Materials Selection in Design (3). Prerequisite: EML 3234 or equivalent. This course examines the application of materials predicated on material science and engineering case studies covering most engineering applications.

EML 5705. Active Flow Control (3). Prerequisites: EML 3014C (or an equivalent undergraduate controls course) and EML 5709. This course covers active flow control. Active flow control is a rapidly emerging field of significant technological importance to the design and capability of a new generation of fluid systems, spawning major research initiatives in government industry, and academic sectors.

EML 5709. Fluid Mechanic Principles with Selected Applications (3). Prerequisites: Graduate standing in mechanical engineering, EML 3015, and EML 5060 (or other course equivalents). This course explores introductory concepts, description, and kinematical concepts of fluid motion, basic field equations, thermodynamics of fluid flow, Navier-Stokes equations, elements of the effects of friction and heat flow, unsteady one-dimensional motion, selected nonlinear steady flows.

EML 5710. Introduction to Gas Dynamics (3). Prerequisite EML 3016C. This course concentrates on the unique features of compressibility in fluid mechanics. It provides the student with knowledge and understanding of the fundamentals of compressible fluid flow and is basic to studies in high-speed aerodynamics, propulsion, and turbomachinery.

EML 5725. Introduction to Computational Fluid Dynamics (3). Prerequisite: EML 5709. Topics for this course include introduction to conservation laws in fluid dynamics; weak solutions; solving the full potential equations for subsonic, transonic, and supersonic flows; solving system of equations. In particular, upwind schemes and flux splitting will be introduced in solving the Euler equations. Coordinate transformation and grid generation methods will also be covered.

EML 5802. Introduction to Robotics (3). Prerequisite: Graduate standing in mechanical engineering. This course studies the fundamentals of robot operation and application including basic elements, robot actuators and servo-control, sensors, senses, vision, voice, microprocessor system design and computers, kinematic equations, and motion trajectories.

EML 5803. Mechatronics II (3). This course focuses on developing greater competence in the application of electromechanical components to solve engineering problems and build ‘smart' systems. The course focuses on the design interplay between electrical and mechanical systems. Students use microprocessors, circuits, sensors, and actuators in both labs and projects to develop multi-purpose electromechanical devices. The course provides instruction and practical exercises in programming, electronics, signal conditioning, communication protocols, mechanical design, prototyping techniques, and system integration.

EML 5831. Introduction to Mobile Robotics (2). Prerequisite: EML 3811 and EML 3811L or instructor permission. Corequisite: EML 5831L. This course examines kinematic modeling and simulation of mobile robots; mobile robot sensors; fundamental methods of computer vision; Kalman filtering and mobile robot localization; SLAM; path, trajectory planning, and obstacle avoidance; intelligent control architectures; and advanced topics in localization, mapping, and motion planning.

EML 5831L. Mobile Robotics Lab (1) Prerequisite: EML 3811 and EML 3811L or instructor permission. Corequisite: EML 5831. This course offers a hands-on implementation of core and advanced mobile robotics algorithms. In addition, it introduces widely used mobile robotics software packages.

EML 5832. Bio/Robotic Locomotion (3). Prerequisite: Permission of Instructor. This course introduces the fundamental concepts for biological and robotic locomotion with limbs. Muscular-skeletal biomechanics for vertebrate and invertebrate animals are briefly reviewed including an overview of the function of muscles. Morphology, gaits, posture, and the effect of scale on legged locomotion are discussed. The history of legged robots is reviewed. Reduced-order dynamic models of walking and running are introduced. Techniques for analyzing the stability of these periodic hybrid-dynamic systems are covered. The course includes the development and analysis of simulation and hardware platforms of locomotion systems.

EML 5905r. Directed Individual Study (1–9). (S/U grade only). Instructor permission required. Individual study topics are determined by the instructor and student. May be repeated to a maximum of forty-five semester hours.

EML 5910r. Supervised Research (1–5). (S/U grade only). A maximum of three semester hours may apply to the master's degree. May be repeated to a maximum of five semester hours.

EML 5930r. Special Topics in Mechanical Engineering (1–6). Prerequisite: Instructor permission. This course explores various topics in mechanical engineering with emphasis on recent developments. Content and credit will vary. Consult the instructor.

EML 5935r. Mechanical Engineering Seminars (0). (S/U grade only). May be repeated to a maximum of ten times.

EML 5946r. Professional Internship Experience in Mechanical Engineering (1–4). Prerequisites: Completion of the Bachelor of Science degree in Mechanical Engineering and permission of the instructor. This course provides practical experience through working as an intern at selected industry or research laboratories supervised both by the on-the-job mentors and by the Department of Mechanical Engineering. The course is designed to provide the student with professional internship experience in preparation for his/her future career development. May be repeated up to four credit hours. May be repeated in the same term.

EML 5955r. MS Professional Traineeship Project (3–6). Prerequisite: B.S. degree in Mechanical Engineering (or a related field) and EML 5946. In this two-semester course, students work on practice-oriented engineering design or research development project defined by industry or research laboratories to partially fulfill graduation requirements for the BS-MS professional Traineeship degree.

EML 5971r. Master's Thesis Research (1-12.) (S/U grade only). This course provides a means of registering for thesis research work and recording progress towards its completion. Student must consult with the academic department for appropriate registration of course credit hours. May be repeated to a maximum of forty-five (45) credit hours; repeatable within the same term.

EML 6980r. Dissertation (2–9). (S/U grade only). May be repeated to a maximum of ninety-nine semester hours.

EML 8968. Preliminary Doctoral Examination (0). (P/F grade only.)

EML 8976r. Master's Thesis Defense (0). (P/F grade only.)

EML 8985r. Dissertation Defense (0). (P/F grade only.) May be repeated to a maximum of three times.

MASTER'S PROGRAM

Master's Program

The Department of Mechanical Engineering offers several options for the Master of Science degree. Students may pursue either a Mechanical or Aerospace Engineering degree (both with a thesis or non-thesis option) or specialize in Sustainable Energy. The department is also a member of the Interdisciplinary Materials Science Program through which students can earn a master's degree in Materials Science. Additionally, highly qualified and current undergraduate students may apply to the joint BSMS Pathway to begin taking graduate-level classes during their junior and senior year. There are two tracks to consider: (1) The BS-MS Professional Traineeship and (2) the New combined BS-MS Program. Full details can be found at https://eng.famu.fsu.edu/me/bs-ms-pathway.

Admissions

Prospective students must have a BS degree (or a recognized equivalent) in Mechanical Engineering or any one of the following related fields: Any Engineering Major, Chemistry, Computer Science, Materials Science, Mathematics/Applied Mathematics, or Physics/Applied Physics. Non-majors, students without a BS degree in Mechanical Engineering, may be required to take up to 12 credit hours of remedial coursework in Mechanical Engineering as a condition of admission.

Applicants must have at least a 3.0 upper-division GPA and a Quantitative GRE score of 155 and Verbal GRE score of 150. International students must take the TOEFL exam and score at least 550 on the paper-based exam, 213 on the computer-based exam, or 80 on the Internet-based exam. Other acceptable English Language Proficiency Exam scores are as follows: Pearson Test in English (50), Duolingo (120), Cambridge C1 Advanced Level (180), and Michigan Language Assessment (55). Applicants must also submit a personal/research statement, résumé, and three letters of recommendation. Please visit the department website for additional details: https://eng.famu.fsu.edu/me.

Note: Effective August 2011, the GRE Revised General Test replaced the GRE General Test. To learn more about this test, go to https://ets.org/gre.

Major in Mechanical Engineering

I. Thesis Option

Mechanical Engineering students must take the following minimum distribution of courses for a total of 30 credit hours:

CORE COURSES

Nine credit hours:

- EML 5060 Analysis in Mechanical Engineering, and
- Two core courses in the major area (either Dynamics and Controls, Fluid Mechanics and Heat Transfer, or Solid Mechanics and Materials Science)

Core courses in Dynamics and Controls

EGM 5444 Advanced Dynamics

EML 5317 Advanced Design and Analysis of Control Systems

EML 5361 Multivariable Control

EML 5930r Special Topics in Mechanical Engineering

Core courses in Fluid Mechanics and Heat Transfer

EML 5152 Fundamentals of Heat Transfer

EML 5155 Convective Heat and Mass Transfer

EML 5709 Fluid Mechanics Principles with Selected Applications

EML 5930r Special Topics in Mechanical Engineering

Core courses in Solid Mechanics and Materials Science

EGM 5611 Introduction to Continuum Mechanics

EML 5930r Special Topics in Mechanical Engineering

Mechanical Engineering Courses

Six credit hours: two courses in Mechanical Engineering.

ELECTIVES

Nine credit hours:

Select three graduate-level courses in any engineering field, mathematics, or science (computer science, physics, etc.).

Courses must be selected in consultation with the student's major professor.

One of the three electives may include EML 5905 (Directed Individual Study) or EML 5910 (Supervised Research).

THESIS

Six credit hours:

EML 5971 Thesis, and

EML 8976 Master's Thesis Defense

II. Non-Thesis Option

The non-thesis option requires 30 credit hours, of which at least 27 credit hours must be letter-graded courses. Students must complete 21 credit hours of coursework within mechanical engineering. Nine credit hours may be taken outside the department in any of the following areas: engineering, mathematics, or science (computer science, physics, etc.).

Major in Sustainable Energy

Sustainable Energy students must take the following minimum distribution of courses for a total of 30 credit hours:

CORE COURSES

Fifteen credit hours:

EML 5060 Analysis in Mechanical Engineering I

CHM 5153 Engineering Electrochemistry

EML 5451 Energy Conversion Systems for Sustainability

EML 5452 Sustainable Power Generation

EML 5930r Special Topics in Mechanical Engineering

ELECTIVES

Nine credit hours:

Select three graduate-level courses in engineering, mathematics, or science (computer science, physics, etc.).

Courses must be selected in consultation with the student's major professor.

One of the three electives may include EML 5905 Directed Individual Study or EML 5910 Supervised Research.

THESIS

Six credit hours:

EML 5971 Thesis, and

EML 8976 Master's Thesis Defense

DEPARTMENT OF MECHANICAL ENGINEERING

PhD PROGRAMS

Doctor of Philosophy

Admissions

PhD Program

Prospective students must have an MS degree in Mechanical Engineering or any one of the following related fields: Engineering , Chemistry, Computer Science, Materials Science, Mathematics/Applied Mathematics, or Physics/Applied Physics. Non-majors, students without a BS degree in Mechanical Engineering, may be required to take up to 12 credit hours of remedial coursework in Mechanical Engineering as a condition of admission.

Applicants must have at least a 3.0 upper-division GPA and a Quantitative GRE score of 155 and Verbal GRE score of 150. International students must take the TOEFL Exam and score at least 550 on the paper-based exam, 213 on the computer-based exam, or 80 on the Internet-based exam. Other acceptable English Language Proficiency Exam scores are as follows: Pearson Test in English (50), Duolingo (120), Cambridge C1 Advanced Level (180), and Michigan Language Assessment (55). Applicants must also submit a personal statement, résumé, and three letters of recommendation. Please visit the department website for additional details: https://eng.famu.fsu.edu/me.

Note: Effective August 2011, the GRE Revised General Test replaced the GRE General Test. To learn more about this test, go to https://ets.org/gre.

BS to PhD Program

In addition to the standard PhD program the department offers a direct BS to PhD program. This program is limited to students with excellent academic transcripts and demonstrated potential for advanced research. Applicants must submit strong letters of recommendation from professors or persons qualified to evaluate their academic potential. Final admission to the PhD program is granted by the Graduate Committee.

Students initially admitted to the master's program may request a transfer to the BS-PhD program at the end of their second term. The student must have maintained a graduate GPA of 3.50 or better during their first two terms.

Degree Requirements

PhD Program

The standard PhD program requires 45 credit hours of coursework, of which at least 24 credit hours must be dissertation hours. The remaining 21 letter-graded credit hours are divided into three areas:

General Engineering and Mathematics

Students must complete six credit hours of general engineering and advanced mathematics courses. One of those courses must be EML 5061 Analysis in Mechanical Engineering II. The remaining course must be from the approved course list. See department website for approved list.

Electives

Students must complete 15 credit hours of graduate-level, letter-graded electives. Courses may be taken in any engineering program, mathematics, and/or any science discipline.

BS to PhD Program

The BS-PhD program requires 60 credit hours of coursework, of which at least 24 credit hours must be dissertation hours. The remaining 36 letter-graded credit hours are divided into five areas:

General Engineering and Mathematics

Students must complete six credit hours of general engineering and advanced mathematics courses. One of those courses must be EML 5061 Analysis in Mechanical Engineering II. The remaining course must be from the approved course list. See department website for approved list.

Core Courses

Students must complete EML 5060 Analysis in Mechanical Engineering I, and two courses in their chosen depth area for a total of nine credit hours.

Mechanical Engineering Courses

Students must complete six credit hours of general mechanical-engineering courses.

Electives

Students must complete 15 credit hours of electives. Courses may be taken in any engineering program, mathematics, and/or any science discipline. Students may substitute one elective course with a Directed Individual Study (DIS) course or Supervised Research (SR) course.

Additional Requirements

Preliminary Examination

All PhD students are required to register for and pass EML 8968 (Preliminary Examination) before the end of their fourth term. The exam is designed to evaluate a student's grasp of a specified spectrum of Mechanical Engineering (at the undergraduate level) and their ability to think creatively. It consists of an oral examination following a written research proposal and is administered each fall and spring term. After passing the exam the student will be granted doctoral candidacy status, allowing the student to register for dissertation credit hours.

Prospectus Defense

Within one year of obtaining candidacy status each PhD student must present a prospectus to their committee on a research project suitable for a doctoral dissertation. A forty-five-minute presentation of the proposed dissertation topic will be presented to the students' graduate committee for approval.

Dissertation Defense

Demonstrated ability to perform original research at the forefront of mechanical engineering is the final and major criterion for granting the doctoral degree. The candidate's dissertation serves, in part, to demonstrate such competence; on completion it is defended orally in a public seminar before the doctoral dissertation committee, which may then recommend the awarding of the degree.

Doctor of Philosophy in Materials Science and Engineering

The Department of Mechanical Engineering is a member of the Interdisciplinary Program in Materials Science and Engineering. For more information on the Materials Science and Engineering program, please visit https://materials.fsu.edu.

DEPARTMENT OF MECHANICAL ENGINEERING

AERODYNAMICS CERTIFICATE

Aerospace Engineering—Aerodynamics Certificate

Certificate Requirements

To be considered for the AE-A Certificate, the applicant must be currently enrolled or admitted as a graduate student or as a graduate non-degree-seeking student at either Florida A&M University or Florida State University. Applicants must have a bachelor’s degree in mechanical engineering or related engineering discipline (computer science, mathematics, applied mathematics, physics or applied physics). Applicants who do not have an B.S. degree in engineering or in one of the approved STEM fields listed above are not eligible for admission to the graduate certificate program. Students without a B.S. degree in Mechanical Engineering, but with a degree in an approved field may be required to complete remedial coursework in Mechanical Engineering as a condition of admission. The remedial course will include EML 3015C Thermal Fluids I or an equivalent course (Fluid Mechanics).

In general, the following criteria will be used for admissions:

- GPA of 3.0/4.0 or greater
- Two letters of recommendation
- A statement of purpose
- A resume or CV
- Unofficial transcripts can be submitted with the certificate application; International applicants must include an English translation
- Submit the online Aerodynamics Engineering Certificate Application Form (https://www.forms-db.com) prior to completion of the second course required for the certificate.

Admission and completion of a graduate-level certificate program does not guarantee admission to a master's or specialist degree program. Students may, however, apply up to 12 credit hours towards the master's or doctoral degree with approval.

Prerequisite Courses

Students who have not taken Thermal Fluids I (Fluid Mechanics) or an equivalent course must take this course as an articulation course. Additional courses may be required if the student's undergraduate major is not mechanical engineering, or a closely related major.

Note: Students must submit the online Aerodynamics Engineering Certificate Application Form (https://www.forms-db.com) prior to completion of the second course required for the certificate.

Required Courses

The online AE-Aerodynamics Graduate Certificate curriculum consists of 12 credit hours (four courses). The certificate program through the Department of Mechanical Engineering can be completed in as little as two terms. Students can also complete the program at their own pace part-time.

Required Course

EAS 5102 Fundamentals of Aerodynamics (offered every fall term)

Elective Courses

EGM 5121 Random Data Measurements and Analysis

EML 5422 Propulsion Systems

EML 5709 Fluid Mechanics and Selected Applications

EML 5710 Introduction to Gas Dynamics

EML 5930 Experimental Methods & Advanced Flow Diagnostics

EML 5725 Computational Fluid Dynamics

EML 5930 Introduction to Physical Acoustics

EML 5930 Introduction to Hypersonic Flows

EML 5930 Flow Control

GRADUATE INTERDISCIPLINARY PROGRAM IN MATERIALS SCIENCE & ENGINEERING

Information for the Master of Science and PhD

FAMU—FSU COLLEGE OF ENGINEERING

Website: https://eng.famu.fsu.edu/mse

Interim Chair: David Larbalestier

Materials Science and Engineering is an a graduate-only department, which was created in 2024, that leads to the degrees of Master of Science (MS) and Doctor of Philosophy (PhD) in Materials Science and Engineering. Students interested in this program have a wide variety of backgrounds: engineering disciplines including: biomedical, civil, chemical, computer, engineering physics, environmental, industrial, manufacturing, materials science, mechanical), applied mathematics, biology, chemistry, geology, and physics.

The curriculum requires core and specialization courses, plus a thesis or dissertation. The core courses are designed to give students from the various disciplines a common background in materials.

Admission Requirements — MS and PhD

Students apply to Materials Science and Engineering through the program's website at https://eng.famu.fsu.edu/mse, where there are links to the online admission system for the Florida State University Office of Admissions. Complete applications including all supporting documents must be received by December 15th to be considered for financial aid for the following Fall semester. Applicants must meet the following minimum requirements:

- 3.0 undergraduate GPA (4.0 scale) as an upper-level undergraduate
- GRE scores of at least the 75th percentile for the Quantitative section and the 55th percentile for the Verbal section
- MS applicants are not required to take the GRE exam.
- Three recent letters of recommendation from individuals who are able to assess the applicant's academic and research potential
- Transcripts—International applicants or degrees earned from international institutions must submit official transcripts through a NACES approved evaluator. We recommend using SpanTran for your course-by-course evaluation. We are unable to review applications with unofficial transcripts from international institutions. The University will not waive this requirement.
- Test of English for applicants whose native language is not English—International applicants whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL) examination and obtain a minimum score of 550 on the paper-based or 80 on the Internet-based TOEFL examination. International students expecting to receive appointments as teaching assistants are required to pass a test of spoken English administered by the FSU Center for Intensive English Studies (https://cies.fsu.edu) when they arrive at Florida State University.

Degree Requirements — MS (Thesis)

Overall requirements for the degree of Master of Science in Materials Science and Engineering are:

- Admission to Materials Science and Engineering
- A minimum of 30 credit hours as follows:
  - Twelve credits of letter graded core courses—three required courses, one elective core course
  - Twelve credits of letter graded specialization courses
  - Six credits of thesis research
  - Interdisciplinary seminar series all semesters
- Complete master's research in materials science and engineering

- Submit and successfully defend an acceptable master's thesis

A list of the core and specialization courses can be found at https://eng.famu.fsu.edu/mse.

Degree Requirements — MS (Coursework Only)

Overall requirements for the degree of Master of Science in Materials Science and Engineering are:

- Admission to Materials Science and Engineering
- A minimum of 30 credit hours as follows:
    - Twelve credits of letter graded core courses - three required courses, one elective core course
    - Fifteen credits of letter graded specialization courses
    - Three additional credits of letter graded specialization courses or S/U graded Directed Independent Study
    - Interdisciplinary seminar series all semesters
- Give an oral presentation in the Materials Science and Engineering seminar series

A list of the core and specialization courses can be found at https://eng.famu.fsu.edu/mse.

Doctoral Degree Requirements

Overall requirements for the degree of Doctor of Philosophy in Materials Science and Engineering for students entering with a BS degree are:

- Admission to Materials Science and Engineering
- A minimum of 54 credits with the following minimum requirements:
    - Twelve credits of letter graded core courses - three required courses, one elective core course
    - Fifteen credits of letter graded specialization courses (five specialization courses)
    - Twenty-four credits of dissertation research
    - Interdisciplinary seminar series all semesters
- Successfully pass a qualifying examination
- Successfully pass a preliminary exam, which includes presenting and defending a prospectus
- Complete PhD research in materials science and engineering
- Submit and successfully defend an acceptable PhD dissertation

A list of the core and specialization courses can be found at https://eng.famu.fsu.edu/mse.

Definition of Prefix

ISC—Interdisciplinary Sciences

Graduate Courses

ISC 5905r. Directed Independent Study - MS&E (1–12). (S/U grade only). This course involves study on a selected topic as designated by the student and the directing professor. May be repeated to a maximum of fifty-four (54) semester hours.

ISC 5937r. Interdisciplinary Seminar Series - MS&E (0). (S/U grade only). This course is a seminar series for Materials Science and Engineering students. It is required every Fall and Spring semester through graduation. May be repeated; repeatable within the same term.

ISC 6970r. Thesis Research - MS&E (1–12). (S/U grade only). A minimum of six semester hours are required for the MS degree. May be repeated to a maximum of twenty-four (24) semester hours; repeatable within the same term.

ISC 6976r. Master's Thesis Defense - MS&E (0). (P/F grade only.) May be repeated with instructor permission.

ISC 8960r. PhD Preliminary Exam - MS&E (0). (P/F grade only.) May be repeated with instructor permission; repeatable within the same term.

ISC 8980r. Dissertation Research - MS&E (1–12). (S/U grade only). A minimum of twenty-four semester hours are required for the PhD degree. May be repeated to a maximum of eighty-one (81) semester hours.

ISC 8983r. PhD Dissertation Defense - MS&E (0). (P/F grade only.) May be repeated with instructor permission; repeatable within the same term.

GRADUATE INTERDISCIPLINARY PROGRAM IN MATERIALS SCIENCE & ENGINEERING

UNDERGRADUTE PROGRAM NOTE

Materials Science and Engineering

FAMU-FSU COLLEGE OF ENGINEERING

Website: https://eng.famu.fsu.edu/mse

Interim Chair: David Larbalestier

Created in 2004, Materials Science and Engineering is a graduate-only department wherein students can obtain the degrees of Master of Science (MS) and Doctor of Philosophy (PhD) in Materials Science and Engineering. Students interested in this program have a wide variety of backgrounds: engineering disciplines including: biomedical, civil, chemical, computer, engineering physics, environmental, industrial, manufacturing, materials science, mechanical), applied mathematics, biology, chemistry, geology, and physics.

The curriculum requires core and specialization courses, plus a thesis or dissertation. The core courses are designed to give students from the various disciplines a common background in materials.