EE Graduate Curriculum Recent Activities

This document describes the changes in the Electrical Engineering (EE) graduate program over the past 3-5 years.

The EE graduate curriculum is divided into three tracks: Antennas and Wireless Communications (AWC), Energy Systems and Power Electronics (EPSE), and Information and Systems Sciences (ISS). These tracks are aligned with the research and teaching interests of our faculty, and every faculty member is affiliated with one track. Every student earning a graduate degree (MS-Non-Thesis, MS-Thesis, or PhD) must choose one of these three tracks, is advised by a faculty member from their corresponding track, and must complete a set of core courses and take the PhD qualifying exam (only for PhD students) in that track.

1. **Addition of the AWC track:** Prior to 2014, there were only two tracks in the EE graduate curriculum: ESPE and ISS. However, beginning with the 2014-15 bulletin, AWC was added as a third track.
   - *Why add:* Profs. Randy Haupt and Atef Elsherbeni, who had been recently hired prior to 2014, have research and teaching interests in AWC. A third tenure-track AWC faculty member (Prof. Payam Nayeri) and a research professor (Prof. Mohammad Hadi) were hired shortly thereafter.
   - *Intended outcomes:* (1) To create a third focus area of research and teaching in our department, with strength in computational electromagnetics, electromagnetic radiation and scattering, antennas and antenna arrays, microwave circuits, radar, remote sensing, electromagnetic measurements, visualization and wireless communications. These topics relate to sensing, energy, and communication challenges that span many engineering and applied science disciplines and thus align with the Mines mission. (2) To successfully educate and graduate students in these areas.

2. **Revision of the double-counting policy:** Masters degrees are becoming increasingly important for practicing electrical engineers, both for securing employment and for boosting salary. The EE department offers a combined BS/MS program which allows Mines students to begin earning graduate credit while still completing their undergraduate degree. Many of our strongest MS-Non-Thesis students have come through this program, mainly from the BS programs in Electrical Engineering or Engineering Physics. Mines allows some combined BS/MS students to double-count certain courses toward both their BS and MS degrees. However, prior to 2018, this option was not available for our BS/MS students because our MS degrees require 30 credit hours. In 2017-18, the EE department (among others) successfully petitioned the Graduate Council to change the university policy and allow double-counting for BS/MS programs with 30-hour MS degrees. Beginning with the 2018-19 catalog, the EE department now allows EE undergraduates to double-count up to 6 hours of 500-level courses toward the BS and MS degrees, as long as they earn a B- or better in those courses.
   - *Why change:* This change helps make the BS/MS program truly a “+1 year” option, which was very difficult to accomplish if a student needed to take 30 graduate EE credit hours in just 2 semesters after completing the BS. The EE department argued that this change would
be very much in line with the current policies at many peer and aspirational universities that offer combined BS/MS degrees in EE.

**Intended outcomes:** (1) More students finishing their MS degree in one extra year beyond their BS degree, which is a benefit to the students practically and financially. (2) More Mines undergraduates attracted to earning a graduate degree here, as increasing the number of MS-Non-Thesis students in the program as this is a target/objective of the department’s Pathways of Distinction.

3. **Proposal to add four graduate certificates:** In Fall 2018, the EE department is proposing to add four new post-baccalaureate certificates: the ISS faculty propose a new certificate in Data and Systems Science; the ESPE faculty propose a new certificate in Renewable Energy, Utility Integration, and Smart-Grid Technology; and the AWC faculty propose two new certificates, one in RF and Microwave Engineering, and one in Antennas and Radar Technology. Each of these certificates builds on the existing courses in the corresponding track, in that most of the certificate courses are already offered on campus. However, some new development of courses is planned, and some courses will transition to online offerings.

**Why add:** The courses in these certificates help fill a gap in the education of many BS-holding electrical engineers working in the local industries such as power, energy, oil/gas, manufacturing, aerospace, defense, and communication. These certificates can be offered with low cost and low risk, as they build on our existing curriculum, and the anticipated costs rise only if the enrollment rises.

**Intended outcomes:** (1) More students from local industries taking classes from Mines, and raising revenues for the university and department. (2) Some of these certificate students may continue for MS-Non-Thesis degrees in our department. (3) The beginning of online course offerings from our graduate program.

4. **Proposal to add graduate program in Smart-Grid Electrical Power and Energy Systems:** In Fall 2018, Prof. Marcelo Simoes is leading a proposal for the creation of a new MS/PhD graduate program in Smart-Grid Electrical Power and Energy Systems. This program is to be led by the Electrical Engineering department, with participation of faculty from Computer Science and Mechanical Engineering. Three new online core courses will be developed for this program, as well as a graduate seminar and an international summer school program.

**Why add:** The future electric grid will be smart, with user-interaction, and bidirectional power flow with deep penetration of renewable energy resources. Students in this graduate program will learn about the combined power system and power electronics approach, in which enabled renewable energy systems will interact with the utility grid, establishing microgrids, and intelligence and data communication will make the future grid a smart grid. The curriculum for these degrees will incorporate elements of energy storage systems, power electronics, linear and nonlinear optimization, network models, and cybersecurity. There is no equivalent program in the State of Colorado nor in any neighbor Western state.

**Intended outcomes:** (1) Increase the overall enrollment of regular and non-traditional students. (2) Supply MS and PhD students for advanced industries, national laboratories, and key leaders for guaranteeing the sustainability of renewable energy based electrical energy conversion.
5. **Assessment of graduate program:** During the 2016-17 academic year, the departmental graduate committee developed performance metrics for assessing our graduate program. These included questionnaires and forms to be filled out assessing our individual courses (one per track per semester), the written part of the PhD qualifying exam (one per track), the oral part of the PhD qualifying exam (one aggregate assessment for each track and one individual assessment for each student taking the exam), thesis defense (for each MS-Thesis and PhD student), and finally, the progress of our individual students towards the completion of their corresponding degrees. These were shared with our faculty as well as the PhD qualifying exam coordinators for each track, and we started collecting data during the 2017-18 academic year.

**Why assess:** This effort helps us evaluate the effectiveness of our teaching efforts in preparing our students both in terms of technical education as well as their capabilities in presenting their ideas in front of their peers. The results and feedback will be shared with the faculty.

**Intended outcomes:** Feedback to our faculty regarding the effectiveness of our graduate level courses in preparing our graduate students for their future careers

Brief summary of other recent actions and ongoing graduate committee responsibilities:

- In Spring 2017, all three tracks (AWC, ESPE, ISS) revised their lists of core courses.
- Various new courses have been added to the graduate curriculum over the past 3-5 years.
- EE has endorsed and plans to participate in other new interdisciplinary certificates/graduate programs in Advanced Manufacturing (led by Aaron Stebner) and Data Center Engineering (led by Greg Jackson).
- EE hosts a graduate school information session each fall for our undergraduate students.
- EE attends the undergraduate advising sessions for students in the Physics department to advertise our BS/MS program and answer registration questions. We also send email advertisements to a number of students from the GRE email list obtained from the Office of Graduate Studies.
- EE students who apply to our combined BS/MS program are automatically admitted if their GPA is 3.0 or above, a fact that we use in advertising the program to our students.
- In response to low attendance at EECS departmental seminars, speakers were asked to begin each talk with a brief history of their career for the benefit of the graduate students, and to ensure that at least half of their talk is at an introductory graduate level. After the EE/CS split, EE seminars were reintroduced in Fall 2016 as an EE departmental colloquium. Speakers are again asked to avoid topics that are too esoteric or narrowly focused.
- An additional responsibility of the EE graduate committee is to coordinate admission decisions and financial aid recommendations each semester. Different models for financial aid/TA support have been tested over the recent years.