ELECTRICAL AND COMPUTER ENGINEERING

Office: Ritchie School of Engineering and Computer Science Mail Code: 2155 E Wesley Ave, Room 283, Denver, CO 80208 Phone: 303.871.6618 Email: eceinfo@du.edu Web Site: ritchieschool.du.edu/departments/ECE (http://ritchieschool.du.edu/departments/ECE/)

Master's and Doctoral Degrees

Why study engineering at the University of Denver?

DU's Department of Electrical and Computer Engineering (ECE) is creating the future of technology by providing a graduate education that emphasizes both multi-disciplinary and cross-disciplinary knowledge. The distinguished faculty continues to create multi-disciplinary education programs that cover both depth and breadth, and research programs that incorporate and account for technological trends in research and development, along with industry. Graduate students will join the faculty in conducting cutting-edge basic and applied research in emerging disciplines developing novel and unique solutions to old and new problems and opportunities.

All laboratories in the Department contain state-of-the-art equipment and software to support basic and applied research in hardware and software design, hardware/software interfacing, communications and signal processing, image processing, computer vision and pattern recognition, optoelectronics, power and energy systems, robotics, mechatronic systems, intelligent systems, unmanned systems, and biosensing technologies, among other research areas. Small classes support our multi-disciplinary and real-time focus by providing close contact between students and faculty, which allows us to meet students' individual career goals.

Denver is a first-rate location for business, government and laboratory partnerships, and technology employment. The Colorado Front Range is consistently rated as one of the top high-tech areas in the country, and DU is located just minutes from the Denver Technological Center, the site of many top technology companies. The Department of Electrical and Computer Engineering is committed to active collaboration with these industry leaders. As a result, our students graduate with relevant research experience and a network of employment contacts in the technology sector that is second to none!

In addition, DU's ECE Department is one of the very few universities that offers BS, MS, and PhD degrees in Mechatronic Systems Engineering.

Doctor of Philosophy in Electrical and Computer Engineering

The objective of the PhD in Electrical and Computer Engineering degree program is to provide an educational environment that encourages students to develop the ability to contribute to the advancement of science, engineering and technology, through independent research. The PhD students of the 21st century may pursue academic, research, entrepreneurial, and/or industrial careers. We offer opportunities to develop individualized plans of study based on the students' previous experience and desired research areas. The plan of study allows students to work on interdisciplinary research, while also satisfying the PhD in ECE degree requirements.

Research requires an in-depth study of engineering problems with a broad knowledge base in science and engineering. Therefore, advanced courses are offered to strengthen the fundamentals and to broaden the engineering and science perspective. The minimum credit requirements are different for individuals entering a program with a closely related master's degree and for those entering with a bachelor's only. All requirements for the degree must be completed within seven years (eight years without a master's degree) from admission to candidacy. A grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation.

The PhD in ECE is appealing to students because it offers the much needed specialization component and the 'degree identity' required to be competitive in the job market. Graduates from this program will be well equipped to follow academic careers, or be hired in federal laboratories, industry and the private sector.

Doctor of Philosophy in Mechatronics Systems Engineering

The objective of the PhD in Mechatronics Systems Engineering (MSE) degree program is to provide an educational environment that encourages students to develop the ability to contribute to the advancement of science, engineering and technology, through independent research. The PhD students of the 21st century may pursue academic, research, entrepreneurial, and/or industrial careers. We offer opportunities to develop individualized plans of study based on the students' previous experience and desired research areas. The plan of study allows students to work on interdisciplinary research, while also satisfying the PhD in MSE degree requirements.

Research requires an in-depth study of engineering problems with a broad knowledge base in science and engineering. Therefore, advanced courses are offered to strengthen the fundamentals and to broaden the engineering and science perspective. The minimum credit requirements are different for individuals entering a program with a closely related master's degree and for those entering with a bachelor's only. All requirements for the degree must be completed within seven years (eight years without a master's degree) from admission to candidacy. A grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation.

The PhD in MSE is at the forefront and intersection of the coupled disciplines of Electrical, Mechanical, Computer Engineering, and Computer Science. This unique degree is appealing to students because they will acquire the knowledge and ability to deal with and solve highly complex problems where integration is a key component. This degree provides a holistic approach to graduate education focusing on the ability to cover both breadth and depth of knowledge. Graduates of this program will lay the foundation for the modern engineering departments of the future, where 'integration' will be the key ingredient of studies.

Master of Science in Computer Engineering

The Master of Science in Computer Engineering (MSCpE) is designed to advance the student's knowledge in several areas of engineering. This degree provides breadth while permitting the student to achieve depth in a specialization area. This specialization area, with thematic sequences of courses, has been selected to coincide with those of high current interest as well as those emerging technologies that hold promise of increasing importance for the future. The purpose of this program is to serve the profession of engineering and the Colorado community through advanced study in computer engineering, electrical engineering, and other related fields. This program prepares the student for academic and industrial advancement. This program offers a thesis and a non-thesis option.

The Department of ECE offers both part-time and full-time programs. The Department recognizes that a student may be employed full-time while studying for a degree. The MSCpE degree program can generally be completed in about four years if one course is taken each quarter, but it is usually possible to take two courses per quarter, bringing completion time closer to the more common duration of two years. Also, students who select the one-year non-thesis will be able to graduate within 12 months, four academic quarters. For part-time students who are working in industry positions and who have chosen the thesis option, a topic related to the job function may be acceptable as the thesis research topic. Furthermore, a qualified staff member at the place of employment may be approved to serve as an Outside Committee Member on the thesis committee.

In addition, a grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation.

Master of Science in Electrical Engineering

The Master of Science in Electrical Engineering (MSEE) is designed to advance the student's knowledge in several areas of engineering. This degree provides breadth while permitting the student to achieve depth in a specialization area. This specialization area, with thematic sequences of courses, has been selected to coincide with those of high current interest as well as those emerging technologies that hold promise of increasing importance for the future. The purpose of this programs is to serve the profession of engineering and the Colorado community through advanced study in computer engineering, electrical engineering, and other related fields. This program prepares the student for academic and industrial advancement. This programs offers a thesis and a non-thesis option.

The Department of ECE offers both part-time and full-time programs. The Department recognizes that a student may be employed full-time while studying for a degree. The MSEE degree program can generally be completed in about four years if one course is taken each quarter, but it is usually possible to take two courses per quarter, bringing completion time closer to the more common duration of two years. Also, students who select the one-year non-thesis will be able to graduate within 12 months, four academic quarters. For part-time students who are working in industry positions and who have chosen the thesis option, a topic related to the job function may be acceptable as the thesis research topic. Furthermore, a qualified staff member at the place of employment may be approved to serve as an Outside Committee Member on the thesis committee.

In addition, a grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation.

Master of Science in Mechatronic Systems Engineering

The Master of Science in Mechatronic Systems Engineering (MSMSE) is designed to advance the student's knowledge in several areas of engineering. This degree provides breadth while permitting the student to achieve depth in a specialization area. This specialization area, with thematic sequences of courses, has been selected to coincide with those of high current interest as well as those emerging technologies that hold promise of increasing importance for the future. The purpose of this programs is to serve the profession of engineering and the Colorado community through advanced study in computer engineering, electrical engineering, and other related fields. This program prepares the student for academic and industrial advancement. This program offer a thesis and a non-thesis option.

The Department of ECE offers both part-time and full-time programs. The Department recognizes that a student may be employed full-time while studying for a degree. The MSMSE degree program can generally be completed in about four years if one course is taken each quarter, but it is usually possible to take two courses per quarter, bringing completion time closer to the more common duration of two years. Also, students who select the one-year non-thesis will be able to graduate within 12 months, four academic quarters. For part-time students who are working in industry positions and who have chosen the thesis option, a topic related to the job function may be acceptable as the thesis research topic. Furthermore, a qualified staff member at the place of employment may be approved to serve as an Outside Committee Member on the thesis committee.

In addition, a grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation.

Master of Science in Systems Engineering (Online)

The Master of Science degree in Systems Engineering (Online) (<u>MSSY</u>) along with the three Specialized Graduate Certificates covers the depth and breadth in systems design, analysis, synthesis, integration, testing, validation, and verification. We train our students with expertise in the fundamentals of the discipline of systems engineering. Our program has an emphasis on support for proposals after contract award, through critical design reviews, as well as systems design and integration and associated validation and verification activities, which are necessarily traceable to system requirements. We also provide practical exposure to the analytical and digital tools which are paramount to the evolving practice of systems engineering. This practical exposure is designed to enable the student to participate in rigorous post-test data analysis, model based design, model based systems engineering, as well as statistically relevant process improvement projects. Learned skills, knowledges, and case studies will be applicable to engineering professionals in many industries, particularly in regulated industries such as aerospace, biomedical, and autonomous vehicles.

The program is built for graduate students and industry professionals. The MSSY program is comprised of three Stackable Certificates that lead to the MS degree in Systems Engineering degree: Fundamentals of Systems Engineering, Systems Design & Architecture, and Systems Analytics and Practice. The program is delivered entirely online.

The MSSY degree program can generally be completed in about three years if two courses are taken each quarter, with each certificate being completed in approximately one year.

Students not interested in pursuing a degree but interested in taking an occasional course may register as special status students by following an abbreviated admissions process. However, only 9 QH earned as a special status student may be applied toward a MS degree.

Doctor of Philosophy in Electrical & Computer Engineering

Degrees and GPA Requirements

Bachelors degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

- A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.
- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

Prerequisites

Students with a MS in CpE, MS in MSE, MS in EE, MS in ME, or closely related areas may apply for admission to the PhD in ECE or PhD in MSE
programs. Admission with only a BS in this field is also possible, but students with only a BS degree are strongly encouraged to enroll first in
the MS (CpE, EE, MSE) programs. All graduate engineering courses presuppose mastery of the subject matter of a modern ABET-accredited
curriculum in engineering. Students with a BS in other engineering or related science fields and students with a BSCpE, BSEE, or BSME who have
not taken graduate academic work for some time may be required to complete preparatory courses that are prerequisites for the core courses of
the engineering concentrations on which the qualifying exams are based. These courses carry no credit toward the graduate degree.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Doctor of Philosophy in Mechatronic Systems Engineering

Degrees and GPA Requirements

Bachelors degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

- · A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.

- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- · A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

Prerequisites

• Students with a MS in CpE, MS in MSE, MS in EE, MS in ME, or closely related areas may apply for admission to the PhD in ECE or PhD in MSE programs. Admission with only a BS in this field is also possible, but students with only a BS degree are strongly encouraged to enroll first in the MS (CpE, EE, MSE) programs. All graduate engineering courses presuppose mastery of the subject matter of a modern ABET-accredited curriculum in engineering. Students with a BS in other engineering or related science fields and students with a BSCpE, BSEE, or BSME who have not taken graduate academic work for some time may be required to complete preparatory courses that are prerequisites for the core courses of the engineering concentrations on which the qualifying exams are based. These courses carry no credit toward the graduate degree.

Other Required Materials

• We recommend PhD applicants contact faculty to find a research advisor BEFORE submitting the application. If we receive an application and there is no research advisor commitment, we will consider the applicant for the master's program only.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Master of Science in Electrical Engineering, Computer Engineering or Mechatronic Systems Engineering

Degrees and GPA Requirements

Bachelors degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

- · A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.
- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

Prerequisites

A Bachelor of Science (BS) degree in computer engineering (BSCpE), electrical engineering (BSEE), or closely related field from a regionally accredited college or university is required for admission to the programs. Those students whose backgrounds differ significantly from EAC/ABET-accredited BS computer, electrical programs may be required to complete prerequisite undergraduate courses. Such courses are not considered part of the 45 quarter hour requirements for the degree. A competency examination may be required of candidates who do not possess a 3.0 GPA or a BS in electrical, electronic, or computer from an EAC/ABET accredited program. Students with BS degrees in physics, mathematics, computer science, engineering science, electrical engineering technology, engineering physics, or similar BS degrees from a regionally accredited college or university may also be admitted. However, these students should be able to demonstrate competency in the following basic subjects by passing an appropriate competency examination: MSCpE: Circuits and Electronics, Digital Systems, Computer Organization, a high- or low-level computer language; MSEE: Digital Design Methods, Physical Electronics, Signals and Systems, Circuits and Electronics, Digital Design Methods, Mechanics, Electromagnetics.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Masters of Science in Systems Engineering (Online)

Degree and GPA Requirements

Bachelor's degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

- · A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.
- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- · A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Specialized Graduate Certificate in Fundamentals of Systems Engineering

Degree and GPA Requirements

Bachelor's degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

- · A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.
- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Specialized Certificate in Systems Analytics and Practice

Degree and GPA Requirements

Bachelor's degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

6 Electrical and Computer Engineering

- · A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.
- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Specialized Graduate Certificate in Systems Design and Architecture

Degree and GPA Requirements

Bachelor's degree: All graduate applicants must hold an earned baccalaureate from a regionally accredited college or university or the recognized equivalent from an international institution.

University GPA requirement: The minimum grade point average for admission consideration for graduate study at the University of Denver must meet one of the following criteria:

- · A cumulative 2.5 on a 4.0 scale for the baccalaureate degree.
- A cumulative 2.5 on a 4.0 scale for the last 60 semester credits or 90 quarter credits (approximately two years of work) for the baccalaureate degree.
- An earned master's degree or higher from a regionally accredited institution or the recognized equivalent from an international institution supersedes the minimum GPA requirement for the baccalaureate.
- · A cumulative GPA of 3.0 on a 4.0 scale for all graduate coursework completed for applicants who have not earned a master's degree or higher.

English Language Proficiency Test Score Requirements

The minimum TOEFL/IELTS/C1 Advanced/Duolingo English Test score requirements for this degree program are:

- Minimum TOEFL Score (Internet-based test): 80
- Minimum IELTS Score: 6.5
- Minimum C1 Advanced Score: 176
- Minimum Duolingo English Test Score: 115

Doctoral Degree Programs

Doctor of Philosophy in Electrical and Computer Engineering

Program requirements

All PhD students who have been admitted to the PhD in ECE program must successfully complete three milestones before the PhD degree can be conferred. These milestones refer to:

- · Demonstrating that the student is qualified to begin PhD studies
- · Demonstrating that the student may identify and formulate a research problem
- · Demonstrating that the student can defend her/his dissertation

These three milestones are referred to as the "PhD Qualifying Exam", the "Comprehensive Exam" (also known as the "PhD Proposal"), and the "Dissertation Defense", respectively.

Coursework requirements

The PhD in ECE does not have specific course requirements. The coursework plan needs to be approved by the student's advisor and the department chair.

Graduate Assessment Requirement

ECE Graduate Assessment (ENEE 4950)

This graduate assessment course is required for all ECE graduate students to be taken in their last quarter (the term they have applied as the graduation term). All required assessment materials are uploaded to the course Assignments online to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. As part of the graduate assessment effort, students' advisors and members of Master's thesis Committee / PhD Committee will be asked to provide related information online.

Specifically, (1) Master's degree thesis-option students are required to complete a written self-reflection essay on entire MS program including thesis research and upload the final OGE approved thesis, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (2) Master's degree non-thesis-option students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (3) PhD students are required to complete a written self-reflection essay on entire PhD program including dissertation research and upload the final OGE approved dissertation, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation.

Minimum credit requirements

Students with a Bachelor of Science in Engineering/Science

For students admitted to the PhD program with a bachelor's degree, 90 QH are required, 75 of which must be completed at the University of Denver. A minimum of 48 QH must be at the 4000-level or higher and may include as many dissertation research hours (Independent Research and Independent Study) as considered appropriate by the advisor and department chair. The student with his/her advisor will develop an appropriate plan of study with core requirements, an area of specialization (depth requirement), breadth requirement and advanced mathematics. The core will consist of 8 QH of coursework. The area of specialization will consist of 16 QH of coursework. An additional 6 QH of coursework (excluding independent research) is required as related breadth requirement. The student must complete a minimum of 16 QH at the 4000-level courses, excluding independent research. Prior to completion of the comprehensive exam, the plan of study must be approved by the student's PhD committee and the chair.

If a student is entering the PhD program without a relevant master's degree, the student should work with his/her advisor in order to meet the degree requirements for a master's degree. All requirements for the given master's degree must be met.

Code	Title	Credits
ENEE 4950	ECE Graduate Assessment	0
A minimum of 48 QH must be at the 4 by advisor and assuming a minimum	4000-level or higher, may include Independent Research or Independent Study as considered appropriate of 16 QH are earned excluding independent research	48
Core Requirement		8
Depth Requirement - Specialization A	Nrea	16
Breadth Requirement ¹		6
Total Credits		90

The breadth requirement must be pre-approved by the student's advisor.

Students with a Master of Science in Engineering/Science

If a student is admitted with a closely related master's degree, up to 45 hours may be transferred and applied to the doctorate degree. The student with his or her advisor will develop an appropriate program consisting of a minimum of 28 quarter hours at the 4000-level, which may include as many dissertation research hours (Independent Research and Independent Study) as considered appropriate by the advisor and the department chair. The student with his or her advisor will develop an appropriate plan of study with an area of specialization, breadth requirements and advanced mathematics. Prior to completion of the comprehensive exam, the student's plan of study must be approved by the student's PhD committee and the department chair.

Code	Title	Credits
ENEE 4950	ECE Graduate Assessment	0
A minimum of 36QH must be at the 4 by advisor	000-level or higher, may include Independent Research or Independent Study as considered appropriate	36
Student with his or her advisor will de mathematics	evelop an appropriate plan of study with an area of specialization, breadth requirements and advanced	
Total Credits		90

Non-coursework Requirements

Qualifying Examination

Each student must demonstrate sufficient breadth and depth of basic engineering knowledge relevant to electrical and computer engineering and be able to demonstrate ability to organize and present her/his thoughts in a convincing manner. To achieve this, each admitted student is required to

demonstrate proficiency in five chosen courses by receiving a final grade of B or better. Students may either enroll or test out these courses. These criteria do not necessarily have to be met within a single quarter; however, a maximum of two attempts is allowed for each course or test.

The five courses will be one from the list of Core Courses, two from two Subject Area Courses, and two courses approved by the advisor. The list of courses is subject to modification with the approval of the department.

Core Courses - Choose one course

Code	Title	Credits
Core Courses		12
MATH 3151	Advanced Linear Algebra	
ENGR 3621	Advanced Engineering Mathematics	
ENGR 3650	Probability and Statistics for Engineers	
Subject Area Courses - choose two	courses from two areas	16
Circuits, Electronics and Electromage	netics	
ENGR 4100	Instrumentation and Data Acquisition	
ENEE 3011	Physical Electronics	
ENEE 3641	Introduction to Electromagnetic Compatibility	
ENEE 4030	Optoelectronics	
ENCE 4110	Modern Digital Systems Design	
Computer Engineering		
ENCE 3231	Embedded Systems Programming	
ENCE 3321	Network Design	
ENCE 4631	Advanced Machine Learning	
Control and Communication Systems	S	
ENEE 3670	Introduction to Digital Signal Processing	
ENGR 3721	Controls	
ENGR 4723	Digital Control	
ENGR 4735	Linear Systems	
ENGR 4740	Adaptive Control Systems	
Biomedical Engineering		
ENGR 3450	Biosensing Technology	
ENGR 4455	Fluorescence and its applications in biomedical sensors	
ENBI 4620	Bioelectronics	
ENEE 4630	Optical Networking	
Robotics		
ENCE 4620	Advanced Computer Vision	
ENGR 4730	Introduction to Robotics	
Power and Energy Systems		
ENGR 3510	Renewable and Efficient Power and Energy Systems	
ENGR 4530	Intro to Power and Energy	

Qualifier Transfer Policy

Policy Statement

The Electrical and Computer Engineering (ECE) Department at Denver University (DU) acknowledges the Qualifying Exam achievements of PhD students transferring from other institutions. Subject to the student having successfully passed the Qualifying Exam at their original institution and upon receiving endorsement from their advisor, the departmental faculty will consider and vote on granting an exemption from the DU ECE Qualifying Exam on a case-by-case basis. A majority decision will be required for approval.

This policy applies exclusively to PhD students transferring to DU ECE under the guidance of their advisor. This scenario primarily arises when the department seeks to attract top talent, with advisors bringing only those students who have already demonstrated their qualifications. In alignment with our strategy to recruit outstanding individuals, it is appropriate for the ECE Department to recognize and accept the results of Qualifying Exams from other reputable institutions. This approach allows both faculty and newly admitted students to devote their efforts towards achieving significant research contributions for the department.

Timeline

Each admitted graduate student must complete/satisfy all Qualifying Exam requirements within <u>at most</u> 5 quarters from initial admittance. Failure to pass any component of the PhD Qualifying Exam within the given time constraints will prevent the student from continuing in the PhD program.

Comprehensive Examination

The purpose of the Comprehensive Examination is to ascertain the potential of the student for PhD quality research. At least two quarters prior to the final defense, the student shall schedule and take the Comprehensive Examination. This oral and written examination will be attended by a minimum of three faculty members, the same faculty who will attend the student's final dissertation defense. The Comprehensive Exam may be open to other students based on the requirements of the student's advisor. The student is expected to make a 30 to 40 minute concise presentation on her/his dissertation topic. The oral and written presentation will highlight previous work in this area, demonstrate a need for the given research, and explain how the given research will contribute to the advancement of the area. The student will also present completed work and results, and a detailed plan for project completion. In addition, the student will be expected to answer general fundamental questions in the area of her/his concentration and detailed questions in the area of the student's graduate course work.

The PhD Qualifying Examination must be taken and passed prior to the student taking the Comprehensive Examination. The Comprehensive Examination can be taken at most 2 times. If the student does not pass the Comprehensive Exam on the second try, the student will be terminated from the program. The comprehensive exam will be graded on a pass/fail system.

Dissertation

The student is required to complete and defend a dissertation of publishable quality based on the student's original research. The dissertation must be completed in written form in accordance with the University's Graduate School guidelines. A summary of the dissertation must be presented in a public seminar and subsequently defended by the student in the final oral defense. The defense committee will consist of the student's entire PhD committee.

Residence Requirement

Enrollment in at least six quarters (four semesters), including at least two consecutive quarters (one semester) of full-time attendance is required for graduation.

PhD Committee

The PhD committee should consist of at least four faculty members. Three faculty members must be from within the student's specialty area; these can include the student's advisor, other faculty in that degree program and, if necessary, off-campus experts. Finally, for the final oral defense of the dissertation, an oral defense chair, who must be a tenured faculty member outside the Department of Electrical and Computer Engineering and Mechanical and Materials Engineering, needs to be identified in consultation with the DU Graduate Studies Office. The PhD committee needs to be identified with the dissertation advisor and approved by the chair of the department and the Office of Graduate Studies.

Doctor of Philosophy in Mechatronics Systems Engineering

Program requirements

All PhD students who have been admitted to the PhD in ECE or PhD in MSE programs must successfully complete three milestones before the PhD degree can be conferred. These milestones refer to:

- · Demonstrating that the student is qualified to begin PhD studies
- · Demonstrating that the student may identify and formulate a research problem
- · Demonstrating that the student can defend her/his dissertation

These three milestones are referred to as the "PhD Qualifying Exam", the "Comprehensive Exam" (also known as the "PhD Proposal"), and the "Dissertation Defense", respectively.

Coursework requirements

The PhD in MSE has specific course requirements that can be found below. The coursework plan needs to be approved by the student's advisor and the department chair.

Graduate Assessment Requirement

ECE Graduate Assessment (ENEE 4950)

This graduate assessment course is required for all ECE graduate students to be taken in their last quarter (the term they have applied as the graduation term). All required assessment materials are uploaded to the course Assignments online to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. As part of the graduate assessment effort, students' advisors and members of Master's thesis Committee / PhD Committee will be asked to provide related information online.

Specifically, (1) Master's degree thesis-option students are required to complete a written self-reflection essay on entire MS program including thesis research and upload the final OGE approved thesis, defense presentation slides, and the completed and signed degree program plan, by the published

OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (2) Master's degree non-thesis-option students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (3) PhD students are required to complete a written self-reflection essay on entire PhD program including dissertation research and upload the final OGE approved dissertation, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation.

Minimum credit requirements

Students with a Bachelor of Science in Engineering/Science

For students admitted to the PhD program with a bachelor's degree, 90 QH are required, 75 of which must be completed at the University of Denver. A minimum of 48 QH must be at the 4000-level or higher and may include as many dissertation research hours (Independent Research and Independent Study) as considered appropriate by the advisor and department chair. The student with their advisor will develop an appropriate plan of study with core requirements, an area of specialization (depth requirement), breadth requirement and advanced mathematics. The core will consist of 8 QH of coursework. The area of specialization will consist of 16 QH of coursework. An additional 6 QH of coursework (excluding independent research) is required as related breadth requirement. The student must complete a minimum of 16 QH at the 4000-level courses, excluding independent research. In addition, a grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation. Prior to completion of the comprehensive exam, the plan of study must be approved by the student's PhD committee and the department chair.

If a student is entering the PhD program without a relevant master's degree, the student should work with their advisor in order to meet the degree requirements for a master's degree. All requirements for the given master's degree must be met.

Code	Title	Credits
ENEE 4950	ECE Graduate Assessment	0
A minimum of 48 QH must be at the by advisor and assuming a minimum	4000-level or higher, may include Independent Research or Independent Study as considered appropriate of 16 QH are earned excluding independent research	48
Core Requirement		8
Depth Requirement - Specialization A	Area	16
Breadth Requirement ¹		6
Total Credits		90

The breadth requirement must be pre-approved by the student's advisor.

Students with a Master of Science in Engineering/Science

If a student is admitted with a closely related master's degree, up to 45 hours may be transferred and applied to the doctorate degree. The student with his or her advisor will develop an appropriate program consisting of a minimum of 36 quarter hours at the 4000-level, which may include as many dissertation research hours (Independent Research and Independent Study) as considered appropriate by the advisor. The remaining 9 credits can be taken at the graduate 3000 level or higher. The student with his or her advisor will develop an appropriate plan of study with an area of specialization, breadth requirements and advanced mathematics. In addition, a grade of C- or better must be obtained in each course in order for that course to count toward the credit hour requirements. An overall minimum GPA of 3.0 is also required for graduation. Prior to completion of the comprehensive exam, the student's plan of study must be approved by the student's PhD committee.

Code	Title	Credits
ENEE 4950	ECE Graduate Assessment	0
A minimum of 36QH must be at the 4 by advisor	1000-level or higher, may include Independent Research or Independent Study as considered appropriate	36
Student with his or her advisor will de mathematics	evelop an appropriate plan of study with an area of specialization, breadth requirements and advanced	
Total Credits		90

Non-coursework Requirements

Qualifying Examination

Each student must demonstrate sufficient breadth and depth of basic engineering knowledge relevant to electrical and computer engineering and be able to demonstrate ability to organize and present her/his thoughts in a convincing manner. To achieve this, each admitted student is required to demonstrate proficiency in five chosen courses by receiving a final grade of B or better. Students may either enroll or test out these courses. These criteria do not necessarily have to be met within a single quarter; however, a maximum of two attempts is allowed for each course or test.

The five courses will be one from the list of Core Courses, two from two Subject Area Courses, and two courses approved by the advisor. The list of courses is subject to modification with the approval of the department.

Code	Title	Credits
Core Courses - Choose one course		4
MATH 3151	Advanced Linear Algebra	
ENGR 3650	Probability and Statistics for Engineers	
ENGR 3621	Advanced Engineering Mathematics	
Subject Area Courses – choose two	courses from two areas	16
Circuits, Electronics and Electromage	netics	
ENGR 4100	Instrumentation and Data Acquisition	
ENCE 4110	Modern Digital Systems Design	
ENEE 3011	Physical Electronics	
ENEE 3641	Introduction to Electromagnetic Compatibility	
ENGR 3455	Fluorescence and Its Applications in Biomedical Sensors	
Computer Engineering		
ENCE 3321	Network Design	
ENCE 4620	Advanced Computer Vision	
Control and Communication Systems	S	
ENEE 3670	Introduction to Digital Signal Processing	
ENGR 3721	Controls	
ENGR 4723	Digital Control	
ENGR 4735	Linear Systems	
ENGR 4740	Adaptive Control Systems	
Biomedical Engineering		
ENGR 3450	Biosensing Technology	
ENGR 4455	Fluorescence and its applications in biomedical sensors	
ENEE 4030	Optoelectronics	
ENBI 4620	Bioelectronics	
Robotics		
ENCE 3231	Embedded Systems Programming	
ENGR 4730	Introduction to Robotics	
Power and Energy Systems		
ENGR 3510	Renewable and Efficient Power and Energy Systems	
ENGR 3540	Electric Power Systems	
ENGR 4530	Intro to Power and Energy	

Qualifier Transfer Policy

Policy Statement

The Electrical and Computer Engineering (ECE) Department at Denver University (DU) acknowledges the Qualifying Exam, in a closely related field, achievements of PhD students transferring from other institutions. Subject to the student having successfully passed the Qualifying Exam, in a closely related field, at their original institution and upon receiving endorsement from their advisor, the departmental faculty will consider and vote on granting an exemption from the DU ECE Qualifying Exam on a case-by-case basis. A majority decision will be required for approval.

This policy applies exclusively to PhD students transferring to DU ECE under the guidance of their advisor. This scenario primarily arises when the department seeks to attract top talent, with advisors bringing only those students who have already demonstrated their qualifications. In alignment with our strategy to recruit outstanding individuals, it is appropriate for the ECE Department to recognize and accept the results of Qualifying Exams from other reputable institutions. This approach allows both faculty and newly admitted students to devote their efforts towards achieving significant research contributions for the department.

Timeline

Each admitted graduate student must complete/satisfy all Qualifying Exam requirements within <u>at most</u> 5 quarters from initial admittance. Failure to pass any component of the PhD Qualifying Exam within the given time constraints will prevent the student from continuing in the PhD program.

Comprehensive Examination

The purpose of the Comprehensive Examination is to ascertain the potential of the student for PhD quality research. At least two quarters prior to the final defense, the student shall schedule and take the Comprehensive Examination. This oral and written examination will be attended by a minimum

of three faculty members, the same faculty who will attend the student's final dissertation defense. The Comprehensive Exam may be open to other students based on the requirements of the student's advisor. The student is expected to make a 30 to 40 minute concise presentation on her/his dissertation topic. The oral and written presentation will highlight previous work in this area, demonstrate a need for the given research, and explain how the given research will contribute to the advancement of the area. The student will also present completed work and results, anticipated work and results, and a detailed plan for project completion. In addition, the student will be expected to answer general fundamental questions in the area of her/his concentration and detailed questions in the area of the student's graduate course work.

The PhD Qualifying Examination must be taken and passed prior to the student taking the Comprehensive Examination. The Comprehensive Examination can be taken at most 2 times. If the student does not pass the Comprehensive Exam on the second try, the student will be terminated from the program. The comprehensive exam will be graded on a pass/fail system.

Dissertation

The student is required to complete and defend a dissertation of publishable quality based on the student's original research. The dissertation must be completed in written form in accordance with the University's Office of Graduate Education guidelines. A summary of the dissertation must be presented in a public seminar and subsequently defended by the student in the final oral defense. The defense committee will consist of the student's entire PhD committee.

Residence Requirement

Enrollment in at least six quarters, including at least two consecutive quarters of full-time attendance is required for graduation.

PhD Committee

The PhD committee should consist of at least four faculty members. Three faculty members must be from within the student's specialty area; these can include the student's advisor, other faculty in that degree program and, if necessary, off-campus experts. Finally, for the final oral defense of the thesis, an oral defense chair, must be a tenured member of the DU faculty and must be from a department, school, or college other than that of the candidate, and needs to be identified in consultation with the DU Office of Graduate Education. The PhD committee needs to be identified with the dissertation advisor and approved by the chair of the department and the Office of Graduate Education.

Master's Degree Programs

Master of Science in Computer Engineering

Minimum Credit Requirements

Every candidate for the MS degree must complete 45 QH of credit, at least 36 of which must be completed at the University of Denver.

Program Structure

Candidates may elect either the thesis or non-thesis option. This choice may be made at any time, although a delay in declaration may impact the completion date. Students who are GTAs or who receive financial support from a University research grant, such as GRAs, are required to elect the thesis option. The program is designed to be completed in about six quarters if two courses (usually 8 QH) are taken each quarter.

Graduate Assessment Requirement

ECE Graduate Assessment (ENEE 4950)

This graduate assessment course is required for all ECE graduate students to be taken in their last quarter (the term they have applied as the graduation term). All required assessment materials are uploaded to the course Assignments online to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. As part of the graduate assessment effort, students' advisors and members of Master's thesis Committee / PhD Committee will be asked to provide related information online.

Specifically, (1) Master's degree thesis-option students are required to complete a written self-reflection essay on entire MS program including thesis research and upload the final OGE approved thesis, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (2) Master's degree non-thesis-option students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (3) PhD students are required to complete a written self-reflection essay on entire PhD program including dissertation research and upload the final OGE approved dissertation, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation.

Non-Thesis Option

The non-thesis option is the more flexible of the two options. This program is designed with the working professional in mind. For this option, a grade of C- or better must be obtained in each course in order for that course to count toward the requirement of 45 QH. An overall minimum GPA of 3.0 is also required for graduation. Students may only take up to 8 quarter hours of independent study to be counted toward the degree, after approval by their advisor and the Chair. Each student must take a minimum of 24 quarter hours at the 4000-level.

One Year (four quarters) - Non-thesis Option

The Department of Electrical and Computer Engineering (ECE) offers a one-year, non-thesis option. Students who select the one-year program will be able to graduate within 12 months, four academic quarters, as there are enough courses offered in each specialization to meet the 20 QH depth requirement. The breadth requirement (14 QH) is fulfilled by taking courses offered in other specializations. In addition, every year courses that satisfy the mathematics requirement (3 QH) are offered. The MS non-thesis structure is shown below. QH in each category denote minimum requirements that must be satisfied. Any changes in the student's plan of study must be approved a-prior by the student's advisor.

The basic structure of the minimum 45 QH for the non-thesis option is as follows:

Requirements for Non-Thesis Op	ption (minimum QH)	
Code	Title	Credits
Graduate Assessment Requirem	nent	0
Core Requirement	8	
Depth Requirement - Specializat	tion Area	20
Mathematics Requirement (requ	3	
Breadth Requirement		14
Total Credits		45

This indicates minimum number of quarter hours. Any credits over the 3 QH from the mathematics courses will count toward the breadth requirement.

Thesis Option

A thesis permits a candidate to obtain depth in an area of study and it is especially useful for individuals who seek to pursue a subsequent degree, for example, a PhD degree. Thesis candidates work closely with a thesis advisor. The thesis option is required for all GRAs and GTAs. For this option, a grade of C- or better must be obtained in each course in order for that course to count toward the 45 QH hour requirements. An overall minimum GPA of 3.0 is also required for graduation. Students may only take up to 8 quarter hours of independent study to be counted toward the degree. Each student must take a minimum of 16 quarter hours at the 4000-level. The basic structure of the minimum 45 QH for the thesis option is as follows:

Requirements for Thesis Option (minimum QH)		
Code	Title	Credits
Graduate Assessment Requirement		0
Core Requirement		8
Depth Requirement - Specialization	rea	16
Breadth Requirement ¹		6
Thesis		15
Total Credits		45

The breadth requirement must be pre-approved by the student's advisor.

If a student who has elected to pursue a thesis option, then at any time thereafter elects to change to a non-thesis option, all requirements for the nonthesis must be met. Any independent research taken may be forfeited and students must adhere to the grade requirements of the non-thesis option.

Breadth Requirement (Non-Thesis and Thesis Option)

Breadth Requirement courses (each with not less than 3 QH of credit) may be chosen from courses offered in other specialization areas. A course that appears in more than one specialization area may only be counted toward either the specialization requirement or the breadth requirement. The remaining courses are chosen from appropriate courses numbered 3000 or higher, offered by the Department Mechanical & Materials Engineering, Department of Computer Science or NSM (Natural Sciences and Mathematics). Prior approval by the student's advisor is required. It is strongly recommended that students choose math related courses to satisfy the breadth requirement.

The MSCpE program offers one area of specialization:

· Computer Systems Engineering

The student's degree program will be a combination of the core courses, specialization areas (depth requirement) and the breadth requirement. Each student is required to complete the 2 core courses. Students may choose from any of the courses from their area of specialization but should keep in mind the 4000-level requirement of the degree.

Core courses for all Computer Engineering Students

The following courses are required for all computer engineering students:

Code	Title	Credits
ENEE 4950	ECE Graduate Assessment	0
ENCE 4110	Modern Digital Systems Design	4
ENGR 3621	Advanced Engineering Mathematics	4

Specialization in Computer Systems Engineering

This area of specialization prepares students with fundamental and working knowledge of methods for analysis, design, and implementation of intelligent systems (IS). Particular attention is given to signal and information processing in IS, design of IS, and implementation of IS using state-of-the-art technology. This is accomplished through several theoretical courses and applied courses. Students must choose from the following courses:

Code	Title	Credits
ENCE 3321	Network Design	4
ENCE 4231	Embedded Systems Programming	4
ENCE 4620	Advanced Computer Vision	4
ENEE 3670	Introduction to Digital Signal Processing	4
ENGR 4622	Advanced Optimization	4
ENCE 4631	Advanced Machine Learning	4

Master of Science in Electrical Engineering

The Master of Science in Electrical Engineering (MSEE) is designed to advance the student's knowledge in several areas of engineering. This degree provides breadth while permitting the student to achieve depth in a specialization area. This specialization area, with thematic sequences of courses, has been selected to coincide with those of high current interest as well as those emerging technologies that hold promise of increasing importance for the future. The purpose of this programs is to serve the profession of engineering and the Colorado community through advanced study in computer engineering, electrical engineering, and other related fields. This program prepares the student for academic and industrial advancement. The program offer a thesis and a non-thesis option.

The Department of ECE offers both part-time and full-time programs. The Department recognizes that a student may be employed full-time while studying for a degree. Therefore, most courses are offered at times and on days that will permit a student to complete the program by taking courses either late in the day or outside normal business hours. The MS degree program can generally be completed in about four years if one course is taken each quarter, but it is usually possible to take two courses per quarter, bringing completion time closer to the more common duration of two years. Also, students who select the one-year non-thesis will be able to graduate within 12 months, four academic quarters. For part-time students who are working in industry positions and who have chosen the thesis option, a topic related to the job function may be acceptable as the thesis research topic. Furthermore, a qualified staff member at the place of employment may be approved to serve as an adjunct faculty on the thesis committee.

Students not interested in pursuing a degree but interested in taking an occasional course may register as special status students by following an abbreviated admissions process. However, only 15 QH earned as a special status student may be applied toward a MS degree.

Minimum Credit Requirements

Every candidate for the MS degree must complete 45 QH of credit, at least 36 of which must be completed at the University of Denver.

Program Structure

Candidates may elect either the thesis or non-thesis option. This choice may be made at any time, although a delay in declaration may impact the completion date. Students who are GTAs or who receive financial support from a University research grant, such as GRAs, are required to elect the thesis option. The program is designed to be completed in about six quarters if two courses (usually 8 QH) are taken each quarter.

Required Graduate Assessment Course

ECE Graduate Assessment (ENEE 4950)

This graduate assessment course is required for all ECE graduate students to be taken in their last quarter (the term they have applied as the graduation term). All required assessment materials are uploaded to the course Assignments online to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. As part of the graduate assessment effort, students' advisors and members of Master's thesis Committee / PhD Committee will be asked to provide related information online.

Specifically, (1) Master's degree thesis-option students are required to complete a written self-reflection essay on entire MS program including thesis research and upload the final OGE approved thesis, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (2) Master's degree non-thesis-option students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (3) PhD students are required to complete a written self-reflection essay on entire PhD program including dissertation research and upload

the final OGE approved dissertation, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation.

Non-Thesis Option

The non-thesis option is the more flexible of the two options. This program is designed with the working professional in mind. For this option, a grade of C- or better must be obtained in each course in order for that course to count toward the requirement of 45 QH. An overall minimum GPA of 3.0 is also required for graduation. Students may only take up to 8 quarter hours of independent study to be counted toward the degree, after approval by their advisor and the Chair. Each student must take a minimum of 24 quarter hours at the 4000-level.

One Year (four quarters) – Non-thesis Option

The Department of Electrical and Computer Engineering (ECE) offers a one-year, non-thesis option. Students who select the one-year program will be able to graduate within 12 months, four academic quarters, as there are enough courses offered in each specialization to meet the 20 QH depth requirement. The breadth requirement (14 QH) is fulfilled by taking courses offered in other specializations. In addition, every year courses that satisfy the mathematics requirement (3 QH) are offered. The MS non-thesis structure is shown below. QH in each category denote minimum requirements that must be satisfied. Any changes in the student's plan of study must be approved a-prior by the student's advisor.

The basic structure of the minimum 45 QH for the non-thesis option is as follows:

Requirements for Non-Thesis Option (minimum QH)		
Code	Title	Credits
Graduate Assessment Requirement		0
Core Requirement		8
Depth Requirement - Specialization	Area	20
Mathematics Requirement (requires	one approved course at the 3000-level or higher) $^{ m 1}$	3
Breadth Requirement		14
Total Credits		45

This indicates minimum number of quarter hours. Any credits over the required 3 QH from the mathematics courses will count toward the breadth requirement.

Thesis Option

A thesis permits a candidate to obtain depth in an area of study and it is especially useful for individuals who seek to pursue a subsequent degree, for example, a PhD degree. Thesis candidates work closely with a thesis advisor. The thesis option is required for all GRAs and GTAs. For this option, a grade of C- or better must be obtained in each course in order for that course to count toward the 45 QH hour requirements. An overall minimum GPA of 3.0 is also required for graduation. Students may only take up to 8 quarter hours of independent study to be counted toward the degree. Each student must take a minimum of 16 quarter hours at the 4000-level. The basic structure of the minimum 45 QH for the thesis option is as follows:

Requirements for Thesis Option (mini	um QH)	
Code	Title	Credits
Graduate Assessment Requirement		0
Core Requirement		8
Depth Requirement - Specialization A	ea	16
Breadth Requirement ¹		6
Thesis		15
Total Credits		45

The breadth requirement must be pre-approved by the student's advisor.

....

If a student who has elected to pursue a thesis option, then at any time thereafter elects to change to a non-thesis option, all requirements for the non-thesis must be met. Any independent research taken may be forfeited and students must adhere to the grade requirements of the non-thesis option.

Breadth Requirement (Non-Thesis and Thesis Option)

.

Breadth Requirement courses (each with not less than 3 QH of credit) may be chosen from courses offered in other specialization areas. A course that appears in more than one specialization area may only be counted toward either the specialization requirement or the breadth requirement. The remaining courses are chosen from appropriate courses numbered 3000 or higher, offered by the Department Mechanical & Materials Engineering, Department of Computer Science or NSM (Natural Sciences and Mathematics). Prior approval by the student's advisor is required. It is strongly recommended that students choose math related courses to satisfy the breadth requirement.

The MSEE program offers three areas of specialization:

- Control & Communication Systems
- · Electric Power & Energy Systems
- · Optics/Optoelectronics/Photonics

Each student must choose an area of specialization. The student's degree program will be a combination of the core courses, specialization areas (depth requirement) and the breadth requirement. Each student is required to complete the 2 core courses. Students may choose from any of the courses from their area of specialization but should keep in mind the 4000-level requirement of the degree.

Core courses for all Electrical Engineering Students

The following courses are required for all electrical engineering students, regardless of area of specialization:			
Code	Title	Credits	
ENEE 4950	ECE Graduate Assessment	0	
ENEE 4640	Electromagnetic Compatibility	4	
ENGR 3621	Advanced Engineering Mathematics	4	

Specialization in Control & Communication Systems

This area of specialization prepares students for basic and applied research and development of complex systems, including, electrical, mechanical, bio-inspired, mechatronic systems, robotic systems, and unmanned systems. This is accomplished through several theoretical courses and applied courses. Students must choose from the following courses:

Code	Title	Credits
ENCE 4231	Embedded Systems Programming	4
ENEE 3670	Introduction to Digital Signal Processing	4
ENGR 3721 & ENGR 3722	Controls and Control Systems Laboratory	4
ENEE 4141	Digital Communications	4
ENGR 4350	Reliability ¹	4
ENGR 4620	Optimization ¹	4
ENGR 4622	Advanced Optimization	4
ENGR 4730	Introduction to Robotics	4
ENGR 4735	Linear Systems	4
ENGR 4740	Adaptive Control Systems	4
ENGR 4745	Adv Non-Linear Control System	4
ENGR 4750	Networked Control Systems	4
ENGR 4755	Optimal Control	4
ENGR 4760	Multivariable Control	4

¹ This course may count toward the specialization with advisors pre-approval. This course may not be offered on a regular basis.

Specialization in Electric Power and Energy Systems

This area of specialization prepares students with the basic foundation and advanced knowledge, required for the research and development in the area of power systems, renewable energy systems, and power electronic devices. This is accomplished through several theoretical courses and applied courses. Students must choose from the following courses:

Code	Title	Credits
ENGR 3510	Renewable and Efficient Power and Energy Systems	4
ENGR 3540	Electric Power Systems	4
ENGR 3721	Controls	4
& ENGR 3722	and Control Systems Laboratory	
ENGR 4530	Intro to Power and Energy	4
ENGR 4545	Electric Power Economy	4
ENGR 4560	Power Generation Operation and Control	4
ENGR 4590	Power System Protection	4

ENGR 4735	Linear Systems	4
ENGR 4740	Adaptive Control Systems	4

Specialization in Optics/Optoelectronics/Photonics

This area of specialization prepares students for research, development, and design of devices and systems operating based on wave theory; focusing on laser, optics, light wave devises, and systems.

Code	Title	Credits
ENEE 4030	Optoelectronics	4
ENEE 4141	Digital Communications	4
ENGR 4735	Linear Systems	4
ENGR 4740	Adaptive Control Systems	4

Master of Science in Mechatronic Systems Engineering

Minimum Credit Requirements

Every candidate for the MS degree must complete 45 QH of credit, at least 36 of which must be completed at the University of Denver.

Program Structure

Candidates may elect either the thesis or non-thesis option. This choice may be made at any time, although a delay in declaration may impact the completion date. Students who are GTAs or who receive financial support from a University research grant, such as GRAs, are required to elect the thesis option. The program is designed to be completed in about six quarters if two courses (usually 8 QH) are taken each quarter.

Required Graduate Assessment Course

ECE Graduate Assessment (ENEE 4950)

This graduate assessment course is required for all ECE graduate students to be taken in their last quarter (the term they have applied as the graduation term). All required assessment materials are uploaded to the course Assignments online to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. As part of the graduate assessment effort, students' advisors and members of Master's thesis Committee / PhD Committee will be asked to provide related information online.

Specifically, (1) Master's degree thesis-option students are required to complete a written self-reflection essay on entire MS program including thesis research and upload the final OGE approved thesis, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (2) Master's degree non-thesis-option students are required to complete a written self-reflection essay on entire MS program and upload an assembled portfolio that includes reports from at least two course projects or homework from the core or depth courses, presentation slides from any course projects, along with the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students of the size a written self-reflection essay on entire PhD program including dissertation research and upload the final OGE approved dissertation, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation. (3) PhD students are required to complete a written self-reflection essay on entire PhD program including dissertation research and upload the final OGE approved dissertation, defense presentation slides, and the completed and signed degree program plan, by the published OGE "Deadline for thesis/dissertation formatting approval" of the students' last quarter before graduation.

Non-Thesis Option

The non-thesis option is the more flexible of the two options. This program is designed with the working professional in mind. For this option, a grade of C- or better must be obtained in each course in order for that course to count toward the requirement of 45 QH. An overall minimum GPA of 3.0 is also required for graduation. Students may only take up to 8 quarter hours of independent study to be counted toward the degree, after approval by their advisor and the Chair. Each student must take a minimum of 24 quarter hours at the 4000-level.

One Year (four quarters) - Non-thesis Option

The Department of Electrical and Computer Engineering (ECE) offers a one-year, non-thesis option. Students who select the one-year program will be able to graduate within 12 months, four academic quarters, as there are enough courses offered in each specialization to meet the 20 QH depth requirement. The breadth requirement (14 QH) is fulfilled by taking courses offered in other specializations. In addition, every year courses that satisfy the mathematics requirement (3 QH) are offered. The MS non-thesis structure is shown below. QH in each category denote minimum requirements that must be satisfied. Any changes in the student's plan of study must be approved a-prior by the student's advisor.

The basic structure of the minimum 45 QH for the non-thesis option is as follows:

Requirements for Non-Thesis Option (minimum quarter hours)			
Code	Title	Credits	
Graduate Assessment Requirement		0	
Core Requirement		8	
Depth Requirement - Specialization Area		20	
Mathematics Requirement (requires one approved course at the 3000-level or higher) ¹		3	

Breadth Requirement

Total Credits

1

This indicates minimum number of quarter hours. Any credits over the required 3 QH from the mathematics courses will count toward the breadth requirement.

Thesis Option

A thesis permits a candidate to obtain depth in an area of study and it is especially useful for individuals who seek to pursue a subsequent degree, for example, a PhD degree. Thesis candidates work closely with a thesis advisor. The thesis option is required for all GRAs and GTAs. For this option, a grade of C- or better must be obtained in each course in order for that course to count toward the 45 QH hour requirements. An overall minimum GPA of 3.0 is also required for graduation. Students may only take up to 8 quarter hours of independent study to be counted toward the degree. Each student must take a minimum of 16 quarter hours at the 4000-level. The basic structure of the minimum 45 QH for the thesis option is as follows:

Requirements for Thesis Option (minimum quarter hours)			
Code	Title	Credits	
Graduate Assessment Requirement		0	
Core Requirement		8	
Depth Requirement - Specialization	rea	16	
Breadth Requirement ¹		6	
Thesis		15	
Total Credits		45	

¹ The breadth requirement must be pre-approved by the student's advisor.

If a student who has elected to pursue a thesis option, then at any time thereafter elects to change to a non-thesis option, all requirements for the non-thesis must be met. Any independent research taken may be forfeited and students must adhere to the grade requirements of the non-thesis option.

Breadth Requirement (Non-Thesis and Thesis Option)

Breadth Requirement courses (each with not less than 3 QH of credit) may be chosen from courses offered in other specialization areas. A course that appears in more than one specialization area may only be counted toward either the specialization requirement or the breadth requirement. The remaining courses are chosen from appropriate courses numbered 3000 or higher, offered by the Department Mechanical & Materials Engineering, Department of Computer Science or NSM (Natural Sciences and Mathematics). Prior approval by the student's advisor is required. It is strongly recommended that students choose math related courses to satisfy the breadth requirement

The MSE program offers one area of specialization:

Robotic Systems

The student's degree program will be a combination of the core courses, specialization areas (depth requirement) and the breadth requirement. Each student is required to complete the 2 core courses. Students may choose from any of the courses from their area of specialization but should keep in mind the 4000-level requirement of the degree.

Core courses for all Mechatronic Systems Engineering Students

The following courses are required for all mechatronic systems engineering students regardless of area of specialization:

Code	Title	Credits
ENEE 4950	ECE Graduate Assessment	0
ENEE 4640	Electromagnetic Compatibility	4
or ENCE 4110	Modern Digital Systems Design	
ENGR 3621	Advanced Engineering Mathematics	4

Specialization in Robotics Systems

This area of specialization is designed to meet the needs of industry and federal research laboratories for engineers with multidisciplinary experience and ability to design and integrate complex systems requiring knowledge from diverse engineering disciplines. Said differently, mechatronic systems involves integration of mechanical, electrical, and computer engineering to design complex systems that perform real-world tasks. This program includes a broad set of common course requirements along with a selection of appropriate technical electives providing both breadth and depth of knowledge in a student's area of interest.

14 **45**

Code	Title	Credits
ENCE 4231	Embedded Systems Programming	4
ENCE 4620	Advanced Computer Vision	4
ENGR 3630	Finite Element Methods ¹	4
ENGR 4620	Optimization ¹	4
ENGR 4730	Introduction to Robotics	4
ENGR 4735	Linear Systems	4
ENME 4020	Adv Finite Element Analysis ¹	4
ENGR 4740	Adaptive Control Systems	4
ENGR 4745	Adv Non-Linear Control System	4

This course may count toward the specialization with advisors preapproval. This course may not or may not be offered on a regular basis.

Master of Science in Systems Engineering (Online)

Minimum of 45 credit hours are required for the degree.

1

Code	Title	Credits
Specialized Graduate Certificate in 1	The Fundamentals of Systems Engineering	
Required Courses		
ENSY 4010	Systems Engineering Fundamentals	
ENSY 4050	Digital Transformation for Advanced Integration	
ENSY 4090	Project Management in Relation to Systems Engineering	
Required Elective Courses (Choose a	at least two courses totaling 6 credit hours)	6
ENMT 4000	Space Systems Design I ²	
ENMT 4010	Space Systems Design II ²	
ENSY 4021	Design of Space Systems Part 1	
ENSY 4022	Design of Space Systems Part 2	
ENSY 4040	Systems Optimization	
ENSY 4060	Practical Model Based Systems Engineering	
ENGR 4501	Graduate Capstone Design I ¹	
ENGR 4502	Graduate Capstone Design II ¹	
ENGR 4503	Graduate Capstone Design III ¹	
ENGR 4504	Graduate Capstone Design IV ¹	
ENGR 4991	Independent Study	
Specialized Graduate Certificate in T	Fhe Systems Design and Architecture	
Required Courses		
ENSY 4012	Systems Engineering Requirements Development	
ENSY 4014	Complex System Architectures	
ENSY 4016	Conceptual Design of Systems	
Required Elective Courses (Choose a	at least two courses totaling 6 credit hours)	6
ENSY 4024	Applied Electrical, Mechanical and Software Systems	
ENSY 4030	Introduction to Aerospace Missions	
ENSY 4040	Systems Optimization	
ENSY 4060	Practical Model Based Systems Engineering	
ENSY 4112	Practical Validation and Verification Test Planning	
ENGR 4501	Graduate Capstone Design I ¹	
ENGR 4502	Graduate Capstone Design II ¹	
ENGR 4503	Graduate Capstone Design III ¹	
ENGR 4504	Graduate Capstone Design IV ¹	
ENGR 4991	Independent Study	
Specialized Graduate Certificate in 1	The Systems Analytics & Practice	

	Required Courses		
	ENSY 4180	Applied Mathematics for Systems Engineering	
	ENSY 4181	Introductory Probability and Statistics for Systems Engineering	
	ENSY 4182	Data Analytics for Systems Engineering	
R	equired Elective Courses (Choose ty	vo courses totaling at least 6 credit hours)	6
	ENSY 4042	Optimization for Advanced Systems	
	ENSY 4112	Practical Validation and Verification Test Planning	
	ENSY 4170	Practical Approaches to Continuous Improvement	
	ENSY 4200	Applied Machine Learning for Advanced Systems Modeling	
	ENGR 4501	Graduate Capstone Design I ¹	
	ENGR 4502	Graduate Capstone Design II	
	ENGR 4503	Graduate Capstone Design III	
	ENGR 4504	Graduate Capstone Design IV ¹	
	ENGR 4991	Independent Study	

A maximum of 9 credit hours of the Graduate Capstone Design series will be applied as Required Elective Credit. Only Lockheed Martin employees in the Engineering Leadership Development Program (ELDP) may take the Graduate Capstone Design series courses.

² These courses are only available to Lockheed Martin Employees at this time.

Specialized Graduate Certificate Programs

Specialized Graduate Certificate in the Fundamentals of Systems Engineering

This Specialized Graduate Certificate provides expertise in fundamentals of the discipline of systems engineering, applicable to engineering professionals in many industries, particularly regulated industries such as aerospace, biomedical, and autonomous vehicles.

<u>Please note that this is the first of the three stackable certificates leading to the MS in Systems Engineering (Online) and is available as a singular</u> <u>Specialized Graduate Certificate.</u>

Minimum Credit Requirements

1

1

Every candidate for the Specialized Graduate Certificate must complete 15 credit hours.

Code	Title	Credits
Required Courses		
ENSY 4010	Systems Engineering Fundamentals	3
ENSY 4050	Digital Transformation for Advanced Integration	3
ENSY 4090	Project Management in Relation to Systems Engineering	3
Required Elective Courses (Choose a	t least two courses totaling 6 credit hours)	
ENSY 4021	Design of Space Systems Part 1	3
ENSY 4022	Design of Space Systems Part 2	3
ENSY 4040	Systems Optimization	3
ENSY 4060	Practical Model Based Systems Engineering	3
ENGR 4501	Graduate Capstone Design I ¹	3
ENGR 4502	Graduate Capstone Design II ¹	3
ENGR 4503	Graduate Capstone Design III ¹	3
ENGR 4504	Graduate Capstone Design IV ¹	3
ENGR 4991	Independent Study	1-5
Total Credits		15

A maximum of 9 credit hours of Graduate Capstone Design courses will be applied as Required Elective Credit. Only Lockheed Martin employees in the current ELDP cohort may take the Graduate Capstone Design series courses.

Specialized Graduate Certificate in Systems Analytics & Practice

This Specialized Graduate Certificate provides systems engineering expertise with practical exposure to the analytical and digital tools which are paramount to the evolving practice of systems engineering. This practical exposure is designed to enable the student to participate in rigorous post-

test data analysis, to participate in model based design and model based systems engineering, as well as statistically relevant process improvement projects. Case studies are applicable to engineering professionals in many industries, particularly regulated industries such as aerospace, biomedical, and autonomous vehicles.

Please note that this is the third of the three stackable certificates leading to the MS in Systems Engineering (Online) and is available as a singular Specialized Graduate Certificate.

Minimum Credit Requirements

Every candidate for the Specialized Graduate Certificate must complete 15 credit hours.

Code	Title	Credits
Required Courses		
ENSY 4180	Applied Mathematics for Systems Engineering	
ENSY 4181	Introductory Probability and Statistics for Systems Engineering	
ENSY 4182	Data Analytics for Systems Engineering	
Required Elective Courses (Choose two courses totaling at least 6 credit hours)		
ENSY 4042	Optimization for Advanced Systems	
ENSY 4112	Practical Validation and Verification Test Planning	
ENSY 4170	Practical Approaches to Continuous Improvement	
ENSY 4200	Applied Machine Learning for Advanced Systems Modeling	
ENGR 4501	Graduate Capstone Design I ¹	
ENGR 4502	Graduate Capstone Design II ¹	
ENGR 4503	Graduate Capstone Design III ¹	
ENGR 4504	Graduate Capstone Design IV ¹	
ENGR 4991	Independent Study	
Total Credits		15

A maximum of 9 credit hours of Graduate Capstone Design courses will be applied as Required Elective Credit. Only Lockheed Martin employees in the current ELDP cohort may take the Graduate Capstone Design series courses.

Specialized Graduate Certificate in Systems Design and Architecture

This Specialized Graduate Certificate provides systems engineering expertise with emphasis on support for proposals after contract award, through critical design reviews, as well as system design and integration and associated validation and verification activities, which are necessarily traceable to system requirements. Case studies are applicable to engineering professionals in many industries, particularly regulated industries such as aerospace, biomedical, and autonomous vehicles.

Please note that this is the second of the three stackable certificates leading to the MS in Systems Engineering (Online) and is available as a singular Specialized Graduate Certificate.

Minimum Credit Requirements

1

Every candidate for the Specialized Graduate Certificate must complete 15 credit hours.

Code	Title	Credits
Required Courses		
ENSY 4012	Systems Engineering Requirements Development	3
ENSY 4014	Complex System Architectures	3
ENSY 4016	Conceptual Design of Systems	3
Required Elective Courses (Choose at least two courses totaling at least 6 credit hours)		
ENSY 4024	Applied Electrical, Mechanical and Software Systems	
ENSY 4030	Introduction to Aerospace Missions	
ENSY 4040	Systems Optimization	
ENSY 4060	Practical Model Based Systems Engineering	
ENSY 4112	Practical Validation and Verification Test Planning	
ENGR 4501	Graduate Capstone Design I ¹	
ENGR 4502	Graduate Capstone Design II ¹	

Total Credits		1	5
ENGR 4991	Independent Study		
ENGR 4504	Graduate Capstone Design IV ¹		
ENGR 4503	Graduate Capstone Design III ¹		

Total Credits

A maximum of 9 credit hours of Graduate Capstone Design courses will be applied as Required Elective Credit. Only Lockheed Martin employees in the current ELDP cohort may take the Graduate Capstone Design series courses.

Engineering, Computer (ENCE)

ENCE 2101 Digital Design (3 Credits)

Basic logic concepts. Boolean algebra, truth tables and logic diagrams. Karnaugh maps; programmable devices including ROM's, PLA's and PAL's; data selectors and multiplexors; flip-flops, and memory design of sequential logic circuits. State diagrams, counters, latches and registers; realization of sequential and arbitrary counters; monostable multivibrators. Course includes engineering ethics. Laboratory.

ENCE 3100 Advanced Digital System Design (4 Credits)

Design of logic machines. Finite state machines, gate array designs, ALU and control unit designs, microprogrammed systems. Hardware design of digital circuits using SSI and MSI chips. Introduction to probability and statistics. Application of probability and stochastic processes for cache and paging performance. Laboratories incorporate specification, top-down design, modeling, implementation and testing of actual digital design systems hardware. Simulation of circuits using VHDL before actual hardware implementation. Laboratory. Cross listed with ENCE 4110. Prerequisite: ENCE 2101.

ENCE 3210 Microprocessor Systems I (4 Credits)

Introduction to microprocessors and to the design and operation of computer systems. A study of the microprocessor and its basic support components. Analysis of CPU architectures of modern computers. Assembly language programming. Use of an assembler and other development tools for programming and developing microprocessor-based systems. Laboratory. Cross listed with ENCE 4210. Prerequisite: ENCE 2101.

ENCE 3231 Embedded Systems Programming (4 Credits)

Design, construction and testing of microprocessor systems. Hardware limitations of the single-chip system. Includes micro-controllers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, design methods and testing of embedded systems. Prerequisite: ENCE 3210.

ENCE 3260 Python for Engineers (3 Credits)

This course introduces python programming to students and gives them programming and mathematical tools that will be useful in different areas of engineering. The course is divided into 2 main parts. Part 1 (Introduction to Python Programming), covers the fundamental concepts of python programming, covering topics from variables and data structures, functions, algorithm complexity, representation of numbers and basics of parallel computing. Part 2 (Introduction to Numerical Methods), gives an overview of a variety of numerical methods that are useful for engineers. The course reviews the basics of linear algebra, discusses the importance of eigenvalues and eigenvectors, regressions and concepts of "discrete Fourier transform" and "fast Fourier transform".

ENCE 3321 Network Design (4 Credits)

Introduction to network components. Lavering of network architecture. Analysis of Local Area Network (LAN) concepts and architecture based on IEEE standards. Design principles including switching and multiplexing techniques, physical link, signal propagation, synchronization, framing and error control. Application of probability and statistics in error detecting and control. Ethernet, Token-ring, FDDI (Fiber Distributed Data Interface), ATM (Asynchronous Transfer Mode), ISDN (Integrated Service Data Networks). Prerequisite: ENEE 3111, ENCE 2101 or permission of instructor.

ENCE 3501 VLSI Design (3 Credits)

Design of Very Large Scale Integration systems. Examination of layout and simulation of digital VLSI circuits using a comprehensive set of CAD tools in a laboratory setting. Studies of layouts of CMOS combinational and sequential circuits using automatic layout generators. Fundamental structures of the layout of registers, adders, decoders, ROM, PLA's, counters, RAM and ALU. Application of statistics and probability to chip performance. CAD tools allow logic verification and timing simulation of the circuits designed. Cross listed with ENCE 4501. Prerequisite: ENCE 3231.

ENCE 3620 Computer Vision (4 Credits)

This course is an introduction to the basic concepts in image processing and computer vision. First, an introduction to low-level image analysis methods, including radiometry and geometric image formation, edge detection, feature detection, and image segmentation are presented. Then, geometric-based image transformations (e.g., image warping and morphing) for image synthesis will be presented in the course. Furthermore, methods for reconstructing three-dimensional scenes including camera calibration, Epipolar geometry, and stereo feature matching are introduced. Other important topics include optical flow, shape from shading, and three-dimensional object recognition. In conclusion, students learn and practice image processing and computer vision techniques that can be used in other areas such as robotics, pattern recognition, and sensor networks. Cross listed with ENCE 4620. Prerequisites: ENGR 3611 or ENGR 3621 AND ENGR 1572 or ENGR 3650 or ENCE 3260 or permission of instructor.

ENCE 3631 Machine Learning (4 Credits)

This class covers topics in machine learning including but not limited to Bayesian decision theory, supervised learning, unsupervised learning and clustering, linear discriminant functions, deep learning, neural networks, linear classification techniques, manifold learning, bag of words, and Support Vector Machines. Cross listed with ENCE-4631.

ENCE 3830 Topics in Computer Engineering (1-5 Credits)

Special topics in computer engineering as announced. May be taken more than once. Prerequisite: varies with offering.

ENCE 3991 Independent Study (1-5 Credits)

Topics in computer engineering investigated under faculty supervision. May be taken more than once. Students must obtain and complete an Independent Study form from the Office of the Registrar. Prerequisite: permission of instructor.

ENCE 3995 Independent Research (1-10 Credits)

ENCE 4110 Modern Digital Systems Design (4 Credits)

This course focuses on the design of digital systems using combinational, sequential, and programmable logic devices and Hardware Description Languages (HDL). Techniques for logic design including asynchronous logic, physical world interfaces to digital systems, and system performance analysis methods are studied. Students also learn HDL-Verilog to program CPLD devices and FPGA systems. Cross listed with ENCE 3100.

ENCE 4231 Embedded Systems Programming (4 Credits)

Design, construction and testing of microprocessor systems. Hardware limitations of the single-chip system. Includes micro-controllers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, design methods and testing of embedded systems.

ENCE 4501 Advanced VLSI Design (4 Credits)

Advanced techniques in the fabrication and design of VLSI circuits and systems. Modeling of parasitic components. Floor-planning, clock distribution, routing, and low power design. Cross listed with ENCE 3501. Prerequisite: ENCE 3501 or permission of instructor.

ENCE 4620 Advanced Computer Vision (4 Credits)

This course covers advanced concepts in image processing and computer vision including but not limited to image radiometry and geometric formation, edge detection, geometric based transformations (e.g., image warping and morphing), camera calibration, Epipolar geometry, and stereo feature matching. Other advanced topics include optical flow, shape from shading, and three-dimensional object recognition. In conclusion, students learn and practice advanced topics in image processing and computer vision techniques that can be used in other areas such as robotics, pattern recognition, and sensor networks. Cross listed with ENCE 3620. Prerequisite: ENEE 3311.

ENCE 4631 Advanced Machine Learning (4 Credits)

This class covers advanced topics in machine learning including but not limited to Bayesian decision theory, supervised learning, unsupervised learning and clustering, linear discriminant functions, deep neural networks, deep learning, linear classification techniques, manifold learning, bag of words, and Support Vector Machines. Cross listed with ENCE 3631.

ENCE 4800 Advanced Topics (CPE) (1-5 Credits)

Various topics in computer engineering as announced. May be taken more than once. Cross-listed with ENCE 3321, ENCE 3620.

ENCE 4991 Independent Study (1-10 Credits)

ENCE 4995 Independent Research (1-18 Credits)

ENCE 5995 Independent Research (1-18 Credits)

Engineering, Electrical (ENEE)

ENEE 3011 Physical Electronics (4 Credits)

The basic physical concepts of electronics, electrons and holes in semiconductors, transport and optical processes. Concentration on device concepts, including material synthesis and device processing, P-N junction diodes, junctions with other materials, bipolar transistors, field effect transistors (JFET, MESFET, MOSFET) and optoelectronic effect transistors (JFET, MESFET, MOSFET) and optoelectronic devices (lasers, detectors). Prerequisites: CHEM 1010 or CHEM 1610, PHYS 1213 or PHYS 1214 or permission of instructor.

ENEE 3141 Digital Communications (3 Credits)

Introductory course on modern digital communication systems. The basic communication system theory, probability and random processes, baseband digital data transmission, coherent and non-coherent digital modulation techniques and analysis of bit error probability. Bandwidth efficiency and transmission of digital data through band-limited channels. Prerequisites: ENEE 3111, ENGR 3611 or permission of instructor.

ENEE 3620 Optical Fiber Communications (4 Credits)

A comprehensive treatment of the theory and behavior of basic constituents, such as optical fibers, light sources, photodetectors, connecting and coupling devices, and optical amplifiers. The basic design principles of digital and analog optical fiber transmission links. The operating principles of wavelength-division multiplexing (WDM) and the components needed for its realization. Descriptions of the architectures and performance characteristics of complex optical networks for connecting users with a wide range of transmission needs (SONET/SDH). Discussions of advanced optical communication techniques, such as soliton transmission, optical code-division multiplexing (optical CDMA) and ultra-fast optical time-division multiplexing (OTDM). Laboratory. Cross listed with ENEE 4620. Prerequisite: ENEE 3030 or permission of instructor.

ENEE 3641 Introduction to Electromagnetic Compatibility (4 Credits)

The study of the design of electronic systems so that they operate compatibly with other electronic systems and also comply with various governmental regulations on radiated and conducted emissions. Topics may include Electromagnetic Compatibility (EMC) requirements for electronic systems; non-ideal behavior of components; radiated emissions and susceptibility; conducted emissions and susceptibility; shielding and system design for EMC. Cross listed with ENEE 4640. Prerequisites: ENEE 2611 and ENEE 2223.

ENEE 3670 Introduction to Digital Signal Processing (4 Credits)

Introduction to the theory and applications of Digital Signal Processing. Special attention is paid to the fast Fourier transform and convolution and to the design and implementation of both FIR and IIR digital filters. Prerequisite: ENEE 3111.

ENEE 4030 Optoelectronics (4 Credits)

Optical fibers: structures, waveguiding, and fabrication; attenuation and dispersion; optical sources (LED, LASER, Fiber laser); power launching and coupling; photodetectors (APD, PIN, MSM); and practical optical transmitter and receivers. Cross listed with ENEE 3030.

ENEE 4141 Digital Communications (4 Credits)

Introductory course on modern digital communication systems. The basic communication system theory, probability and random processes, baseband digital data transmission, coherent and non-coherent digital modulation techniques and analysis of bit error probability. Bandwidth efficiency and transmission of digital data through band-limited channels.

ENEE 4620 Adv Optical Fiber Comm (4 Credits)

A comprehensive treatment of the theory and behavior of basic constituents, such as optical fibers, light sources, photodetectors, connecting and coupling devices, and optical amplifiers. The basic design principles of digital and analog optical fiber transmission links. The operating principles of wavelength-division multiplexing (WDM) and the components needed for its realization. Descriptions of the architectures and performance characteristics of complex optical networks for connecting users who have a wide range of transmission needs (SONET/SDH). Discussions of advanced optical communication techniques, such as soliton transmission, optical code-division multiplexing (optical CDMA), and ultra-fast optical time division multiplexing (OTDM). Advanced Project. Cross listed with ENEE 3620. Prerequisite: instructor permission.

ENEE 4640 Electromagnetic Compatibility (4 Credits)

The study of the design of electronic systems so that they operate compatibly with other electronic systems and also comply with various governmental regulations on radiated and conducted emissions. Topics may include: Electromagnetic Compatibility (EMC) requirements for electronic systems; non-ideal behavior of components; radiated emissions and susceptibility; conducted emissions and susceptibility; shielding and system design for EMC. Final Project. Cross listed with ENEE 3641.

ENEE 4800 Advanced Topics (EE) (1-5 Credits)

Various advanced topics in electrical engineering as announced. May be taken more than once. Cross-listed with ENEE 3035.

ENEE 4950 ECE Graduate Assessment (0 Credits)

This class does not meet. All graduate (MS and PhD) ECE students will enroll in this class during their last quarter. All required assessment materials will be uploaded online in Canvas Assignments to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. The purpose is to collect data for the assessment and continuous improvement of the graduate programs.

ENEE 4991 Independent Study (1-10 Credits)

ENEE 4995 Independent Research (1-16 Credits)

ENEE 5995 PhD Independent Research (1-10 Credits)

ENEE 6991 Ph.D Independent Study (1-10 Credits)

ENEE 6995 Independent Research (1-16 Credits)

Engineering, Systems (ENSY)

ENSY 4010 Systems Engineering Fundamentals (3 Credits)

An overview of systems engineering, including V-diagrams, functional architecture, physical architecture, system assembly and integration, verification and validation, and milestones to monitor the progress of the design.

ENSY 4012 Systems Engineering Requirements Development (3 Credits)

The course covers fundamentals of design and requirements analysis of complex systems to meet overall mission requirements. Spanning the requirements engineering phase, topics include: decomposition, derivation, allocation, verification and validation planning. Prerequisite: ENSY 4010, or permission of instructor.

ENSY 4014 Complex System Architectures (3 Credits)

The course focuses on mission requirements and how an overall mission should function by examining different architecture configurations and tools for modeling purposes. Topics include: allocation of functional and non-functional requirements, Service Oriented Architecture (SOA) and architectural modeling using the System Modeling Language (SysML). Prerequisite: ENSY 4010.

ENSY 4016 Conceptual Design of Systems (3 Credits)

Conceptual design is the part of the design process that yields a basic solution path, which leads to the principle solution. The focus of the course is on two important decision making principles: understanding a problem and devising a plan. Topics include: intellectual property and the development of engineering drawings, schematics and 3D models.

ENSY 4021 Design of Space Systems Part 1 (3 Credits)

This course is part one of a two-part series on spacecraft design by integrated systems and subsystems. Topics include: spacecraft overview, subsystem interfaces, concepts of operation (CONOPS) and the systems engineer's role as a generalist as opposed to specialists.

ENSY 4022 Design of Space Systems Part 2 (3 Credits)

This course is part two of a two-part series on spacecraft design by integrated systems and subsystems. Topics correspond to decomposition of the spacecraft into classical spacecraft subsystems. Practical applications and core functionality of these subsystems are presented, including required testing and integration at the subsystem and spacecraft levels. Prerequisite: ENSY 4021.

ENSY 4024 Applied Electrical, Mechanical and Software Systems (3 Credits)

This is a practice-centered course. Assess case studies of design, implementation and testing, validation and verification of complete complex (e.g. spacecraft) systems to meet mission requirements with performance guarantees. Prerequisites: ENSY 4012, ENSY 4014, and ENSY 4016, or permission by the Instructor.

ENSY 4030 Introduction to Aerospace Missions (3 Credits)

This class is for individuals working in aerospace engineering and related fields. Topics include: design of orbital spacecraft, design for Moon missions (such as landers), design for Mars missions (including rovers), design of an unmanned drone for surveillance (high-altitudes), CubeSats (having large constellations), and rockets and missiles (including hypersonic).

ENSY 4040 Systems Optimization (3 Credits)

The development and application of various optimization techniques will be explored with engineering examples. Topics include: analytical and numerical methods, linear and non-linear programming techniques for unconstrained and constrained problems, and advanced optimization techniques, e.g. global optimization. Assignments are in context of Systems Engineering case studies.

ENSY 4042 Optimization for Advanced Systems (3 Credits)

Advanced optimization algorithms are presented, as a pillar of data science and machine learning. Topics include: linear, nonlinear and integer programming models. Students will learn to understand tractability of models, particularly complex models as are central to the discipline of Systems Engineering. Prerequisite: ENSY 4040.

ENSY 4050 Digital Transformation for Advanced Integration (3 Credits)

Digital engineering technologies address the difficulties of managing complex and evolving technologies over their lifecycles of (i) development and (ii) operations & maintenance. This course will focus on digital technologies to integrate data across the enterprise, break organizational silos, and drive culture to realize risk reduction. Topics include: elements of the digital thread, such as digital twins and simulation, as well as machine learning and data analytics to inform decision-making throughout the lifecycle.

ENSY 4060 Practical Model Based Systems Engineering (3 Credits)

MBSE is part of a long-term trend toward model-centric approaches adopted by other engineering disciplines, including mechanical, electrical and software. In this course, students will be given hands-on access to MBSE tools in order to learn the UML/SysML language of MBSE and to practice systems engineering methods using the digital thread that is enabled by MBSE. Students will also gain an understanding of MBSE being a subset of Model Based Design (MBD). Prerequisite: ENSY 4050, or permission of instructor.

ENSY 4090 Project Management in Relation to Systems Engineering (3 Credits)

An overview of the skills and strategies for managing people, risks, schedules, and information to meet goals and objectives in large, complicated engineering projects. Includes managing project constraints, and best practices for working with project managers. Emphasis is on People, Process and the Business Environment.

ENSY 4112 Practical Validation and Verification Test Planning (3 Credits)

In this course, students gain a practical understanding of V-diagrams, and the path that must be traveled to fully validate and verify any system. Topics include: traceability between requirements and validation and verification test plans, including practical development of detailed test procedures at any level of integration. Prerequisite ENSY 4012, or permission by the instructor.

ENSY 4170 Practical Approaches to Continuous Improvement (3 Credits)

In this course, students learn practical differences between Continuous Improvement (CI) methods, such as Kaizen, Lean, Six Sigma, and Total Quality Management (TQM). Current events will be used as case studies to apply practical understanding of these CI methods. Practical application of the methods will leverage principles taught in ENSY 4010. Case studies and assignments are based on illustrations of value added CI engineering in the Systems Engineering discipline. Prerequisites: ENSY 4010 or instructor approval.

ENSY 4180 Applied Mathematics for Systems Engineering (3 Credits)

The course reviews topics in continuous and discrete mathematics (integral and differential calculus, matrices, vector calculus, discrete math: matrices, graphs, sets) and introductory probability, as they apply to engineering, and introduces students to more advanced concepts aiding the understanding and design of complex engineering systems. Examples are drawn from engineering systems applications. Students apply the techniques using engineering computing platform.

ENSY 4181 Introductory Probability and Statistics for Systems Engineering (3 Credits)

This course introduces fundamentals of probability for Systems Engineers. Students survey data visualization methods and summary statistics, develop models for data, and apply statistical techniques to assess the validity of the models. Techniques include parametric and nonparametric methods for parameter estimation and hypothesis testing for a single sample mean and two sample means, for proportions, and for simple linear regression. Students will apply methods to real-world engineering data, primarily using R.

ENSY 4182 Data Analytics for Systems Engineering (3 Credits)

This course is designed for students to develop skills in data analytics specifically tailored for systems engineering applications. It combines theoretical understanding with practical applications, covering various models for data inference, statistical methodologies, and the use of data analytics tools and software.

ENSY 4200 Applied Machine Learning for Advanced Systems Modeling (3 Credits)

This course covers topics in Machine Learning including Bayesian decision theory, supervised learning, unsupervised learning and clustering, linear discriminant functions, linear classification techniques such as Support Vector Machines, as well as Artificial Neural Networks and Deep Learning methods.

ENSY 4950 Graduate Assessment for Master of Science degree in Systems Engineering (0 Credits)

This class does not meet. All MS in Systems Engineering (MSSY) graduate students will enroll in this class during their last quarter. The purpose is to collect data for the assessment and continuous improvement of the graduate programs. All required assessment materials will be uploaded online in Canvas Assignments to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded.

Engineering, Computer Courses

ENCE 3231 Embedded Systems Programming (4 Credits)

Design, construction and testing of microprocessor systems. Hardware limitations of the single-chip system. Includes micro-controllers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, design methods and testing of embedded systems. Prerequisite: ENCE 3210.

ENCE 3321 Network Design (4 Credits)

Introduction to network components. Layering of network architecture. Analysis of Local Area Network (LAN) concepts and architecture based on IEEE standards. Design principles including switching and multiplexing techniques, physical link, signal propagation, synchronization, framing and error control. Application of probability and statistics in error detecting and control. Ethernet, Token-ring, FDDI (Fiber Distributed Data Interface), ATM (Asynchronous Transfer Mode), ISDN (Integrated Service Data Networks). Prerequisite: ENEE 3111, ENCE 2101 or permission of instructor.

ENCE 3501 VLSI Design (3 Credits)

Design of Very Large Scale Integration systems. Examination of layout and simulation of digital VLSI circuits using a comprehensive set of CAD tools in a laboratory setting. Studies of layouts of CMOS combinational and sequential circuits using automatic layout generators. Fundamental structures of the layout of registers, adders, decoders, ROM, PLA's, counters, RAM and ALU. Application of statistics and probability to chip performance. CAD tools allow logic verification and timing simulation of the circuits designed. Cross listed with ENCE 4501. Prerequisite: ENCE 3231.

ENCE 3620 Computer Vision (4 Credits)

This course is an introduction to the basic concepts in image processing and computer vision. First, an introduction to low-level image analysis methods, including radiometry and geometric image formation, edge detection, feature detection, and image segmentation are presented. Then, geometric-based image transformations (e.g., image warping and morphing) for image synthesis will be presented in the course. Furthermore, methods for reconstructing three-dimensional scenes including camera calibration, Epipolar geometry, and stereo feature matching are introduced. Other important topics include optical flow, shape from shading, and three-dimensional object recognition. In conclusion, students learn and practice image processing and computer vision techniques that can be used in other areas such as robotics, pattern recognition, and sensor networks. Cross listed with ENCE 4620. Prerequisites: ENGR 3611 or ENGR 3621 AND ENGR 1572 or ENGR 3650 or ENCE 3260 or permission of instructor.

ENCE 3631 Machine Learning (4 Credits)

This class covers topics in machine learning including but not limited to Bayesian decision theory, supervised learning, unsupervised learning and clustering, linear discriminant functions, deep learning, neural networks, linear classification techniques, manifold learning, bag of words, and Support Vector Machines. Cross listed with ENCE-4631.

ENCE 4110 Modern Digital Systems Design (4 Credits)

This course focuses on the design of digital systems using combinational, sequential, and programmable logic devices and Hardware Description Languages (HDL). Techniques for logic design including asynchronous logic, physical world interfaces to digital systems, and system performance analysis methods are studied. Students also learn HDL-Verilog to program CPLD devices and FPGA systems. Cross listed with ENCE 3100.

ENCE 4231 Embedded Systems Programming (4 Credits)

Design, construction and testing of microprocessor systems. Hardware limitations of the single-chip system. Includes micro-controllers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, design methods and testing of embedded systems.

ENCE 4501 Advanced VLSI Design (4 Credits)

Advanced techniques in the fabrication and design of VLSI circuits and systems. Modeling of parasitic components. Floor-planning, clock distribution, routing, and low power design. Cross listed with ENCE 3501. Prerequisite: ENCE 3501 or permission of instructor.

ENCE 4620 Advanced Computer Vision (4 Credits)

This course covers advanced concepts in image processing and computer vision including but not limited to image radiometry and geometric formation, edge detection, geometric based transformations (e.g., image warping and morphing), camera calibration, Epipolar geometry, and stereo feature matching. Other advanced topics include optical flow, shape from shading, and three-dimensional object recognition. In conclusion, students learn and practice advanced topics in image processing and computer vision techniques that can be used in other areas such as robotics, pattern recognition, and sensor networks. Cross listed with ENCE 3620. Prerequisite: ENEE 3311.

ENCE 4631 Advanced Machine Learning (4 Credits)

This class covers advanced topics in machine learning including but not limited to Bayesian decision theory, supervised learning, unsupervised learning and clustering, linear discriminant functions, deep neural networks, deep learning, linear classification techniques, manifold learning, bag of words, and Support Vector Machines. Cross listed with ENCE 3631.

ENCE 4800 Advanced Topics (CPE) (1-5 Credits)

Various topics in computer engineering as announced. May be taken more than once. Cross-listed with ENCE 3321, ENCE 3620.

ENCE 4991 Independent Study (1-10 Credits)

ENCE 4995 Independent Research (1-18 Credits)

ENCE 5995 Independent Research (1-18 Credits)

Engineering, Electrical Courses

ENEE 3011 Physical Electronics (4 Credits)

The basic physical concepts of electronics, electrons and holes in semiconductors, transport and optical processes. Concentration on device concepts, including material synthesis and device processing, P-N junction diodes, junctions with other materials, bipolar transistors, field effect transistors (JFET, MESFET, MOSFET) and optoelectronic effect transistors (JFET, MESFET, MOSFET) and optoelectronic devices (lasers, detectors). Prerequisites: CHEM 1010 or CHEM 1610, PHYS 1213 or PHYS 1214 or permission of instructor.

ENEE 3141 Digital Communications (3 Credits)

Introductory course on modern digital communication systems. The basic communication system theory, probability and random processes, baseband digital data transmission, coherent and non-coherent digital modulation techniques and analysis of bit error probability. Bandwidth efficiency and transmission of digital data through band-limited channels. Prerequisites: ENEE 3111, ENGR 3611 or permission of instructor.

ENEE 3620 Optical Fiber Communications (4 Credits)

A comprehensive treatment of the theory and behavior of basic constituents, such as optical fibers, light sources, photodetectors, connecting and coupling devices, and optical amplifiers. The basic design principles of digital and analog optical fiber transmission links. The operating principles of wavelength-division multiplexing (WDM) and the components needed for its realization. Descriptions of the architectures and performance characteristics of complex optical networks for connecting users with a wide range of transmission needs (SONET/SDH). Discussions of advanced optical communication techniques, such as soliton transmission, optical code-division multiplexing (optical CDMA) and ultra-fast optical time-division multiplexing (OTDM). Laboratory. Cross listed with ENEE 4620. Prerequisite: ENEE 3030 or permission of instructor.

ENEE 3641 Introduction to Electromagnetic Compatibility (4 Credits)

The study of the design of electronic systems so that they operate compatibly with other electronic systems and also comply with various governmental regulations on radiated and conducted emissions. Topics may include Electromagnetic Compatibility (EMC) requirements for electronic systems; non-ideal behavior of components; radiated emissions and susceptibility; conducted emissions and susceptibility; shielding and system design for EMC. Cross listed with ENEE 4640. Prerequisites: ENEE 2611 and ENEE 2223.

ENEE 3670 Introduction to Digital Signal Processing (4 Credits)

Introduction to the theory and applications of Digital Signal Processing. Special attention is paid to the fast Fourier transform and convolution and to the design and implementation of both FIR and IIR digital filters. Prerequisite: ENEE 3111.

ENEE 4030 Optoelectronics (4 Credits)

Optical fibers: structures, waveguiding, and fabrication; attenuation and dispersion; optical sources (LED, LASER, Fiber laser); power launching and coupling; photodetectors (APD, PIN, MSM); and practical optical transmitter and receivers. Cross listed with ENEE 3030.

ENEE 4141 Digital Communications (4 Credits)

Introductory course on modern digital communication systems. The basic communication system theory, probability and random processes, baseband digital data transmission, coherent and non-coherent digital modulation techniques and analysis of bit error probability. Bandwidth efficiency and transmission of digital data through band-limited channels.

ENEE 4620 Adv Optical Fiber Comm (4 Credits)

A comprehensive treatment of the theory and behavior of basic constituents, such as optical fibers, light sources, photodetectors, connecting and coupling devices, and optical amplifiers. The basic design principles of digital and analog optical fiber transmission links. The operating principles of wavelength-division multiplexing (WDM) and the components needed for its realization. Descriptions of the architectures and performance characteristics of complex optical networks for connecting users who have a wide range of transmission needs (SONET/SDH). Discussions of advanced optical communication techniques, such as soliton transmission, optical code-division multiplexing (optical CDMA), and ultra-fast optical time division multiplexing (OTDM). Advanced Project. Cross listed with ENEE 3620. Prerequisite: instructor permission.

ENEE 4640 Electromagnetic Compatibility (4 Credits)

The study of the design of electronic systems so that they operate compatibly with other electronic systems and also comply with various governmental regulations on radiated and conducted emissions. Topics may include: Electromagnetic Compatibility (EMC) requirements for electronic systems; non-ideal behavior of components; radiated emissions and susceptibility; conducted emissions and susceptibility; shielding and system design for EMC. Final Project. Cross listed with ENEE 3641.

ENEE 4800 Advanced Topics (EE) (1-5 Credits)

Various advanced topics in electrical engineering as announced. May be taken more than once. Cross-listed with ENEE 3035.

ENEE 4950 ECE Graduate Assessment (0 Credits)

This class does not meet. All graduate (MS and PhD) ECE students will enroll in this class during their last quarter. All required assessment materials will be uploaded online in Canvas Assignments to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded. The purpose is to collect data for the assessment and continuous improvement of the graduate programs.

ENEE 4991 Independent Study (1-10 Credits)

ENEE 4995 Independent Research (1-16 Credits)

ENEE 5995 PhD Independent Research (1-10 Credits)

ENEE 6991 Ph.D Independent Study (1-10 Credits)

ENEE 6995 Independent Research (1-16 Credits)

Engineering, Systems Courses

ENSY 4010 Systems Engineering Fundamentals (3 Credits)

An overview of systems engineering, including V-diagrams, functional architecture, physical architecture, system assembly and integration, verification and validation, and milestones to monitor the progress of the design.

ENSY 4012 Systems Engineering Requirements Development (3 Credits)

The course covers fundamentals of design and requirements analysis of complex systems to meet overall mission requirements. Spanning the requirements engineering phase, topics include: decomposition, derivation, allocation, verification and validation planning. Prerequisite: ENSY 4010, or permission of instructor.

ENSY 4014 Complex System Architectures (3 Credits)

The course focuses on mission requirements and how an overall mission should function by examining different architecture configurations and tools for modeling purposes. Topics include: allocation of functional and non-functional requirements, Service Oriented Architecture (SOA) and architectural modeling using the System Modeling Language (SysML). Prerequisite: ENSY 4010.

ENSY 4016 Conceptual Design of Systems (3 Credits)

Conceptual design is the part of the design process that yields a basic solution path, which leads to the principle solution. The focus of the course is on two important decision making principles: understanding a problem and devising a plan. Topics include: intellectual property and the development of engineering drawings, schematics and 3D models.

ENSY 4021 Design of Space Systems Part 1 (3 Credits)

This course is part one of a two-part series on spacecraft design by integrated systems and subsystems. Topics include: spacecraft overview, subsystem interfaces, concepts of operation (CONOPS) and the systems engineer's role as a generalist as opposed to specialists.

ENSY 4022 Design of Space Systems Part 2 (3 Credits)

This course is part two of a two-part series on spacecraft design by integrated systems and subsystems. Topics correspond to decomposition of the spacecraft into classical spacecraft subsystems. Practical applications and core functionality of these subsystems are presented, including required testing and integration at the subsystem and spacecraft levels. Prerequisite: ENSY 4021.

ENSY 4024 Applied Electrical, Mechanical and Software Systems (3 Credits)

This is a practice-centered course. Assess case studies of design, implementation and testing, validation and verification of complete complex (e.g. spacecraft) systems to meet mission requirements with performance guarantees. Prerequisites: ENSY 4012, ENSY 4014, and ENSY 4016, or permission by the Instructor.

ENSY 4030 Introduction to Aerospace Missions (3 Credits)

This class is for individuals working in aerospace engineering and related fields. Topics include: design of orbital spacecraft, design for Moon missions (such as landers), design for Mars missions (including rovers), design of an unmanned drone for surveillance (high-altitudes), CubeSats (having large constellations), and rockets and missiles (including hypersonic).

ENSY 4040 Systems Optimization (3 Credits)

The development and application of various optimization techniques will be explored with engineering examples. Topics include: analytical and numerical methods, linear and non-linear programming techniques for unconstrained and constrained problems, and advanced optimization techniques, e.g. global optimization. Assignments are in context of Systems Engineering case studies.

ENSY 4042 Optimization for Advanced Systems (3 Credits)

Advanced optimization algorithms are presented, as a pillar of data science and machine learning. Topics include: linear, nonlinear and integer programming models. Students will learn to understand tractability of models, particularly complex models as are central to the discipline of Systems Engineering. Prerequisite: ENSY 4040.

ENSY 4050 Digital Transformation for Advanced Integration (3 Credits)

Digital engineering technologies address the difficulties of managing complex and evolving technologies over their lifecycles of (i) development and (ii) operations & maintenance. This course will focus on digital technologies to integrate data across the enterprise, break organizational silos, and drive culture to realize risk reduction. Topics include: elements of the digital thread, such as digital twins and simulation, as well as machine learning and data analytics to inform decision-making throughout the lifecycle.

ENSY 4060 Practical Model Based Systems Engineering (3 Credits)

MBSE is part of a long-term trend toward model-centric approaches adopted by other engineering disciplines, including mechanical, electrical and software. In this course, students will be given hands-on access to MBSE tools in order to learn the UML/SysML language of MBSE and to practice systems engineering methods using the digital thread that is enabled by MBSE. Students will also gain an understanding of MBSE being a subset of Model Based Design (MBD). Prerequisite: ENSY 4050, or permission of instructor.

ENSY 4090 Project Management in Relation to Systems Engineering (3 Credits)

An overview of the skills and strategies for managing people, risks, schedules, and information to meet goals and objectives in large, complicated engineering projects. Includes managing project constraints, and best practices for working with project managers. Emphasis is on People, Process and the Business Environment.

ENSY 4112 Practical Validation and Verification Test Planning (3 Credits)

In this course, students gain a practical understanding of V-diagrams, and the path that must be traveled to fully validate and verify any system. Topics include: traceability between requirements and validation and verification test plans, including practical development of detailed test procedures at any level of integration. Prerequisite ENSY 4012, or permission by the instructor.

ENSY 4170 Practical Approaches to Continuous Improvement (3 Credits)

In this course, students learn practical differences between Continuous Improvement (CI) methods, such as Kaizen, Lean, Six Sigma, and Total Quality Management (TQM). Current events will be used as case studies to apply practical understanding of these CI methods. Practical application of the methods will leverage principles taught in ENSY 4010. Case studies and assignments are based on illustrations of value added CI engineering in the Systems Engineering discipline. Prerequisites: ENSY 4010 or instructor approval.

ENSY 4180 Applied Mathematics for Systems Engineering (3 Credits)

The course reviews topics in continuous and discrete mathematics (integral and differential calculus, matrices, vector calculus, discrete math: matrices, graphs, sets) and introductory probability, as they apply to engineering, and introduces students to more advanced concepts aiding the understanding and design of complex engineering systems. Examples are drawn from engineering systems applications. Students apply the techniques using engineering computing platform.

ENSY 4181 Introductory Probability and Statistics for Systems Engineering (3 Credits)

This course introduces fundamentals of probability for Systems Engineers. Students survey data visualization methods and summary statistics, develop models for data, and apply statistical techniques to assess the validity of the models. Techniques include parametric and nonparametric methods for parameter estimation and hypothesis testing for a single sample mean and two sample means, for proportions, and for simple linear regression. Students will apply methods to real-world engineering data, primarily using R.

ENSY 4182 Data Analytics for Systems Engineering (3 Credits)

This course is designed for students to develop skills in data analytics specifically tailored for systems engineering applications. It combines theoretical understanding with practical applications, covering various models for data inference, statistical methodologies, and the use of data analytics tools and software.

ENSY 4200 Applied Machine Learning for Advanced Systems Modeling (3 Credits)

This course covers topics in Machine Learning including Bayesian decision theory, supervised learning, unsupervised learning and clustering, linear discriminant functions, linear classification techniques such as Support Vector Machines, as well as Artificial Neural Networks and Deep Learning methods.

ENSY 4950 Graduate Assessment for Master of Science degree in Systems Engineering (0 Credits)

This class does not meet. All MS in Systems Engineering (MSSY) graduate students will enroll in this class during their last quarter. The purpose is to collect data for the assessment and continuous improvement of the graduate programs. All required assessment materials will be uploaded online in Canvas Assignments to meet the course requirements. Students will receive Canvas course announcements and or emails from the instructor notifying the students of what are required to be uploaded.