SPECIAL REPORT
OF THE
ACADEMIC MATTERS AND
PROGRAM AND BUDGET COUNCIL
concerning
REVISION TO A DEGREE PROGRAM:
ELECTRICAL AND COMPUTER ENGINEERING
ELECTRICAL ENGINEERING (BS)
(#4698)

Presented at the
776th Regular Meeting of the Faculty Senate
March 8, 2018

COUNCIL MEMBERSHIP

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PROGRAM AND BUDGET COUNCIL

ACADEMIC MATTERS COUNCIL
The Academic Matters Council recommends approval of this proposal.

PROGRAM AND BUDGET COUNCIL
The Program and Budget Council voted unanimously to recommend this proposal.
Please describe your proposal

The Department of Electrical and Computer Engineering (hereafter referred to as ECE) offers two undergraduate programs that lead to a Bachelor of Science in Electrical Engineering (hereafter referred to as BS-EE) and a Bachelor of Science in Computer Systems Engineering (hereafter referred to as BS-CSE). (Note: In an accompanying proposal, we are requesting to change the name of the Computer Systems Engineering program to Computer Engineering, with the designation CompE.). These programs are accredited every 6 years by the Accreditation Board of Engineering and Technology Inc. (hereafter referred to as ABET), which is the national accrediting body for engineering departments. ABET has a set of curricular requirements that this curricular revision must adhere to in order to ensure a successful ABET site visit in 2019 and re-accreditation.

ABET’s general criterion 5 (http://www.abet.org/accreditation/accreditation-criteria/criteriafor-accrediting-engineering-programs-2016-2017/) stipulates that both BS-EE and BS-CSE curricula must include: (a) One year (one year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation) of a combination of college level mathematics and basic sciences (defined as biological, chemical and physical sciences) appropriate to the discipline; (b) One and one-half years of engineering topics consisting of engineering sciences and engineering design appropriate to the students’ field of study.

(According to ABET, engineering science provides a bridge between mathematics and basic sciences and engineering practices. Engineering design is the process of devising a system, component or process to meet desired needs.) (c) A general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives. (d) Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints. As it will become clear later on, the present proposal closely adheres to those requirements.

Following the successful ABET accreditation of the BS-EE and BS-CSE programs in 2013, the ECE Department Head tasked the department’s Instructional Development Committee (hereafter referred to as IDC) to explore whether the ECE curriculum should undergo a minor or major revision, or if the curriculum did not need any revision. The IDC formed a curriculum assessment subcommittee to study the data and materials gathered in the course of the previous ABET accreditation period, as well as consider curricula from peer institutions considered in the University’s Academic Quality and Development (AQAD) review and a few other aspirational peer departments across the nation (e.g. UC Berkley, UIUC, UMich), and recommend whether the BS-EE and/or BS-CSE curricula had to be revised. After approximately half a year of deliberations the sub-committee determined that it would be beneficial for ECE to revise both BS-EE and BS-CSE curricula in the period before the next ABET visit in 2019. The study and results of this sub-committee were shared and discussed in IDC and ECE faculty meetings, and a general consensus was reached that a major curriculum revision for both BS-EE and BS-CSE would be appropriate. The IDC immediately started working in this revision, and it labored diligently throughout for the following three years. During this time, the committee met and debated the curriculum revision issues at more than twenty meetings, and solicited and received inputs from: (a) ECE faculty by periodically engaging faculty members in different curricular areas, faculty meetings (at least ten meetings were devoted to this curricular revision), and three ECE department retreats (January 2014, January 2015, January 2016). (b) ECE Alumni through an extensive online
survey that had a surprisingly high return rate, and many face-to-face conversations at homecomings and other events. (c) Current ECE students by engaging their main student governance body, the ECE Student Advising Council (ESAC), and cohosting a “curriculum town-hall” meeting in Spring of 2016. (d) Employers and industry studies by incorporating findings of the American Society for Engineering Education (ASEE). Transforming Undergraduate Engineering Education (TUEE) phase I and phase II reports (http://tuee.asce.org/). The final framework of the proposed curriculum revision was presented to the faculty during the November 2016 faculty meeting. It was amended with minor modifications, and was unanimously approved by the ECE faculty in December of 2016. It is important to note that in addition to the analyzing and studying the long-term effects of this curriculum revision on faculty member workload, and graduate course offerings, the IDC considered in great detail a rollout plan that ensures a smooth transition for both students and the Department. Throughout this process the ECE Department Head, Undergraduate Program Director and the ECE representative to the College of Engineering curriculum committee, who are ex-officio IDC members, were active and instrumental participants. It is also worth noting that after a clear picture of the proposed curriculum started to emerge, the ECE Department engaged and notified the Department of Mathematics & Statistics and the Computer Science Department of course and curricular changes that pertain those departments.

The proposed curriculum is set to achieve the following broad objectives: (a) Create “breathing room” for students to absorb and reflect on technical materials, but also allow instructors to focus on improving students’ skills and professional preparation, in addition to covering core ECE knowledge/technical topics. (b) Focus on and reinforce a smaller set of ECE knowledge/technical topics that the faculty consider fundamental for ECE. (c) Give more flexibility to students to tailor the curriculum to their interests and needs. (d) Allow for more connection between theory and practice. (e) Allow for more connections between courses.

In achieving these objectives, the proposed curriculum reduces total graduation requirements from 128 credits to 124 credits (bringing it closer to the University’s 120 credit graduation requirement) while also incorporating three major curricular innovations: (a) The concept of “Computing Across the Curriculum” that will be introduced and coordinated through the new course E&C-ENG 202 – Computational Tools for ECE. This will require every core ECE, CSE or EE course to include engineering problems in the form of computer-based exercises and projects that, in addition to theoretical or analytical means, must also be analyzed and solved with modern engineering computational tools. Along with connecting theory and practice, and connecting different courses and technical topics with one another, the implementation of this concept will focus on improving students’ computing and problem-solving abilities, skills that are becoming as important as engineering knowledge in rapidly evolving fields like ECE. (b) A new junior year open-ended project based course, E&C-ENG 304 – ECE Junior Design Project. This course is modeled after the successful E&C-ENG 415-416 – Senior Design Project, and aims to further strengthen connections between theory, practice, and engineering design. (c) A curricular structure that allows for more electives, starting from the sixth semester (second semester of junior year) instead of starting in the senior year. This aims to provide more flexibility for students to further develop their interests in particular ECE areas, or broaden their education among many ECE sub-areas.

Please describe the existing program requirements, listing all required courses and available electives, as well as any additional requirements, and continuation or admissions policies.

Admission to the major: Students must complete the first-year requirements before admission to the Electrical Engineering (EE) major. Applicants are required to have earned grades of C or better in each of the following six courses: MATH 131; MATH 132; ENGIN 110, 111, 112 or 113; E&C-ENG 122;
PHYSICS 151; and ENGLWRIT 112. Students planning to apply for admission to EE should take ENGIN 112, MATH 131, and PHYSICS 151 in the first semester and E&C-ENG 122 and MATH 132 in the second semester. (PHYSICS 152 is not required for admission to the major, but it should be taken in the second semester, if at all possible.) Students must also be in good academic standing with a cumulative GPA of at least 2.0.

Current Curriculum for the B.S. Degree in Electrical Engineering (BS-EE):

1. First Year, Fall [19 credits]
   - ENGIN 11x – Introduction to Engineering [3 credits]
   - MATH 131 – Calculus I [4 credits]
   - PHYSICS 151 – General Physics I [4 credits]
   - ENGLWRIT 112 – College Writing [3 credits]
   - Social World Elective [4 credits]
   - ENGIN 191 – Freshman Seminar [1 credit]

2. First Year, Spring [16 credits]
   - E&C-ENG 122 – Introduction to Programming for ECE [4 credits]
   - MATH 132 – Calculus II [4 credits]
   - PHYSICS 152 – General Physics II [4 credits]
   - Biological Sciences Elective [4 credits]

3. Second Year, Fall [19 credits]
   - E&C-ENG 211 – Circuit Analysis I [4 credits]
   - E&C-ENG 221 – Introduction to Digital & Computer Systems [4 credits]
   - E&C-ENG 242 – Data Structures & Algorithms [4 credits]
   - MATH 331 – Ordinary Differential Equations for Scientists & Engineers [3 credits]
   - Social World Elective [4 credits]

4. Second Year, Spring [18-19 credits]
   - E&C-ENG 212 – Circuit Analysis II [4 credits]
   - E&C-ENG 232 – Hardware Organization & Design [4 credits]
   - COMPSCI 250 – Introduction to Computation [4 credits]
   - MATH 235 – Linear Algebra [3 credits]
   - Science Elective [3 or 4 credits]

5. Third Year, Fall [15 credits]
   - E&C-ENG 313 – Signals & Systems [4 credits]
   - E&C-ENG 323 – Electronics I [4 credits]
   - E&C-ENG 344 – Semiconductor Devices & Materials [4 credits]
   - E&C-ENG 353 – Computer Systems Lab I [3 credits]

6. Third Year, Spring [15 credits]
   - E&C-ENG 314 – Introduction to Probability & Random Processes [4 credits]
• E&C-ENG 324 – Electronics II [3 credits]
• E&C-ENG 333 – Fields & Waves [4 credits]
• ENGIN 351 – Writing in Engineering [3 credits]
• E&C-ENG 303 – Junior Seminar [1 credit]

(See Note 4 below.)

7. Fourth Year, Fall [13-15 credits]
• E&C-ENG 415 – Senior Design Project I [3 credits]
• EE Elective [3 or 4 credits]
• EE Elective [3 or 4 credits]
• Social World Elective [4 credits]

(See Notes 5 and 6 below.)

8. Fourth Year, Spring [13-15 credits]
• E&C-ENG 416 – Senior Design Project II [3 credits]
• EE Elective [3 or 4 credits]
• EE Elective [3 or 4 credits]
• Social World Elective [4 credits]

(See Note 6 below.)

Notes:

1. Students must earn a grade of C or better in one of the courses ENGIN 110, 111, 112, or 113. ENGIN 112 (Introduction to Electrical and Computer Engineering) is strongly recommended for students who intend to pursue the EE major.
2. The Biological Sciences Elective can be any course that fulfills the University’s BS General Education requirement.
3. The Science Elective is required for all CSE and EE majors. There are currently five approved courses, as listed below.
   • BIO 110: Intro. Biology for Science Majors (2nd sem) 4 cr
   • BIO 151: Intro. Biology I (both sem) 4 cr
   • CHEM 111: Gen. Chemistry for Science Majors (both sem) 4 cr
   • CHEM 121H: Hon. Gen. Chem. for Science Maj. (1st sem) 4 cr
   • PHYSICS 287: Physics III – Waves & Thermo. (1st sem) 3 cr

To propose a different course to satisfy either the Science Elective or EE Elective (see note 7), students must fill out the Alternative Elective Request Form to be approved by the Undergraduate Program Director (UPD) and the chair of the Instructional Development Committee (IDC). The form is online at: http://ece.umass.edu/undergraduate-students/forms-documents.

4. A student must be enrolled in either the Electrical Engineering (EE) or Computer Systems Engineering (CSE) major and have the requisite course requirements before taking any 300-level E&C-ENG courses.
5. E&C-ENG 415 satisfies the University’s Integrative Experience General Education requirement.
6. The following courses may be used as EE electives. All E&C-ENG 597 Special Topics courses and all 600-level E&C-ENG courses (except E&C-ENG 696) are allowed as well. Note that instructor permission is required to enroll in any 600-level course. At least two of the EE electives must be at the 500 level and not used to fulfill requirements of another major or minor.

- ECE 354: Computer Systems Lab II (2nd sem) 4 cr
- ECE 373: Software Intensive Engineering (1st sem) 4 cr
- ECE 374: Computer Networks & the Internet (2nd sem)
- ECE 544: Trustworthy Computing (1st sem)
- ECE 558: Intro. to VLSI Design (1st sem) 4 cr
- ECE 559: VLSI Design Project (2nd sem)
- ECE 563: Intro. to Comm. & Signal Processing (1st sem)
- ECE 564: Communication Systems (2nd sem) 4 cr
- ECE 565: Digital Signal Processing (2nd sem) 4 cr
- ECE 568: Introduction to Computer Architecture (1st sem)
- ECE 570: System Software Design (2nd sem)
- ECE 571: Microelectronic Fabrication (2nd sem) 4 cr
- ECE 572: Optoelectronics (1st sem)
- ECE 575: Intro. to Analog IC Design (1st sem)
- ECE 580: Feedback Control Systems (1st sem) 4 cr
- ECE 584: Microwave Engineering I (1st sem) 4 cr
- ECE 585: Microwave Engineering II (2nd sem)
## Curriculum Worksheet for the Electrical Engineering Class of 2020

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<td><strong>Fall [19 cr]</strong></td>
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<tr>
<td>ENGLWRIT 112 College Writing [3 cr]</td>
<td>Social World Elective [4 cr] [Note 2]</td>
<td>Science Elective [3 or 4 cr] [Notes 5 &amp; 6]</td>
<td>ENGIN 351 Writing in Engineering [3 cr]</td>
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<td>ENGIN 191 Freshman Seminar [1 cr] [Note 3]</td>
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### KEY
- To be replaced by new course(s)
- Minor modification of existing course
- Eliminated required course
- Unaffected course by revision
Please describe the requirements that you are proposing, listing course requirements, elective options, as well as any additional requirements, and continuation or admissions policies.

1. Proposed change in requirements: Graduation Requirements: Cumulative GPA of 2.00 or above in the major (this is same as the existing requirement), and successful completion of 124 total credits or more in the major. This corresponds to 4 credits less than the current requirement.

2. List of courses by semester followed by proposed change:
   1. First Year, Fall [19 credits]:
      - ENGIN112 – Intro to Electrical and Computer Engineering (see note 1) [3 credits]
      - PHYSICS 151 – General Physics I [4 credits]
      - MATH 131 – Calculus I [4 credits]
      - Social World Elective (see note 2) [4 credits]
      - ENGLWRIT 112 – College Writing [3 credits]
      - ENGIN 191 – Freshman Seminar [1 credit]
   2. First Year, Spring [16 credits]
      - E&C-ENG 122 – Introduction to Programming for ECE [4 credits]
      - PHYSICS 152 – General Physics II [4 credits]
      - MATH 132 – Calculus II [4 credits]
      - E&C-ENG 124 – Introduction to Digital and Computer Systems [4 credits]. Proposed required course change: This course describes basic hardware aspects of computer systems and under the current curriculum is offered in the third semester under the designation E&C-ENG 221. In this proposal, it is moved one semester earlier, the same semester as E&C-ENG 122 – Intro. to Programming for ECE, that describes basic software/programming aspects of computer systems. It is believed that this better balancing between software and hardware will provide first-year students with a more well-rounded picture of ECE. The material in E&C-ENG 124 is at an appropriate level for a first-year course - in fact, a few years back the topics included in this course were offered in the first semester as ENGIN 112. This course remains required by both CompE and EE majors.
   3. Second Year, Fall [18 credits]
      - E&C-ENG 201 – Analytical Tools for ECE [4 credits]
      - E&C-ENG 202 – Computational Tools for ECE [4 credits]
      - E&C-ENG 212 – Circuit Analysis II, MATH 235 – Linear Algebra, and MATH 331 – Differential Equations, respectively. Because E&CENG 212 is eliminated in the new curriculum, and also to achieve the objective of reducing student workload to only fundamental topics and reducing graduation credits to a number closer to the University minimum, the key mathematical concepts for ECE from the three courses have been combined into a single 4 credit course required by all EE and CompE majors.

Proposed new required course: This course provides students with fundamental knowledge of mathematical analysis concepts such as complex numbers, linear algebra and differential equations that are necessary to study ECE. In the current EE curriculum those topics are covered in E&C-ENG 212 – Circuit Analysis II, MATH 235 – Linear Algebra, and MATH 331 – Differential Equations, respectively. Because E&CENG 212 is eliminated in the new curriculum, and also to achieve the objective of reducing student workload to only fundamental topics and reducing graduation credits to a number closer to the University minimum, the key mathematical concepts for ECE from the three courses have been combined into a single 4 credit course required by all EE and CompE majors.

Proposed new required course: This course is a major new component of the proposed curriculum. In addition to introducing students to modern scripting and visualization computational engineering tools such as MATLAB, Python, and Excel spreadsheet programming, this course will act as a “hub” course that will implement the novel model of “Computing Across the Curriculum”. Under this instructional model instructors of all required EE and CompE major courses after the second semester will collaborate with the instructor(s) teaching E&C-ENG 202 to develop appropriate weekly engineering problem assignments that require the use of computational and visualization tools to be solved. This
innovation is proposed to achieve two curriculum revision objectives, i.e., to build stronger connections between courses, and to strengthen preparation in contemporary engineering tools and methods.

- **E&C-ENG 210 – Circuits and Electronics I [4 credits]**
  Proposed new required course: This course combines the most widely useful topics from the current third semester course E&C-ENG 211 – Circuit Analysis I, and fifth semester course E&C-ENG 323 – Electronics I. By focusing only on the most important topics this new course provides a great opportunity to combine theory and practice, e.g., using circuit analysis methods to solve practical engineering problems arising in electronics applications. In addition, this consolidation better distributes the currently very heavy fifth semester student workload and reduces total graduation credits in the EE major closer to the University minimum. This course will include a lab component that consolidates those of E&C-ENG 211 and 323.

- **MATH 233 – Multivariate Calculus [3 credits]**
  Proposed required course change: This course is moved one semester earlier to provide students with necessary mathematical background for the second-year spring semester course ECE 244 – Modern Physics and Materials for EE. It is noted that currently MATH 233 is offered both semesters.

- **Social World Elective (see note 2) [4 credits]**

### Second Year, Spring [16 credits]

- **E&C-ENG 213 – Continuous-Time Signals and Systems [4 credits]**
  Proposed new required course: This course covers in more depth some fundamental topics that are included in the current fifth semester course E&C-ENG 313 Signals & Systems. E&C-ENG 313 includes coverage of both continuous-time and discrete-time signals and systems. As one result of the information-gathering process that led to this proposed revision, it was determined that some discrete-time signal and system topics that are essential for EE majors are not critical for CompE majors. Thus, the proposed E&C-ENG 213 covers only continuous-time signals and systems, and it is required for both EE and CompE majors. To maximize curricular flexibility and allow earlier offerings of electives, this course will be offered one semester earlier that its predecessor E&C-ENG 313.

- **E&C-ENG 214 – Probability & Statistics [4 credits]**
  Proposed new required course: The majority of the topics covered in this proposed course are covered in the current curriculum in the sixth semester course E&C-ENG 314 – Introduction to Probability & Random Processes. E&C-ENG 214 does not include the more advanced topic of random processes, but instead focuses on statistical techniques that are increasingly used in EE and CompE applications such as machine learning and data analytics. This course will be offered one year earlier than the current course because it is prerequisite for the EE core courses E&C-ENG 315 – Signal Processing Methods and E&C-ENG 304 – ECE Junior Design Project. This course in required for both EE and CompE majors.

- **E&C-ENG 231 – Introduction to Embedded Systems [4 credits]**
  Proposed new required course: This course was introduced as a response to recent trends in ECE. Fifteen years ago, when the last major program revision of the CSE and EE majors took place, embedded systems (that is, systems that include embedded processors) where not as ubiquitous as they are today. Thus, the only course in the current curriculum that tangentially touches on that subject is E&C-ENG 353 – Computer Systems Lab, which includes some limited exposure to embedded systems, but mainly focused on broader principles of computer systems. With this proposed new course, which also includes a lab
component, students will be better prepared for work with contemporary ECE systems and applications. This course is required for both EE and ComE majors.

- E&C-ENG 244 – Modern Physics and Materials for EE [4 credits]
  Proposed new required course: This course addresses a deficiency in the current curriculum with regards to student’s preparation in engineering science topics related to modern physics, mainly quantum mechanics. The course also includes some engineering science topics that are currently included in the third-year courses E&CENG 344 – Semiconductor Devices & Materials and E&C-ENG 333 – Fields & Waves. Moving those topics into E&C-ENG 244 transforms E&C-ENG 344 and E&C-ENG 333 into core engineering course that focus solely on applications and engineering design (see changes below).

5. Third Year, Fall [15 credits]

- E&C-ENG 310 Circuits & Electronics II [4 credits]
  Proposed new required course: This course is a re-packaging of the current second and third year courses E&C-ENG 212 – Circuit Analysis II, E&C-ENG 323 – Electronics I, E&C-ENG 324 – Electronics II. The course will include a lab component that will be similar to the labs in E&C-ENG 212 and E&C-ENG 323, thus new resources will not be necessary. This re-packaging is motivated by the need to focus on the most fundamental materials in the area to create some “breathing room” for students and instructors, but also to reduce overall major credit hours and to facilitate the introduction of Junior Year EE Electives that increase flexibility.

- E&C-ENG 315 – Signal Processing Methods [3 credits]
  Proposed new required course: This course covers discrete-time signals and systems topics that are included in the current fifth semester course E&C-ENG 313 Signals & Systems, and also the random processes part from the current seventh semester course E&C-ENG 314 – Introduction to Probability & Random Processes. It will also include new topics on noise in electronic systems, and will emphasize applications and engineering design. This change was motivated by the need to better connect theory and practice.

- E&C-ENG 333 – Fields & Waves I [3 credits]
  Proposed required course change: This course will change from 4 credits to 3 credits, and some of its current engineering science topics have been moved to E&C-ENG 244 – Modern Physics and Materials for EE. Also, the course has been moved one semester earlier. This change was done to increase flexibility, by making space for Junior Year EE Electives in the spring semester of the third year. The proposed course only focuses on applied and engineering design aspects in the field of Electromagnetics. This change was motivated by the need to better connect theory and practice.

- E&C-ENG 344 – Fundamentals of Semiconductor Devices I [3 credits]
  Proposed required course change: This course will change from 4 credits to 3 credits, and some of its current engineering science topics have been moved to E&C-ENG 244 – Modern Physics and Materials for EE. The proposed course only focuses on applied and engineering design aspects in the field of Semiconductor Devices. This change was motivated by the need to better connect theory and practice.

- E&C-ENG 303 – Junior Seminar [1 credit]
  Proposed required course change: This course remains the same but will be offered the fifth semester instead of the sixth semester. The course will continue to be required for both the EE and CompE majors. This change in timing for the course was motivated by the introduction of the open-ended project course E&C-ENG 304 – ECE Junior Design Project in the sixth semester and the offering ECE electives starting in the sixth semester. Among other topics, E&C-ENG 303 gives students an overview of the most important ECE sub-
disciplines, and thus helps students choose their elective focus and lays the foundation for subsequent open-ended project based courses.

6. Third Year, Spring [14-17 credits]
   - E&C- ENG 304 – ECE Junior Design Project [2 credits]
     Proposed new required course: This course is another innovation in the proposed curriculum, as only very few ECE departments in the nation offer such a course. This could be thought of as the junior year version of the very popular and Accreditation Board of Engineering and Technology Inc. (ABET)-required capstone sequence E&CENG 415 and 416 - Senior Design Project I and II. This course will be required for both the EE and CompE majors, and will focus on principles of engineering design. The course is intended to strengthen connections between theory and practice, and between core Junior year course topics, and to give students their first open-ended project-based learning experience.
   - Electrical & Computer Engineering Elective (see note 5) [3 or 4 credits]
     Proposed requirement change: In the current curriculum, all Junior year courses in the EE major are required – there is no room for electives. In the proposed revision students in the EE major will be able to choose two electives from a list of Junior year EE elective courses (see the course list in note 5). This curricular feature is meant to increase flexibility and allow students to develop more depth in one or more EE areas of their interest, or/and alternatively expand the breadth of their studies in ECE.

7. Fourth Year, Fall [13-15 credits]
   - E&C-ENG 415 – Senior Design Project I [3 credits]
   - Electrical & Computer Engineering Elective (see note 5) [3 or 4 credits]
   - Social World Elective (see note 2) [4 credits]

8. Fourth Year, Spring [13-15 credits]
   - E&C-ENG 416 – Senior Design Project II [3 credits]
   - Electrical & Computer Engineering Elective (see note 5) [3 or 4 credits]
   - Social World Elective (see note 2) [4 credits]

Notes:
1. Students must earn a grade of C or better in one of the courses ENGIN 110, 111, 112, 113, 114 or 197E. ENGIN 112 (Introduction to Electrical and Computer Engineering) is strongly recommended for students who intend to pursue the Computer Engineering major. Note that this “C or better” requirement is a continuation policy, and does not differ from the current curriculum (in fact it is less restrictive as the new course list is enlarged to include the new courses: ENGIN 114 – Introduction to Biomedical Engineering, and ENGIN 197E –
Introduction to Engineering).

2. Social World Electives and Diversity requirement: Choose four Social World Electives (four credits each) consisting of:
   • One Literature or Arts elective: AL or AT
   • One Historical Studies elective: HS
   • One Social and Behavioral elective: SB
   • One more elective: AL, AT, SB, I or SI

   Also, choose two courses to meet the Social & Cultural Diversity requirement: one course focusing on United States diversity (U, ALU, ATU, HSU, IU, SBG, or SIU) and one course focusing on Global diversity (G, ALG, ATG, HSG, IG, SBG, or SIG). Most students satisfy the Diversity requirement with two of their four Social World electives. In other words, with careful planning, four courses may be used to satisfy all six graduation requirements.

3. The Biological Sciences Elective can be any course that fulfills the University’s BS General Education requirement.

4. A student must be enrolled in either the Electrical Engineering (EE) or Computer Engineering (CompE) major and have the requisite course requirements before taking any 300-level E&C-ENG courses.

5. Electrical & Computer Engineering Electives. The electives must include at least two 500-level courses (or above) that may not be used to satisfy the requirements for any other major. Each is 3 credits unless otherwise indicated.
   • E&C-ENG 241: Advanced Programming I (1st sem)
   • E&C-ENG 322: Systems Software & Networking I (1st sem)
   • E&C-ENG 372: Intro. to Security Engineering (1st sem) 4 cr
   • E&C-ENG 331: Hardware Organization I (1st sem)
   • E&C-ENG 334: Fields & Waves II (2nd sem)
   • E&C-ENG 311: Intermediate Electronics (2nd sem)
   • E&C-ENG 341: Advanced Programming II (2nd sem)
   • E&C-ENG 325: Systems Software and Networking II (2nd sem)
   • E&C-ENG 332: Hardware Organization & Digital Design II (2nd sem)
   • E&C-ENG 544: Trustworthy Computing (1st sem)
   • E&C-ENG 547: Security Engineering
   • E&C-ENG 556: Intro. to Cryptography
   • E&C-ENG 558: Intro. to VLSI Design (1st sem) 4 cr
   • E&C-ENG 559: VLSI Design Project (2nd sem)
   • E&C-ENG 563: Intro. to Comm. & Signal Processing (1st sem)
   • E&C-ENG 564: Communication Systems (2nd sem) 4 cr
   • E&C-ENG 565: Digital Signal Processing (2nd sem) 4 cr
   • E&C-ENG 568: Introduction to Computer Architecture (1st sem)
   • E&C-ENG 570: System Software Design (2nd sem)
   • E&C-ENG 571: Microelectronic Fabrication (2nd sem) 4 cr
   • E&C-ENG 572: Optoelectronics (1st sem)
   • E&C-ENG 575: Intro. to Analog IC Design (1st sem)
   • E&C-ENG 580: Feedback Control Systems (1st sem) 4 cr
   • E&C-ENG 584: Microwave Engineering I (1st sem) 4 cr
   • E&C-ENG 585: Microwave Engineering II (2nd sem)

   Students may also take any E&C-ENG 300-level course not listed and not required for the EE major. All E&C-ENG 597 Special Topics courses and all 600-level E&C-ENG courses (except
E&C-ENG 696) are allowed as well. Note that instructor permission is required to enroll in any 600-level course.
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<td>ENGLWRIT 112 College Writing [3 cr]</td>
<td>Social World Elective [4 cr]</td>
<td>Biological Sciences Elective [3 or 4 cr]</td>
<td>ENGIN 191 Freshman Seminar [1 cr]</td>
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**KEY**
- New proposed course
- Minor modification of existing course
- Unaffected course by revision
Please provide the rationale for these revisions.

We believe that the existing BS program in Electrical Engineering (EE) prepares our students very well for employment and graduate studies. Recent placement reports show that nearly all program graduates are employed or are in graduate school within six months of graduation. However, data gathered over a number of years have pointed to aspects of our curriculum that could and should be improved. In annual surveys of graduating seniors, students consistently have expressed dissatisfaction with required courses that they feel are not relevant to their intended careers, and the stress of the workload needed to meet all of the requirements. They also frequently have mentioned a wish for more software/programming and embedded system courses, more exposure to modern engineering applications and project-oriented work, and more electives in the curriculum. Assessments of student achievement of program outcomes that we gather as part of our regular accreditation review show a continuing shortfall in the ability to apply knowledge of math and science to solve engineering problems. In the discussion of curriculum issues at a 2014 department retreat that was the first step in the process leading to this proposal, faculty generated a list of desired improvements that included more emphasis on fundamentals, more coordination and connection between topics and courses, fewer required topics and courses, more exposure for students, more connection between theory and practice, and a greater focus on technical and non-technical skills. We describe below how the proposed curriculum revisions address these concerns.

First Year: First year courses are intended to provide the preparation that students need before embarking on the EE major. In revisions already implemented in the past two years, we have modified the Fall semester course ENGIN 112 – Introduction to ECE, to provide a better overview of the range of ECE technology, and the Spring semester course E&C-ENG 122 – Introduction to Programming for ECE, to more closely tie object-oriented programming instruction to applications in ECE. We have also moved the course E&C-ENG 124 – Introduction to Digital and Computer Systems, from the second-year Fall to first-year Spring. Together with E&C-ENG 122, this will give first-year students a strong foundation in both the software and hardware aspects of ECE.

Second Year: For the most part, second-year courses introduce topics and skills needed for both the EE and CompE majors. The new courses E&C-ENG 210 – Circuits and Electronics I, E&CENG 213 – Continuous-Time Signals and Systems, and E&C-ENG 231 – Introduction to Embedded Systems, are revised versions of existing courses that are required for both majors. The new versions have been developed to emphasize only the topics that are truly necessary in both majors and to leave more time for exploration of applications, and E&C-ENG 231 will include a lab component. The current course E&C-ENG 314 – Introduction to Probability and Random Processes, will be moved from the Spring of the third year to Spring of the Spring semester of the second year (also renumbered and renamed as E&C-ENG 214 – Probability and Statistics, to give students an earlier exposure to principles used in statistical analysis of data. The new course E&C-ENG 202 – Computational Tools for ECE, will provide instruction in scripting languages and problem-solving practices that are not formal parts of our current curriculum. The course will be the basis for a new approach to “Computing Across the Curriculum” that we view as one of the key innovations in the revised major. As part of teaching duties, the instructor of E&C-ENG 202 will also be dedicated to working with instructors of other second- and third-year courses to develop computing exercises that emphasize applications tied to topics within and across the courses. We see this as a key to helping students develop a better ability to integrate topics from different courses and to apply fundamental knowledge to solve engineering problems. The new courses E&C-ENG 201 – Analytical Tools for ECE and E&C-ENG 244 – Modern Physics and Materials for EE are also connected to these goals. EE students currently take the calculus courses MATH 131 and 132, along with the MATH 233 – Multivariate Calculus, and we intend to continue with those courses in the revised curriculum to provide fundamental background. Students
Currently also take MATH 235 – Linear Algebra, and MATH 331 – Ordinary Differential Equations. As opposed to basic background, in our curriculum those courses are meant more to give students exposure to specific analytical tools and techniques for modeling and problem solving. We have found, though, that many students have difficulty connecting what they learn in the math courses to the applications in ECE. In the proposed curriculum, we will replace MATH 235 and MATH 331 with E&C-ENG 201. The new course will cover elements of linear algebra and differential equations with a focus on how they are used in the context of ECE. It will be incorporated in Computing Across the Curriculum to further tie the mathematical concepts to applications. E&C-ENG 244 – Modern Physics and Materials for EE, will fill a knowledge gap in engineering science that exists in the current curriculum. Prerequisite topics in quantum mechanics and electronic and electromagnetic properties of materials are currently covered somewhat incoherently, too late in the curriculum, and without sufficient depth as part of the junior year courses E&C-ENG 344 – Semiconductor Devices and Materials and E&C-ENG 333 – Fields and Waves I that use those topics. EE students have repeatedly complained that they are not adequately prepared for the junior year courses. This change will not only address this issue, but it will create room in E&C-ENG 344 and E&C-ENG 333 to focus on more applied and engineering design aspects of semiconductor devices and electromagnetic systems, respectively.

**Third Year:** The third year focuses on core topics covering the breadth of EE. These represent what we believe every graduating electrical engineer should know and be able to do. They also prepare students for advanced electives in the fields of most interest to them. In the revised curriculum, the core courses will be concentrated in the Fall semester. The new course E&CENG 310 – Circuits & Electronics II, is part of a course re-packaging and credit reduction in this area in order to focus on what we consider to be the most important concepts while giving students the necessary “breathing room” to better absorb them. The new course E&C-ENG 315 – Signal Processing Methods, mainly includes topics from the current E&C-ENG 313 – Signals & Systems, that were deemed not necessary for CompE majors but core to EE majors, and also to incorporate noise modeling concepts as they apply to ECE systems (currently tangentially covered in E&C-ENG 314 – Probability & Random Processes). More importantly, this core EE course will be fully focused on applied and engineering design aspects of signal processing systems which helps strengthen the connections between theory and practice in the curriculum. Both E&C-ENG 333 – Fields and Waves I and E&C-ENG 344 – Fundamentals of Semiconductor Devices, are 3 credit versions of the respective 4 credit courses in the current curriculum. The credit reduction follows mainly because some engineering science topics that were covered in the present versions have been moved in the fourth semester course E&C-ENG 244 – Modern Physics & Materials for EE. This change allows the junior year courses to concentrate on applied and engineering design aspects, effectively strengthening connections between theory and practice. Paring the number of topics covered in the courses also allows for a more in-depth presentation of some core EE concepts. All of the Fall semester courses will be incorporated in Computing Across the Curriculum and will emphasize how core concepts are applied. The current course E&C-ENG 303 – Junior Seminar, will be moved from Spring to Fall. This 1-credit seminar covers topics in engineering ethics and social impacts of technology. It also includes a discussion of different fields within ECE that is useful information for students as they choose their elective focus. With the background provided up through the Fall semester of the third year, students will be ready to begin choosing elective courses in the Spring semester. EE students will select two Junior Year elective courses that can be used to explore aspects of electrical engineering in more depth or to expand the breadth of their studies in ECE. The Spring semester will also include the new course E&C-ENG 304 – ECE Junior Design Project. This course is intended to foster design skills and further help students integrate what they have learned in ECE through work on small design projects drawn from across the curriculum.
Fourth Year: The fourth year in the revised curriculum has the same structure as in the current curriculum. It is intended to be the culminating experience that prepares students for work after graduation in their chosen areas of ECE. The curriculum in the fourth year includes the year-long capstone experience of the Senior Design Project sequence (E&C-ENG 415 and 416), along with four advanced elective courses drawn from ECE.

Academic Requirements Review

Will be completed later, after consultation with the Registrar’s office.

If this proposal requires no additional resources, say so and briefly explain why. If this proposal requires additional resources, explain how they will be paid for. For proposals involving instruction, indicate how many new enrollments are expected and whether the courses have room to accommodate them.

The Electrical & Computer Engineering (ECE) instructional development committee (IDC) has thoroughly analyzed the long-term impacts of this curriculum revision on ECE faculty member workload, graduate course offerings, and elective and experimental course offerings. It was found that even under rather conservative assumptions, the proposed revisions to E&C-ENG designated courses could be delivered by ECE faculty members and require approximately the same number of full time equivalents (FTEs) as the current curriculum. The IDC further considered a rollout plan that ensures a smooth transition between the current and proposed curricula. Under the same conservative assumptions, it was found that at the semester of the greatest stress (when the two curricula would partially coexist) a total of 2 extra FTEs would be required. This extra workload on the ECE faculty can be covered via a “roll-over” that is already in place in the current ECE department workload policy.

Additional financial resources required by the proposed curriculum are associated with new or restructured laboratory and project-based courses. The Dean of the College of Engineering has provided the ECE department a one-time curriculum development fund of approximately $60K. This fund will be used for the development of project based courses, or courses that require development of new labs. That will include the following courses:

E&C-ENG 202 – Computational Tools for ECE (fall semester): Part of the Dean’s fund will be used for the development of this course that is responsible for the implementation and coordination of the “Computing Across the Curriculum” concept. No new laboratory space is required as the UMass College of Engineering requires incoming students to have a laptop (https://engineering.umass.edu/future-students/laptop-requirement) and maintains at least two 24/7 computer laboratories in Marcus 133 and Grossman 155 (https://engineering.umass.edu/about-us/engineering-computer-services/labs). The ECE department maintains additional computers in Marcus 8.

E&C-ENG 231 – Introduction to Embedded Systems (spring semester): The ECE department will request from the dean’s strategic investment pool additional funds for course development. The lab component of this course will be in Duda Hall, that is currently used for E&C-ENG 353 – Computer Systems Lab, a course that is proposed to be eliminated.
E&C-ENG 210 – Circuits and Electronics I (spring semester): This course will include a lab component that will be held in Marston 221, the place that hosts the labs of the current courses E&C-ENG 212, 323 and 324. Although most of the equipment in Marston 221 will be reused, E&C-ENG 210 will require some funds for development and equipment, this amount will be drawn from the ECE department’s course development fund.

E&C-ENG 304 – ECE Junior Design Project (spring semester): The majority of the Dean’s fund will be used for the development of this new project-based, lab-intensive course. Noted that the lab-based spring semester course E&C-ENG 324 – Electronics II, in the proposed curriculum has been eliminated, thus its lab space in Marston 221 will be used by E&C-ENG 304. Additional space is available in Marcus 5 (M5) maker-space, and/or Duda Hall.

E&C-ENG 310 – Circuits and Electronics II (fall semester): This course will include a lab component that will be hosted in Marston 221, which is the place that host the labs of the current courses E&C-ENG 212, 323 and 324. Although most of the equipment in Marston 221 will be re-used, E&C-ENG 310 will require some funds for development and equipment, this amount will be drawn from the ECE departments course development fund.

The implementation of the proposed revision does not require any other additional resources (FTEs or financial support) from other departments or university units.

Enrolments in all new courses are expected to be at approximately the same historical levels as (the corresponding year) courses in the current curriculum. Classroom and laboratory sizes will not be affected by this revision.

Attachments

No Files Uploaded at This Time

MOTION: That the Faculty Senate approve the Revision to a Degree Program: Electrical and Computer Engineering Electrical Engineering (BS), as presented in Sen. Doc. No. 18-042.