Master's and Doctoral Degrees

Why study engineering at the University of Denver?

The University of Denver’s department of mechanical and materials engineering (MME) is creating the future of technology by providing a graduate education emphasizing cross-disciplinary knowledge. A distinguished faculty is creating multidisciplinary education and research programs that anticipate technological trends in research and industry. Engineering graduate students join the faculty in conducting cutting-edge research in emerging disciplines to develop unique solutions to old and new problems and opportunities.

The well-equipped laboratories in the department contain state-of-the-art equipment and software to support research in biomedical engineering, advanced materials, atmospheric aerosol science, and mechanical design among others. Small classes support our multidisciplinary and real-time focus by providing close contact between students and faculty, which allows us to meet students’ individual career goals.

Recognizing the different aims and goals of students, we offer joint degree programs in management and engineering for students who wish to add to their technical skills and acquire business skills. The general engineering graduate student can choose courses from mechanical engineering, electrical engineering, computer engineering, computer science, nanoscale science and engineering, materials science, and bioengineering.

Denver is a first-rate location for business, governmental 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 the University of Denver is located just minutes from the Denver Technological Center, site of many top technology companies. The department of mechanical and materials 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.

Time Commitment

Our 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. Many employers will permit additional flexibility by releasing employees early to attend classes.

The master's program offer thesis and non-thesis options and can be completed in one (non-thesis track only) to four years depending on the number of courses taken per quarter. The choice of thesis or non-thesis can be made at any time, although a delay in declaration may impact the completion date.

The doctoral program is generally completed in three to seven years, depending on the number of courses taken per quarter and whether the student enters with a BS or MS.

A student 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. If at a later time the student chooses to enter a graduate degree program at DU, you may apply up to 15 special status credits to your degree, with departmental approval. Just follow the regular graduate application requirements, including submitting the application fee, to get started.

master of science in engineering, master of science in engineering with a concentration in management

Following are the simple steps to apply for the master’s programs in Engineering at the University of Denver. If you have any questions about the process, please contact the Office of Graduate Studies.

Apply Online / Application Deadlines

• Application for graduate study at the University of Denver must be submitted online.
• All online materials must be received, and all supplemental materials including transcripts must be on file in the Office of Graduate Studies by the program's stated deadline: February 1, for the fall quarter.
• Students interested in competing for graduate teaching assistantships (GTAs) are encouraged to submit their applications by this deadline to ensure full consideration for an appointment in September of a given year. GTAs are offered to students who have been admitted to the PhD program and rarely to master's students who have chosen the thesis option.
• Applications received after the priority deadline will be accepted, processed and reviewed on a rolling basis for the fall, winter or spring quarters. International applicants are encouraged to have the admission application and all supporting documents in the Office of Graduate Studies by the deadline or no later than May 1, for fall admission.
• A $65 non-refundable application fee is required for an application to be processed. Application fee waivers are available for McNair Scholars.

Course and Degree Prerequisites and Requirements

• Applicants must earn and submit proof of earning the equivalent of a baccalaureate degree from a regionally accredited institution prior to beginning graduate coursework at DU.

• A Bachelor of Science degree in Mechanical Engineering (BS ENME) or closely related field is required for admission to the MS ENME program. Those students whose backgrounds differ significantly from EAC/ABET-accredited BS computer/electrical/mechanical engineering programs may be required to complete prerequisite undergraduate courses.

• A bachelor’s degree in materials science or closely related field (physics, metallurgy, engineering, or chemistry) is usually required for admission to the Materials Science program. If the student did not receive adequate preparation for studying materials, they may need to take several prerequisite courses in materials science.

• The interdisciplinary nature of Nanoscale Science and Engineering mandates certain flexibility in order to accommodate students with a variety of backgrounds. The program accepts students with a Bachelor of Science, Bachelor of Arts, Master of Science, or Master of Arts in biological sciences, chemistry, biochemistry, computer science, engineering, physics or related discipline. As a minimum, to be admitted into the program, students are expected to have earned as a part of their undergraduate degree: 1 year of calculus, 1 year of algebra- or calculus-based physics with accompanying laboratory, 1 quarter of general chemistry with accompanying laboratory. Furthermore, the program accepts students with a Master of Science or Master of Arts degrees in biological sciences, biophysics, chemistry, biochemistry, computer science, engineering, physics or related discipline.

Transcripts

• Applicants are required to submit an official transcript from each post-secondary institution they have attended, or are presently attending, where two quarter hours (or one semester hour) or more were completed including study abroad and college coursework completed in high school.

• The applicant is responsible for obtaining all transcripts. Applicants who have earned a degree outside the U.S. must submit transcripts accompanied by certified English translations, if not normally issued in English. DU students and alumni do not need to provide DU transcripts.

• Official study abroad transcripts are required unless the course titles, grades and credit earned abroad appear on another transcript. Transcripts from outside of the U.S. are evaluated by the Office of International Student Admission. This process can take three to four weeks and must be complete by the program’s stated deadline. Therefore, applicants with a degree from outside of the U.S. are encouraged to apply early. Applicants educated outside the U.S. are encouraged to contact the Office of Graduate Studies for assistance regarding transcript-related materials.

• The University of Denver will consider electronic transcripts official from a domestic institution provided by the following approved agencies: Army/American Council on Education Registry Transcript System (AARTS); Docufide/Parchment; National Student Clearinghouse; Naviance; Royall and Company; and, Scrip-Safe.

• Mail official transcripts to

  University of Denver
  Office of Graduate Studies
  Mary Reed Building, Room 5
  2199 S. University Blvd.
  Denver, CO 80208-4802

• Electronic transcripts should be sent to gradinfo@du.edu.

Language Proficiency

• Official scores from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS) are required of all graduate applicants, regardless of citizenship status, whose native language is not English or who have been educated in countries where English is not the native language. Applications will not be processed until the required TOEFL or IELTS score is received. The TOEFL and IELTS scores are valid for two years from the test date. The minimum TOEFL score accepted by the University is 80 (iBT) or 550 (paper-based). The institution code for the University of Denver is 4842. The minimum IELTS score accepted by the University is 6.0. Graduate Teaching Assistants (GTAs) must demonstrate fluency in spoken English by scoring a 26 on the TOEFL speaking section or 8.0 on the IELTS speaking section. Please see the Graduate Policy Manual for complete English language proficiency requirements.

• Applicants may be exempted from English proficiency test requirements if by the time of matriculation they have earned a post-secondary degree from a formally-recognized/accredited university where the language of instruction and examination is English. Such applicants may be exempt from the TOEFL/IELTS requirement but not from other standardized graduate entrance examinations. There are no exemptions for graduate teaching assistants.

• Students whose native language is not English and who are required to submit TOEFL/IELTS (http://bulletin.du.edu/graduate/admissions/additionalstandardsfornonnativeenglishspeakers) scores will be assessed by the University of Denver English Language Center (ELC) prior to matriculation.

• In cases where minimum TOEFL/IELTS scores were not achieved or no English proficiency test was taken, the Anthropology program may offer English Conditional Admission (ECA) to academically qualified non-native English speakers. Such applicants must take training through DU’s English Language Center to meet the English language requirement. English language training at centers outside of DU will not be counted.
toward meeting English language proficiency requirements. International applicants with a three-year baccalaureate degree or any other academic deficiencies cannot be granted English Conditional Admission.

Test Scores
- The Graduate Record Examination (GRE) is required. Scores must be received directly from the appropriate testing agency by the program’s stated deadline. The institution code for the University of Denver is 4842.
- GRE score requirements are a minimum score of 140 verbal AND 154 quantitative

Personal Statement
- A personal statement of at least 300 words is required. The statement should be submitted via upload through the online application process.

Resume / C.V.
- A resume or C.V. is required. This should include work experience, research, and/or volunteer work. The resume or C.V. should be submitted via upload through the online application process.

Recommendation Letters
- Two letters of recommendation are required. Letters should be solicited and uploaded by recommenders through the online application system. Requests for letters should be sent to recommenders well in advance so the letters are on file by the application deadline.

Financial Support
- To be considered for financial support, domestic applicants should apply early and submit the Free Application for Federal Student Aid (FAFSA) by the priority deadline, February 15. Information about financial aid can be found on the Office of Financial Aid website. International students are not eligible for federal financial aid.
- The Department of Mechanical and Materials Engineering also offers a number of competitive graduate teaching assistantships (GTA) that provide full tuition remission along with a stipend for the nine-month academic year (three academic quarters). Priority for these GTAs is given to PhD and masters-thesis students whose undergraduate degrees are in engineering.
- Graduate research assistantships (GRAs), either with or without tuition remission, are awarded by individual faculty based on available funding.

Application Status
- We encourage you to be actively engaged in the admission process. You can check your application status online at PioneerWeb. Applicants will receive login information post application submission.

Contact Information
- Mail official transcripts and any supplemental admission materials not submitted with the online application to:
  University of Denver
  Office of Graduate Studies
  Mary Reed Building, Room 5
  2199 S. University Blvd.
  Denver, CO 80208-4802

- Electronic transcripts should be sent to gradinfo@du.edu

- For more information call (303) 871-2706.

International Applicants
- For complete international applicant information, please visit the Office of Graduate Studies International Student Application Information. International applicants are strongly encouraged to have their applications complete, with all materials on file in the admission office, at least eight weeks prior to the program’s application deadline.

The Graduate Policies and Procedures provides complete details regarding admission requirements.

Degree Programs
The following are our general engineering degrees. Please see the Mechanical and Materials Engineering Programs for our other graduate engineering degrees.

- Master of Science in Engineering (MS ENGE)
- Master of Science in Engineering with a Concentration in Management (MS ENGE (CM))
- Doctor of Philosophy in Engineering (PhD ENME)
Doctor of Philosophy in Engineering

The objective of the Doctor of Philosophy in Engineering (PhD ENGE) 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. Individualized plans of study are based on students’ previous experience and desired research areas. The plan of study allows students to work on interdisciplinary research, while also satisfying the PhD in engineering degree requirements.

The MME department offers an interdisciplinary Engineering PhD degree. The interdisciplinary PhD program offers opportunities for a student to develop a plan of study combining engineering and a complementary discipline (e.g. natural sciences). In the plan of study, coursework in the complementary discipline can be included up to the maximum number of technical elective credits. The student’s plan of study must be approved by the PhD committee and the department chair. When the student is completing research and coursework in a complementary discipline, the student’s PhD committee must include a faculty member from the related department or division/school.

For a part-time student who is working in industry position, a topic related to the job function may be acceptable as the dissertation research topic. Furthermore, a student may request for a qualified staff member at the place of employment to serve as a special committee member on the dissertation committee.

Exam Structure:

1. Each student must pass the qualifying exam to obtain official entrance into the PhD program. In consultation with the advisor, students should expect to take the qualifying exam about 1.5 years (30 credits) into their academic study. Students must take exams in three subject areas. The Design exam is required for all participants, and is an open-book exam, where the student will have one week to prepare a written and oral response to an open-ended design problem. The other two exams are closed-book, written exams and should be related to the student’s research area. The exam is offered twice a year: once in the summer interterm (usually in June) and once in the winter interterm (usually in December or early January). The qualifying exam can be retaken only once, and must be completed prior to the comprehensive exam.

2. Generally within three years after completion of the qualifying exam, the student should schedule and take the comprehensive exam attended by the student's PhD committee. The student will be expected to make concise presentation on his/her dissertation topic. The presentation will highlight previous work in this area, demonstrate a need for the research, and explain how the 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. The comprehensive exam can be retaken only once.

3. After successful completion of the qualifying exam and the comprehensive exam, 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, and must be defended by the student in the final oral examination. The examining committee members will consist of the student's entire PhD committee. The dissertation defense can be retaken only once.

PhD Residence Requirement

One year of full-time graduate work and two consecutive years of part-time graduate work satisfy the minimum residency requirement at the University of Denver. For those applicants from industry with established special degree programs with RSECS, the residency requirement can be waived by the dean of RSECS.

PhD Students with a Bachelor of Science Degree

Program Structure

1. For students entering with a bachelor’s degree, 90 credits are required, at least 72 of which must be completed at the University of Denver.

2. A minimum of 48 credits must be at the 4000- or 5000-level and may include as many dissertation research credits as considered appropriate by the advisor.

3. No courses at the 1000- or 2000-level are acceptable.

4. An overall GPA of 3.0 is required for the degree.

5. Any individual grade lower than C- renders the credit unacceptable.

6. Students who have completed the required 90 credits and are still working on the dissertation are eligible for Continuous Enrollment to maintain active student status at the University. Students working on internships are not eligible for Continuous Enrollment.

7. Students must complete all requirements for the doctoral degree no later than eight years after doctoral studies begin.

8. International students must enroll in at least eight credits each quarter to maintain full-time status, except during the annual vacation term (usually the summer quarter) or the final quarter of study that requires fewer credits than the minimum full-time enrollment to complete your program. Failure to maintain full-time enrollment is a violation of student status and may result in the termination from the program. Based on the recommendation of the academic advisor, an international student advisor may authorize the student to drop below full-time status for academic reasons specifically permitted under immigration regulations. However, academic authorizations may only be given once per degree level and are usually issued during the first term of study.

Course Requirements:
1. Candidates who hold only a bachelor’s degree on entering the doctoral program are expected to meet all degree requirements of the corresponding master’s degree program (as part of the doctoral requirements).

2. Students are required to take ENME 4950 Graduate Assessment in the last quarter of study. **NOTE:** Students are required to complete a written self-reflection on their thesis and upload the report to Assess-It along with thesis, defense presentation slides, and the completed and signed degree program plan before graduation.

3. PhD students who enter the program with a bachelor’s are required to take ENME 4900 Graduate Professional Development in the first year (this is offered once a year; usually in winter quarter).

### Required Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ENME 4900</td>
<td>Grad Professional Development (Graduate Professional Development)</td>
<td>1</td>
</tr>
<tr>
<td>ENME 4950</td>
<td>Graduate Assessment (Graduate Assessment)</td>
<td>0</td>
</tr>
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</table>

### Mechanical Engineering Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 3630</td>
<td>Finite Element Methods</td>
<td>4</td>
</tr>
<tr>
<td>ENME 3545</td>
<td>Mechanisms</td>
<td>4</td>
</tr>
<tr>
<td>ENME 3651</td>
<td>Computational Fluid Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4020</td>
<td>Adv Finite Element Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4520</td>
<td>Intermediate Dynamics (Intermediate Dynamics)</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4541</td>
<td>Advanced Mechanics of Materials (Advanced Mechanics of Materials)</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4630</td>
<td>Viscous Flow (Viscous Flow)</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4670</td>
<td>Advanced Computational Fluid Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4800</td>
<td>Advanced Topics (ME) (Convective Heat Transfer)</td>
<td>4</td>
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### Bioengineering Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ENBI 4500</td>
<td>Biofluids</td>
<td>4</td>
</tr>
<tr>
<td>ENBI 4510</td>
<td>Biomechanics</td>
<td>4</td>
</tr>
<tr>
<td>ENBI 4520</td>
<td>Introduction to Cardiovascular Engineering (Intro to Cardiovascular Engineering)</td>
<td>4</td>
</tr>
<tr>
<td>ENBI 4800</td>
<td>Adv Topics (Bioengineering) (Computational Biomechanics)</td>
<td>4</td>
</tr>
</tbody>
</table>

### Materials Science Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 4200</td>
<td>Introduction to Nanotechnology</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4400</td>
<td>Fatigue</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4010</td>
<td>Mechanical Behavior of Materials</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4020</td>
<td>Composite Materials I</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4215</td>
<td>Composite Materials II</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4450</td>
<td>Fracture Mechanics</td>
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### Electrical & Computer Engineering Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ENCE 4110</td>
<td>Modern Digital Systems Design</td>
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</tr>
<tr>
<td>ENEE 4640</td>
<td>Electromagnetic Compatibility</td>
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</tr>
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</table>

### Advanced Math Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 3620</td>
<td>Advanced Engineering Mathematics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4300</td>
<td>Advanced Numerical Methods (Advanced Numerical Methods)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4350</td>
<td>Reliability</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4620</td>
<td>Optimization</td>
<td>4</td>
</tr>
</tbody>
</table>

**PhD Students with a Master of Science**

1. A minimum of 36 credits must be completed at the 4000- or 5000-level, which may include as many research credits as considered appropriate by the advisor.

2. For students entering with a master’s degree, up to 45 credits may be transferred and applied to the doctorate degree. In addition, a minimum of 45 credits must be completed at DU. The total number of credits required for the degree is 90.

3. No courses at the 1000- or 2000-level are acceptable.

4. An overall GPA of 3.0 is required for the degree.

5. Any individual grade lower than C- renders the credit unacceptable.

6. A student who holds a master’s degree on entering the doctoral program is expected to complete all requirements for the degree no later than seven years after beginning the program.
7. **International students** must enroll in at least eight credits each quarter to maintain full-time status, except during the annual vacation term (usually the summer quarter) or the final quarter of study that requires fewer credits than the minimum full-time enrollment to complete the program. Failure to maintain full-time enrollment is a violation of student status and may result in the termination from the program. Based on the recommendation of the academic advisor, an international student advisor may authorize the student to drop below full-time status for academic reasons specifically permitted under immigration regulations. However, academic authorizations may only be given once per degree level and are usually issued during the first term of study.

Course Requirements:

1. Students are required to take ENME 4950 **Graduate Assessment** in the last quarter of study. **NOTE:** Students are required to complete a written self-reflection on their thesis and upload the report to Assessment along with thesis, defense presentation slides, and the completed and signed degree program plan before graduation.

2. If a PhD student fails his/her qualifying exam on the first try, he/she will be required to take ENME 4900 **Graduate Professional Development** as well. ENME 4900 will be offered once a year, usually in winter quarter.

**Master of Science in Engineering**

The Master of Science in Engineering (MS ENGE) is designed to advance the knowledge of students in areas differing from those in which they received their bachelor’s degree. The program is particularly intended for students with bachelor’s degrees in the natural sciences, mathematics, computer science or engineering who are making a change of discipline or wanting to develop expertise in an engineering area, often one that is of emerging importance or interdisciplinary in nature. The program combines a solid background in an area of engineering with a distinctly personal specialization. It enables the student to focus on a particular area of engineering, while providing breadth through its technical elective requirement addressing the student’s specific interests.

A master’s in engineering with a concentration in management (CM) is also offered (see below). These engineering and management courses are focused on developing core knowledge and competencies in innovation and entrepreneurship, and providing concrete tools to successfully translate ideas and initiative into marketplace success.

**Program Structure (non-management)**

1. Every candidate for this degree must complete 45 credits, at least 36 of which must be completed at the University of Denver.

2. A minimum of six 4000-level courses of at least three credits each are required for non-thesis track; four 4000-level courses of at least three credits each are required for thesis track.

3. No courses at the 1000- or 2000-level are acceptable.

4. An overall GPA of 3.0 is required for the degree.

5. Any individual grade lower than C- renders the credit unacceptable.

6. Students who have completed the required 45 credits and are still working on a thesis or project are eligible for Continuous Enrollment to maintain active student status at the University. Students working on internships are not eligible for Continuous Enrollment.

7. Master’s degree candidates are expected to complete degree requirements no later than five years after beginning their programs. These programs are designed to be completed in about six quarters if two courses (eight credits) are taken each quarter.

8. **International students** must enroll in at least eight credits each quarter to maintain full-time status, except during the annual vacation term (usually the summer quarter) or the final quarter of study that requires fewer credits than the minimum full-time enrollment to complete the program. Failure to maintain full-time enrollment is a violation of student status and may result in the termination from the program. Based on the recommendation of the academic advisor, an international student advisor may authorize the student to drop below full-time status for academic reasons specifically permitted under immigration regulations. However, academic authorizations may only be given once per degree level and are usually issued during the first term of study.

**Course Requirements**

1. **Core Courses:** a minimum of nine credits (two courses from ME, MTSC, ENBI or ECE Core Course List; no more than one course from a single discipline) plus the required courses.

2. **Required Courses:** All master's students are required to take ENME 4900 **Graduate Professional Development** in the first year (this will be offered once a year; usually in winter quarter) and ENME 4950 **Graduate Assessment** in the last quarter of study. **NOTE:** Students on the thesis track are required to complete a written self-reflection on their thesis and upload the report to Assessment along with thesis, defense presentation slides, and the completed and signed degree program plan before graduation. Students on the non-thesis track are required to upload to Assessment an assembled portfolio that includes reports from at least two course projects or homework from the core courses, a mini-proposal and presentation slides from ENME 4950 along with the completed and signed degree program plan.

3. **Technical Electives:** a minimum of 16 credits for thesis track and 28 credits for non-thesis track. These do not include independent research credits.
   a. Technical electives must be in engineering (bioengineering, mechanical engineering, materials science, etc.) or related areas (mathematics, computer science, physics, chemistry, etc.) and are at the advisor’s discretion.
b. A student may take one business/management course as a technical elective. Special permission should be obtained in writing from the advisor PRIOR TO REGISTRATION if more than one business/management course is taken.

4. Advanced Math Requirement: a minimum of three credits for thesis track and six credits for non-thesis track from the Core Course List or advisor approval.


MS ENGE Thesis/Non-thesis Minimum Credit Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Thesis</th>
<th>Non-Thesis</th>
<th>CM</th>
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<tbody>
<tr>
<td>Core</td>
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<tr>
<td>Technical Electives</td>
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<td>Advanced Math</td>
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</tr>
<tr>
<td>Thesis</td>
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<tr>
<td>Total Credits Required</td>
<td>45</td>
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Mechanical Engineering Core Courses

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Bioengineering Core Courses

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<tbody>
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<td>Biofluids</td>
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<tr>
<td>ENBI 4510</td>
<td>Biomechanics</td>
<td>4</td>
</tr>
<tr>
<td>ENBI 4520</td>
<td>Introduction to Cardiovascular Engineering (Intro to Cardiovascular Engineering)</td>
<td>4</td>
</tr>
<tr>
<td>ENBI 4800</td>
<td>Adv Topics (Bioengineering) (Computational Biomechanics)</td>
<td>4</td>
</tr>
</tbody>
</table>

Materials Science Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 4200</td>
<td>Introduction to Nanotechnology</td>
<td>4</td>
</tr>
<tr>
<td>ENME 4400</td>
<td>Fatigue</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4010</td>
<td>Mechanical Behavior of Materials</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4020</td>
<td>Composite Materials I</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4215</td>
<td>Composite Materials II</td>
<td>4</td>
</tr>
<tr>
<td>MTSC 4450</td>
<td>Fracture Mechanics</td>
<td>4</td>
</tr>
</tbody>
</table>

Electrical & Computer Engineering Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENCE 4110</td>
<td>Modern Digital Systems Design</td>
<td>4</td>
</tr>
<tr>
<td>ENEE 4640</td>
<td>Electromagnetic Compatibility</td>
<td>4</td>
</tr>
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</table>

Advanced Math Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 3620</td>
<td>Advanced Engineering Mathematics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4300</td>
<td>Advanced Numerical Methods (Advanced Numerical Methods)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4350</td>
<td>Reliability</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4620</td>
<td>Optimization</td>
<td>4</td>
</tr>
</tbody>
</table>

Master of Science in Engineering with a Concentration in Management

The degree of Master of Science in Engineering allows students to pursue a concentration in management (MS ENGE (CM)). This is an engineering degree with both engineering and management focuses. The concentration in management is designed to meet the increasing needs of students to enhance their career opportunities as managers or as entrepreneurs by supplementing advanced engineering knowledge with a fundamental understanding of business principles within the context of technology enterprises. Drawing upon the strengths of both RSECS and the Daniels College of
Business, the program provides the relevant content for graduates to lead technology enterprises. Candidates for the degree of master of science with a concentration in management will be on non-thesis track only.

Program Structure (management focus)
1. Every candidate for this degree must complete 45 credits, at least 36 of which must be completed at the University of Denver.
2. A minimum of six 4000-level courses of at least three credits each are required for non-thesis track; four 4000-level courses of at least three credits each are required for thesis track. No courses at the 1000- or 2000-level are acceptable.
3. An overall GPA of 3.0 is required for the degree.
4. Any individual grade lower than C- renders the credit unacceptable.
5. Students who have completed the required 45 credits and are still working on a thesis or project are eligible for Continuous Enrollment to maintain active student status at the University. Students working on internships are not eligible for Continuous Enrollment.
6. Master’s degree candidates are expected to complete degree requirements no later than five years after beginning their programs.
7. International students must enroll in at least eight credits each quarter to maintain full-time status, except during the annual vacation term (usually the summer quarter) or the final quarter of study that requires fewer credits than the minimum full-time enrollment to complete the program. Failure to maintain full-time enrollment is a violation of student status and may result in the termination from the program. Based on the recommendation of the academic advisor, an international student advisor may authorize the student to drop below full-time status for academic reasons specifically permitted under immigration regulations. However, academic authorizations may only be given once per degree level and are usually issued during the first term of study.

Course Requirements:
1. Core Courses: a minimum of nine credits (one course from ME, ENBI, MTSC or ECE Core Course List AND one course from Management Concentration Core Course List) plus required courses.
2. Required Courses: All master's students are required to take ENME 4900 Graduate Professional Development in the first year (this will be offered once a year; usually in winter quarter) and ENME 4950 Graduate Assessment in the last quarter of study. NOTE: Students on this non-thesis track are required to upload to Assessment.du.edu an assembled portfolio that includes reports from at least two course projects or homework from the core courses, a mini-proposal and presentation slides from ENME 4900, along with the completed and signed degree program plan.
3. Technical Electives: a minimum of 16 credits should be selected from the engineering Core Course List.
4. Management Electives: a minimum of 12 credits should be selected from the Management Concentration Core Course List. These management electives are in addition to the management core credit requirement. If a student wishes to take courses not on the Management Concentration Core Course List, written approval by the advisor is required, PRIOR TO REGISTRATION.
5. Advanced Math Requirement: a minimum of three credits from Core Course List or advisor approval.

MS ENGE with a Concentration in Management Minimum Credit Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Thesis</th>
<th>Non-Thesis</th>
<th>CM</th>
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<tbody>
<tr>
<td>Core</td>
<td>NA</td>
<td>NA</td>
<td>9</td>
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<tr>
<td>Technical Electives</td>
<td>NA</td>
<td>NA</td>
<td>16</td>
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<tr>
<td>Management Electives</td>
<td>NA</td>
<td>NA</td>
<td>12</td>
</tr>
<tr>
<td>Advanced Math</td>
<td>NA</td>
<td>NA</td>
<td>3</td>
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<tr>
<td>Total Credits Required</td>
<td>NA</td>
<td>NA</td>
<td>45</td>
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Required Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ENME 4900</td>
<td>Grad Professional Development (Graduate Professional Development)</td>
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</tr>
<tr>
<td>ENME 4950</td>
<td>Graduate Assessment (Graduate Assessment)</td>
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</tr>
</tbody>
</table>

Concentration in Management Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BUS 4500</td>
<td>Creating Sustainable Enterprises</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4810</td>
<td>Advanced Topics (ENGR) (Operations Management)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4810</td>
<td>Advanced Topics (ENGR) (Project Management)</td>
<td>4</td>
</tr>
<tr>
<td>IMBA 4142</td>
<td>Global Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4490</td>
<td>Global Strategy</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4630</td>
<td>Strategic Human Resources Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4690</td>
<td>Strategic Management</td>
<td>4</td>
</tr>
<tr>
<td>MKTG 4100</td>
<td>Marketing Concepts</td>
<td>4</td>
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</table>

Mechanical Engineering Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 3630</td>
<td>Finite Element Methods</td>
<td>4</td>
</tr>
</tbody>
</table>
ENME 3545  Mechanisms  4
ENME 3651  Computational Fluid Dynamics  4
ENME 4020  Adv Finite Element Analysis  4
ENME 4520  Intermediate Dynamics (Intermediate Dynamics)  4
ENME 4541  Advanced Mechanics of Materials (Advanced Mechanics of Materials)  4
ENME 4630  Viscous Flow (Viscous Flow)  4
ENME 4670  Advanced Computational Fluid Dynamics  4
ENME 4800  Advanced Topics (ME) (Convective Heat Transfer)  4

Bioengineering Core Courses
ENBI 4500  Biofluids  4
ENBI 4510  Biomechanics  4
ENBI 4520  Introduction to Cardiovascular Engineering (Intro to Cardiovascular Engineering)  4
ENBI 4800  Adv Topics (Bioengineering) (Computational Biomechanics)  4

Materials Science Core Courses
ENGR 4200  Introduction to Nanotechnology  4
ENME 4400  Fatigue  4
MTSC 4010  Mechanical Behavior of Materials  4
MTSC 4020  Composite Materials I  4
MTSC 4215  Composite Materials II  4
MTSC 4450  Fracture Mechanics  4

Electrical & Computer Engineering Core Courses
ENCE 4110  Modern Digital Systems Design  4
ENEE 4640  Electromagnetic Compatibility  4

Advanced Math Courses
ENGR 3620  Advanced Engineering Mathematics  4
ENGR 4300  Advanced Numerical Methods (Advanced Numerical Methods)  4
ENGR 4350  Reliability  4
ENGR 4620  Optimization  4

Courses

ENGR 3210 Intro Nano-Electro-Mechanics (4 Credits)
Familiarize science and engineering students with the electromechanical aspects of the emerging field of Nanotechnology (NEMS). NEMS is a relatively new and highly multidisciplinary field of science and technology with applications to state of the art and future sensors, actuators, and electronics. Starting with an overview of nanotechnology and discussion on the shifts in the electromechanical behavior and transduction mechanisms when scaling the physical dimensions from centimeters to micro-meters and then down to nanometers. Several electromechanical transduction mechanisms at the micro and nanoscale are presented and discussed in an application based context. New electromechanical interactions appearing in the nano and molecular scale, such as intra-molecular forces and molecular motors, are discussed. A detailed discussion and overview of nanofabrication technologies and approaches are also provided. Cross listed with ENGR 4210. Prerequisite: must be an engineering or science major of at least junior standing.

ENGR 3510 Renewable and Efficient Power and Energy Systems (4 Credits)
This course introduces the current and future sustainable electrical power systems. Fundamentals of renewable energy sources and storage systems are discussed. Interfaces of the new sources to the utility grid are covered. Prerequisite: ENEE 2021.

ENGR 3520 Introduction to Power Electronics (4 Credits)
This covers fundamentals of power electronics. We discuss various switching converters topologies. Basic knowledge of Efficiency and small-signal modeling for the DC-DC switching converters is covered. Furthermore, magnetic and filter design are introduced. Prerequisites: ENEE 2211 and ENGR 3722.

ENGR 3525 Power Electronics and Renewable Energy Laboratory (1 Credit)
In this course the fundamentals of switching converters and power electronics in a real laboratory set-up are covered. The course incorporates hardware design, analysis, and simulation of various switching converters as a power processing element for different energy sources. The energy sources are power utility, batteries, and solar panels. Prerequisite: ENGR 3520.

ENGR 3540 Electric Power Systems (4 Credits)
This course covers methods of calculation of a comprehensive idea on the various aspects of power system problems and algorithms for solving these problems. Prerequisite: ENGR 3530.
ENGR 3550 Introduction to Machine Drive Control (4 Credits)
This course provides the basic theory for the analysis and application of adjustable-speed drive systems employing power electronic converters and ac or dc machines. Prerequisites: ENGR 3520 and ENGR 3530.

ENGR 3610 Engineering Analysis (3 Credits)
Applied mathematics for engineers. Generalized Fourier analysis, complex variables, vector calculus, introduction to Bessel functions, and applied probability and statistics. Cross listed with ENGR 3620. Prerequisites: MATH 2070, MATH 2080.

ENGR 3620 Advanced Engineering Mathematics (4 Credits)

ENGR 3630 Finite Element Methods (4 Credits)
Introduction to the use of finite element methods in one or two dimensions with applications to solid and fluid mechanics, heat transfer and electromagnetic fields; projects in one or more of the above areas. Prerequisite: ENGR 3610 or equivalent.

ENGR 3710 Controls (3,4 Credits)
Modeling, analysis and design of linear feedback control systems using Laplace transform methods. Techniques and methods used in linear mathematical models of mechanical, electrical, thermal and fluid systems are covered. Feedback control system models, design methods and performance criteria in both time and frequency domains. A linear feedback control system design project is required. Prerequisites: ENEE 2021, ENGR 3610 or permission of instructor.

ENGR 3722 Control Systems Laboratory (1 Credit)
This laboratory course serves as supplement to ENGR 3721. It aims at providing “hands on” experience to students. It includes experiments on inverted pendulum, gyrosopes, motor control, feedback controller design, time-domain and frequency domain. Corequisite: ENGR 3721.

ENGR 3730 Robotics (3 Credits)
Introduction to the analysis, design, modeling and application of robotic manipulators. Review of the mathematical preliminaries required to support robot theory. Topics include forward kinematics, inverse kinematics, motion kinematics, trajectory control and planning, and kinetics. Cross listed with ENGR 4730. Prerequisites: ENME 2520 and MATH 2060 or MATH 2200 or permission of instructor.

ENGR 3731 Robotics Lab (1 Credit)
Laboratory that complements the analysis, design, modeling and application of robotic manipulators. Implementation of the mathematical structures required to support robot operation. Topics include forward kinematics, inverse kinematics, motion kinematics, trajectory control and planning and kinetics. Applications include programming and task planning of a manufacturing robot manipulator. Corequisite: ENGR 3730 or permission of instructor.

ENGR 3742 LabVIEW Programming, a primer for certification as an Applicaitons Developer (4 Credits)
The LabVIEW course covers numeric, Boolean, and string controls; programming structures include loops, sequences, formula, and case structures. VISA (virtual instrumentation and software structure) and SCPI (standard commands for programmable instruments) are used to control test equipment and acquire data via the GPIB (general purpose interface bus, IEEE488 standard). Vis (virtual instruments) for data acquisition and analysis are developed utilizing mathematical, signal processing, and statistical LabVIEW programming modules. LabVIEW structures will be used to mathematically model and solve second order differential equations and Laplace transforms.

ENGR 3800 Topics (ENGR) (1-4 Credits)
Special topics in engineering as announced. May be taken more than once. Prerequisite: varies with offering.

ENGR 3900 Engineering Internship (0-4 Credits)
Students in engineering may receive elective credit for engineering work performed for engineering employers with the approval of the chair or associate chair of the department. At the end of the term, a student report on the work is required, and a recommendation will be required from the employer before a grade is assigned. Junior, senior, or graduate status in engineering is normally required. May not be used to satisfy technical requirements. May be taken more than one for a maximum of 6 quarter hours. Prerequisite: permission of instructor.

ENGR 3951 Engineering Assessment II (0 Credits)
Students in Mechanical Engineering must register for and take the Fundamentals of Engineering Examination (FE). All students must complete an engineering exit interview and other assessment related tasks. To be taken in the last quarter of attendance.

ENGR 3970 Entrepreneurship for Engineers and Computer Scientists (4 Credits)
The course presents an overview of fundamentals of understanding entrepreneurship and entrepreneurial characteristics; the focus is on aspects of engineering entrepreneurship, technology-based innovation and new product development. Topics to be covered: learning an industry; recognizing and creating opportunities; new product development process, phases and cycle, risks and benefits; ‘testing’ of an engineering-focused business concept; marketing, organizational plan strategies and financing for new start ups. Special attention is given to technological innovation, considering both incremental or routine innovation, and more radical or revolutionary changes in products and processes. Prerequisite: ENGR 3610 or permission of the instructor.

ENGR 4100 Instrumentation and Data Acquisition (4 Credits)
Cross listed with ENGR 3100.
ENGR 4200 Introduction to Nanotechnology (4 Credits)
The most important recent accomplishments so far in the application of nanotechnology in several disciplines are discussed. Then a brief overview of the most important instrumentation systems used by nanotechnologists is provided. The nature of nanoparticles, nanoparticle composites, carbon nanostructures, including carbon nanotubes and their composites is subsequently discussed. The course also deals with nanopolymers, nanobiological systems, and nanoelectronic materials and devices. The issues of modeling of nanomaterials and nanostructures is also covered. Multiscale modeling based on finite element simulations, Monte Carlo methods, molecular dynamics and quantum mechanics calculations are briefly addressed. Most importantly, students should obtain appreciation of developments in nanotechnology outside their present area of expertise. Cross listed with ENGR 3200.

ENGR 4210 Introduction to Nano-Electro-Mechanical-Systems (4 Credits)
This course familiarizes science and engineering students to the electromechanical aspects of the emerging field of Nanotechnology (NEMS). NEMS is a relatively new and highly multidisciplinary field of science and technology with applications in the state of the art and future sensors, actuators, and electronics. This course starts with an overview of nanotechnology and discussion on the shifts in the electromechanical behavior and transduction mechanisms when scaling the physical dimensions from centimeters to micro-meters and then down to nanometers. Several electromechanical transduction mechanisms at the micro and nanoscale are presented and discussed in an application based context. New electromechanical interactions appearing in the nano and molecular scale, such as intra-molecular forces and molecular motors, are discussed. A detailed discussion and overview of nanofabrication technologies and approaches are also provided. Cross listed with ENGR 3210.

ENGR 4215 Nanoscale Electromechanical Systems and Nanofabrication Laboratory (4 Credits)
This course provides science and engineering students with comprehensive hands-on experience in design, fabrication and characterization of Nanoscale Electromechanical Systems (NEMS). This laboratory-based course starts with a number of sessions including brief lectures reviewing the fundamentals and theories followed by pre-designed lab experiments. The students are then provided with a choice of different comprehensive design and implementation projects to be performed during the quarter. The projects include design, layout, fabrication, and characterization of the devices potentially resulting in novel findings and publications.

ENGR 4220 Introduction to Micro-Electro-Mechanical-Systems (4 Credits)
This course introduces students to the multi-disciplinary field of Micro-Electro-Mechanical-Systems (MEMS) technology. MEMS and Microsystem technology is the integration of micro-scale electro-mechanical elements, sensors, actuators, and electronics on a common substrate or platform through semiconductor microfabrication technologies. The course gives a brief overview of the involved physical phenomena, electromechanical transduction mechanisms, design principles, as well as fabrication and manufacturing technologies. Cross listed with ENGR 3220.

ENGR 4300 Advanced Numerical Methods (4 Credits)
Fundamental and advanced numerical methods to approximate mathematical problems for engineering applications using modern software such as Matlab. Topics include numerical differentiation and integration, solution to linear and non-linear equations, ordinary and partial differential equations, and initial, boundary, and eigen value problems. Recommended prerequisite: MATH 2070.

ENGR 4350 Reliability (4 Credits)
An overview of reliability-based design. Topics include: fundamentals of statistics, probability distributions, determining distribution parameters, design for six sigma, Monte Carlo simulation, first and second order reliability methods (FORM, SORM). Most Probable Point (MPP) reliability methods, sensitivity factors, probabilistic design. Cross listed with ENGR 3350.

ENGR 4530 Intro to Power and Energy (4 Credits)
Basic concepts of AC systems, single-phase and three-phase networks, electromechanical energy conversion, electric power generation, transformers, transmission lines, AC machinery, DC motors, and contemporary topics in power and energy conversion. Cross listed with ENGR 3530.

ENGR 4545 Electric Power Economy (4 Credits)
This course covers economy aspects of electric power industry and the implications for power and energy engineering in the market environment. Cross listed with ENGR 3545.

ENGR 4550 Probabilistic Methods in Electric Power Systems (4 Credits)
The course covers techniques for probabilistic power system analysis and design, power system reliability, probabilistic structural design and analysis of transmission lines, analysis and assessment of transmission line reliability, probability-based power system design criteria, probabilistic load-flow studies and probabilistic power system stability. Prerequisites: ENGR 3540 or equivalent; permission of instructor; knowledge of MATLAB/Simulating is required.

ENGR 4560 Power Generation Operation and Control (4 Credits)
This course covers economic dispatch of thermal units and methods of solution; transmission system effects; generate with limited energy supply; production cost models; control of generation; interchange of power and energy; power system security; state estimation in power systems; optimal power flow. Prerequisite: ENGR 4540.

ENGR 4590 Power System Protection (4 Credits)
This course covers methods of calculation of fault currents under different types of fault; circuit breakers, current transformers, potential transformers; basic principles of various types of relays; applications of relays in the protection of generator, transformer, line, and bus, etc. Prerequisite: ENGR 4540.

ENGR 4620 Optimization (3,4 Credits)
Engineering problems will be formulated as different programming problems to show the wide applicability and generality of optimization methods. The development, application, and computational aspects of various optimization techniques will be discussed with engineering examples. The application of nonlinear programming techniques will be emphasized. A design project will be assigned.
ENGR 4730 Introduction to Robotics (4 Credits)
Introduction to the analysis, design, modeling and application of robotic manipulators. Review of the mathematical preliminaries required to support robot theory. Topics include forward kinematics, inverse kinematics, motion kinematics, trajectory control and planning, and kinetics. Applications include programming and task planning of a manufacturing robot manipulator. Cross listed with ENGR 3730. Prerequisites: ENME 2520 and MATH 2060 or MATH 2200 or instructor approval.

ENGR 4735 Linear Systems (4 Credits)
This course focuses on linear system theory in time domain. It emphasizes linear and matrix algebra, numerical matrix algebra and computational issues in solving systems of linear algebraic equations, singular value decomposition, eigenvalue-eigenvector and least-squares problems, linear spaces and linear operator theory. It studies modeling and linearization of multi-input/multi-output dynamic physical systems, state-variable and transfer function matrices, analytical and numerical solutions of systems of differential and difference equations, structural properties of linear dynamic physical systems, including controllability, observability and stability. It covers canonical realizations, linear state-variable feedback controller and asymptotic observer design, and the Kalman filter. Cross listed with ENGR 3735. Prerequisites: ENGR 3610, ENGR 3721/3722, or permission of the instructor.

ENGR 4740 Adaptive Control Systems (4 Credits)
Theoretical and application aspects of robust adaptive control design for uncertain dynamical systems. Topics include: parameter estimation, stability, model reference adaptive systems, self-tuning regulators, gain scheduling, design for robustness against unmodeled dynamics and disturbance signals. Examples will be given from aerospace engineering (changes in the dynamics of aircraft), process control, and robotics. Modern alternatives to traditional adaptive control will be discussed (switching multi-model/multi-controller adaptive schemes). Prerequisites: ENEE 3111, ENGR 3610, and ENGR 3721, or permission of instructor. Familiarity with MATLAB/Simulink.

ENGR 4745 Advanced Non-Linear Control Systems (4 Credits)

ENGR 4750 Networked Control Systems (4 Credits)
Fundamental tools and recent advances in networked control. Topics include the control of multi-agent networks found in multi-vehicle coordination, control of sensor networks, unmanned vehicles, and energy systems. Network models, distributed control and estimation, distributed control under limited communications and sensing, formation control, coverage control in mobile sensor networks. Prerequisites: linear algebra, linear control systems, differential equations, familiarity with MATLAB, or permission of instructor.

ENGR 4810 Advanced Topics (ENGR) (1-5 Credits)
ENGR 4991 Independent Study (1-5 Credits)
ENGR 4992 Directed Study (1-10 Credits)
ENGR 4995 Independent Research (1-16 Credits)
ENGR 5991 Independent Study (1-10 Credits)
ENGR 5995 Independent Research (1-16 Credits)